EXCELLENT PUBLISHERS

Congestion control of the GSM network in Nigeria

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A B S T R A C T

The study of congestion control on GSM network in Nigeria is necessary as congestion remains a major challenge to telecommunication service provision both to service providers and the subscribers as well. The subscribers are threatened to quite service providers who fail to meet up with the services required of them. Invariably, quitting the service providers will not solve the problems; instead it will create more problems. In science, problem paves way for research and development and that is the brain child of this project work. Analytical method used in this project is recommended as the best control measure for GSM congestion. This research work has made it possible for some of the key performance indicators to reach a bench mark as recommended by the International Telecommunication Union. Chapter five gives a summary of the recommendation made for the service providers to create a mutual benefit between the service providers and subscribers.

Introduction

The current trend on the telephone technology is the cellular telephone usually referred to as the cell phone.

A cellular telephone is designed to afford user a maximum degree of freedom of movement.

Consequently, there is a rapid increase in the cellular telephone density. Other factors are as well responsible for this growth and include reduction in service cost as well as the ever increasing range of services available through the cell phone. The cellular system began in the United States of America with the release of the Advanced Mobile Phone Service (AMPS) system in year 1983 (Lee, 2006). Asia, Latin America and Oceanic countries adopted the AMPs standard creating the largest potential market in the world for cellular (Mehrotra, 1997).

GSM communication revolution in Nigeria started in August 2001 and this brought a great change in the face of Information and

Communication Technology (ICT) (Adegoke et al., 2000).

In the early 1980s, most mobile telephone system was based on electronics technology.

Some of the challenges facing analog systems are their inability to accommodate the growing bandwidth needs in a cost efficient manner because analog transceiver cannot handle more than one call at a point in time. Also several facilities as well as services are not possible in the analog system,. On the contrary, digital technology was welcomed. The advantages of digital system over analog system include ease of signaling lower level of interference, integration of transmission and switching as well as increased ability to meet capacity demands. Therefore the limitation of analog system become clearer as the number of subscribers increased. This gave way to the digital system. The GSM is more advanced than the analog system and uses digital data which accommodates more subscribers. This technology increased the number of subscriber beyond expectations.

The GSM mobile telephone offers high quality voice communications and low bandwidth, data connection for fax, short message services (SMS) as well as full dial-up connection to the internet for e-mail and web browsing. The resultant effect is felt on emergence of mobile computers, the intelligent handset, the personal digital assistants (PDA) computer or intelligent handset. The need for mobile computing came as a result of the need to access information anywhere and anytime. The drawback of this system is its inefficient use of the radio resources.

The increasing need of mobile telephone and ancillary devices for data communication has driven the need for a fast, reliable and available infrastructure. Mobile communications are now showcases a wide range of services ranging from e-payment, e-government, e-health, etc. Mobile terminals are now becoming computer embedded system with stringent real time requirement for signaling and voice processing (Sconres,1997) it thus becomes imperative that numerous technical challenges bemoans its engineering and applications.

The handset sold over the next few years are likely to operate much more differently than those of today. GSM is going to play a practical and pragmatic role in making all these features work. Many people are attracted to GSM because of its mobility features. GSM is now a means of livelihood for many people as more individuals are engaged in phone related businesses. In Nigeria today, the number of subscribers has continuously pushed the infrastructure beyond the optimum limit, here again, part of the reason is the marketing strategies of the operator and competition to get many subscribers on their existing infrastructure which is insufficient. The operators complain that they pay an exorbitant fee to obtain licenses for operation in Nigeria, so they have to get as many subscribers as possible for them to recover their money as well as keep with the exorbitant running costs. All of these factors have led to congestion on the Nigeria GSM network.

In 1947, researchers in AT & T Bell Laboratories conceived the idea of cellular phones. They realized that by using small service areas or cells they can reuse the frequency (Asoke, 2005). This in turn can enhance the traffic capacity of mobile phones. AT & T requested the Federal Communication Commission (FCC) to allocate a large number of radio-spectrum frequencies so that widespread mobile

telephone service would become feasible. FCC is a government agency in United States who regulates the usage and licensing of frequency bands. Every country has its regulatory agencies like FCC. In India, the regulatory authority is Telecom Regulatory Authority of India (TRAI). FCC in USA is charged with regulating interstate and international communications by radio, television, wire, satellite and cable. Initially, FCC agreed to license a very small band to AT& T. This small frequency range made only twenty three (23) simultaneous phone conversations possible in one service area. With twenty three (23) channels, there was no market incentive for either research or commercial deployment for AT& T. Though the idea of cellular was very much available in the late forties, and did not take off.

Adegoke *et al.* (2008) came out with the following evaluation after a thorough study on GSM performance in Nigeria. The table below indicates the network state of GSM performance for call setup failures (congestion) alone.

The government on the other hand went ahead to say that the major problem encountered by GSM subscribers is the inability to access the network when initiating a call. This is worrisome to the extent that subscribers often have to dial several times before getting connected. Worse still, when connected, it may not be to the number actually dialed.

The following control measures were recommended.

1) GSM operators should upgrade and optimize all the exiting base stations.
2) Install additional base stations across the country. This would create room for the network to handle more traffic.
3) Build additional switching centre across the country to increase the traffic carry capacity.
4) Operators should invest heavily in transmission network development and have proper radio planning. This would ensure increased network resilience improved bandwidth utilization and elevated capacity bottleneck.

Zeng (2013) introduced a novel intelligent packet dropping systems into the high level design of broadband and satellite-based internet protocol (IP) network. This is to contend with inherent impacts of dynamic weather changes on the system performance. A network congestion mechanism based on Random Early Detection (RED) with fuzzy inferencing for satellite-based internet protocol network.

Presently, in the satellite network, when rain fade situation occurs due to excessive precipitation conditions, the capacity of ground terminal is lost and this consequently leads to loss of service. This is due to the incapability of the ground terminal to properly predict and react to the rain fade situation on its own. In addition, the hub does not have any intelligence to assist the ground terminal during rain fade situation.

Causes of congestion on gsm network

In October 1986, the internet had the first of what became a series of congestion collapses in America (Jacobson, 1988). Presently, Nigeria is facing the same GSM congestion problem and having the following as the likely causes of the problem:

Lack of Adequate Base Stations

On December 29, 2003 Vanguard published a report where Adrian Wood, MTN

managing director, made a declaration that they have one million; five hundred thousand subscribers and that they had only six hundred and seventy base stations all over the country. That gave an average of 2,238 subscribers to a base station, which is highly inadequate. By now the number of their subscribers has increased considerably due to landslide reduction in the prices of their network card. It is doubtful if their present ratio has not reached up to 15,000 subscribers to one base station.

Lack of Adequate Channels

Since there are inadequate base stations, it therefore implies that there will be a lack of adequate channels to support the subscribers and the service rolled out by these operators. The number of channels determine the total number of subscribers that can be allowed to use a base station simultaneously at any point in time (NCC 2003). This trends remain the same because any time a base station is added to their network, a high level of promotion is usually rolled out in order to attract more customers, thereby returning the system to status quo.

Competition for Subscribers among the Operators

It seems the highest priority of the GSM operators in Nigeria is the total sum of money they make from the subscriber and not the overall quality of service. Subsequently they have catching advertisements and often make false declarations to attract customers to their network, but they don't have the infrastructure to satisfy customers' demands.

Lack of Adequate End to End System

The GSM operators in Nigeria are still depending on radio waves to transfer speeches and data from one base station to the mobile switching centers. Ratio wave signals are subject to interference from other electromagnetic wave generating system such as radio and television. When such interference occurs, it could lead to call setup failure, call drop or other distortions.

Lack of Good Quality Phones

In any radio link communication, it is the radio link between the handset and the base station that remains the weakest part of the communication system. If conditions are unfavourable or the user moves into a tunnel during a call, the is connection is lost. Good quality handsets with higher frequency wave characteristics makes calls more stable as they reduce interference amongst caller. This is justified by the regulation of the power control that transmits power between the terminal and the base station. It is very important to have efficient power control in order to keep interference at a minimum.

Congestion control in the GSM network

Congestion is the unavailability of the network to the subscriber at the time of making a call (Kuboye, 2010). Congestion occurs when there are limited resources at the service point. This type of congestion is known as traffic congestion. This traffic congestion identifies a block of GSM network otherwise known as the cell. One cell is a geographical area covered by one base transceiver station (BTS). The actual size of a cell depends on several factors such as environment, number of users etc. Cells are grouped within a base station controller (BSC).

Dimensioning a cell means finding answers to two fundamental questions:

- How many traffic channels (TCH) does the cell need to handle?

- How many traffic channels are necessary or required?

To solve the above question, we need to determine the traffic capacity measured in Erlangs, as;

1 Erlang =

Calls per hour $\times$ average conversation time
                3600 Seconds.

Having discussed the meaning of congestion, one need to find out how some researchers tackled congestion problems.

In GSM control, a key operation should be a technique that creates a congestion free network. This implies congestion avoidance.

An adage says that prevention is better cure; therefore, it is better to avoid congestion in GSM network rather than allowing it to ensure.

Nokia 2002 worked out plans for GSM congestion avoidance as indicated below.
Network dimensioning based on coverage and capacity requirements. The main objective here is to optimize the network in a cost- effective manner. In order to succeed, detailed information about the network is needed, such as growth estimates, protection, available and required infrastructure. Also necessary are the goals for the attainment of a good quality and high performance network. The out-come is an integrated network architecture design that shows how the different services will be implemented as well as what equipment will be needed at each point. Also, a preliminary roll out plan should be included.
Selection of a Mobile Service Switching Center (MSC), Base Station Controller and base station site and a base station site in this stated order.

Detailed network planning. Computer aided design system and tools are used for coverage prediction, interference analysis, frequency planning, microwave link planning, documentation etc. The following activities are important for a proper network planning.

Switching Network Planning

This plays an important role in the network planning process. During network dimensioning process, there are several important tasks to be considered. Switches need to be dimensioned in accordance with the estimated needed capacity, for instance, average conversation time, the need for signaling, estimated number of handovers, location updates, short message distribution etc.

It is necessary to define the network anticipated performance level, for instance the intended capacity of the switching network.

The implementation of the switching and signally network must also be considered. Moreover, there is a need to create rules for routing, protection, synchronization and signaling . Traffic matrixes must be explicitly defined as well as the equipment desired for the system operation.

After the network has been dimensioned, a detailed plan is made with a number of inputs, for instance Data Communication Network (DCN) setting with respect to the network management system (NMS), network diagrams, synchronization plan, a detailed routing plan, digit analysis, detailed signaling, numbering and charging plans etc. In addition, planners must also consider the future expansion plans in order to have a road map to the future.

Cellular Transmission Network planning

Cellular transmission network refers to the usage of the microwave link in the GSM network, for instance between the base transceiver stations and base station controllers. Usually, the main alternative is to use a leased line, which is to utilize the already existing fixed infrastructure.

In the network dimensioning phase, a lot of different information has to be collected and co-ordinated. The general transmission network diagram for base station access and core network must be drawn, in order to get clear general picture of the network connections. It is also necessary to define the capacity requirements. Furthermore, rules for the general management of the network are to be defined. Gateway and switching network connections need to be identified as well as the synchronization principles for the network. Finally, the future expansion plan must be taken into consideration.

Radio network planning

The type and location of the BTS depends on the environment especially in the city areas. Cells are usually smaller than in the country side. A larger traffic volume also affects the number of channel frequencies in a certain cell (TRX).

The maximum theoretical distance from a BTS to the edge of the cell is thirty five (35) kilometers. The timing advance is adapted for these distances (that is the ability of the mobile station to send the bursts in advance so that they arrive in the BTS in the right time slot). One factor that limits the cell size is the wave length and the frequency. The rule is that the higher the frequency, the smaller the size of he cell. It means that the potential cell coverage in GSM 900 is larger than for 1800 and 1900 networks frequency. Another factor that affects the cell size is the geographical condition. For example, open water attenuates the signal less than for instance forest or other land environment. It means that the signal can travel longer distance on open water.

Result and Discussion

Computation of key performance indicators (KPI) was inevitable for information on the quality of service offered to Nigerians by the four major GSM operators.

The table results obtained were displayed in appendixes

Call set- up success rate (CSSR)

In telecommunications, the call set- up success rate (CSSR) is the fraction of the attempt to make a call that results, in a connection to the dialed number. This is one of the key performance indicators used by the network operators to access the performance of their networks. This parameter is believed to have direct influence on the customer satisfaction with the service provided by the network and its operator (Oniasheye, 2012). It is expressed in percentage as:

$$CSSR = \frac{\text{Number of call set- up}}{\text{Number of call attempt}} \times 100\%$$

Dropped call rate (DCR)

This is a fraction of telephone calls, which due to technical reasons were cut off before the speaking parties had finished their conversation and before one of them had hug- up or dropped calls. It is also expressed in percentage as:"

CDR   =

Number of dropped call
─────────────────────   X   100%
Number of call set- up

Call set- up failure rate (CSFR)

This refers to the number of call set- up failures divided by the total number of call attempts. It is also called the blocking probability or congestion. It is expressed in percentage as:

CSFR =

Number of blocked calls
────────────────────   x 100%
Number of call attempts

Call success rate (CSR)

These are calls that were successfully set- up and received by the called party including the released failed calls. It is also called call completed rate (CCR) and expressed in percentage as:

CSR (or CCR)   =

        Number of call completed
        ─────────────────────   X   100%
        Number of call attempted

Pictorial representation (bar chart) of key performance indicators of GSM operators

The graphs shown below are bar chart of key performance indicators of the four major GSM operators in Nigeria

Looking at the bar chart, one can see percentage values of the key performance indicators (kpi) of the GSM operators.

Fig1 is a bar chart that represents the average call set-up success rate of MTN, GLOBACOM, ETISALAT and AIRTEL, with AIRTEL having the best quality of service (qos) and followed by ETISALAT.

Figure 2 is also a bar chart that represents an average call set-up failure rate of the same GSM operators having MTN as the most

poorly performed GSM operators in the country and then followed by GLOBACOM. AIRTEL also emerged as the best followed by ETISALAT.

Fig 3 is a bar chart representation of average call success rate of the same GSM operators with AIRTEL as the best GSM operator.

Fig 4 is also a bar chart which shows the average call drop rate of the GSM operators with ETISALAT having a few drop rate and followed with AIRTEL.

Summary of findings

The International Telecommunication Union (ITU) has a bench mark on the above key performance indicators (KPI).

Call drop rate should be 1 out of 1000 (Juan *et al.,* 2002) calls in a busy hour to assume good network in order to have a good customer satisfaction. This is also applicable to call set-up failure rate.

Looking at the above analysis, one can infer that from April 2013 to October none of the GSM operators met up international standard.

Conclusion

Congestion is a canker worm that has devastated GSM network starting from the year 1986 to date.

Researchers have been trying their best to ensure that it is brought under control.

The bench mark created by the international telecommunication union has not been achieved even in the developed nations, a reason being that service providers are bent on making fabulous gains instead of satisfying their customers.

An adage in Igbo land says that good name is better than money. With this statement, the GSM service provider in the country should queue behind to recognize the adage and stop pursuing excess money at the detriment of their subscribers.

Table.1 Subscribers Dialing Three or More Times before Getting Connected

City	Zain%	MTN%	Glo%
Abuja	56	63	67
Kaduna	39	50	45
Kano	61	53	39
Marduguri	41	42	53
Jos	33	38	48
Bauchi	57	68	49
Ibadan	46	41	42
Calabar	45	79	50
Port-Harcourt	44	47	20
Owerri	63	54	45
Enugu	37	59	61
Benin	51	60	58
Lagos	35	39	50
Kwara	46	36	33

Table.2 Average call set up success rate (%) ratio for operators

MTN	GLOBACOM	ETISALAT	AIRTEL
69.15	72.88	94.72	96.47

Table.3 Average call set up failure rate (%) ratio for operation

MTN	GLOBA COM	ETISALAT	AIRTEL
30. 82	27.10	5.30	3.70

Table.4 Average call success rate (%) ratio for operators

MTN	GLOBA COM	ETISALAT	AIRTEL
45.17	48.57	92.00	92.03

Table.5 Average call set up failure rate (%) ratio for operators

MTN	GLOBA COM	ETISALAT	AIRTEL
25.40	21.12	2.72	4.42

Figure.1 Average call set up success rate (%) ratio for operators
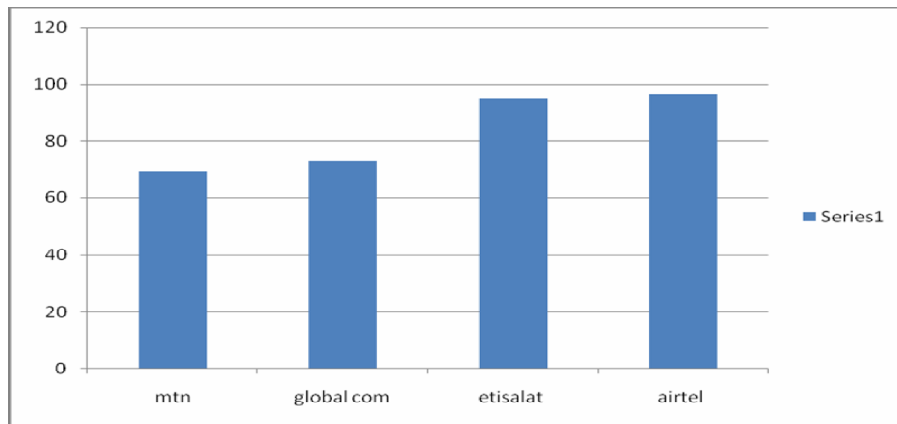
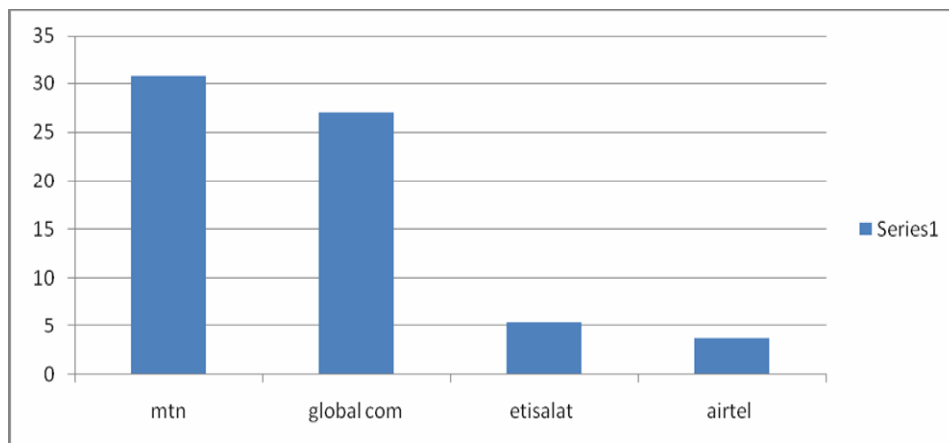**Figure.2** Average call set up failure rate (%) ratio for operation

Figure.3 Average call success rate (%) ratio for operators
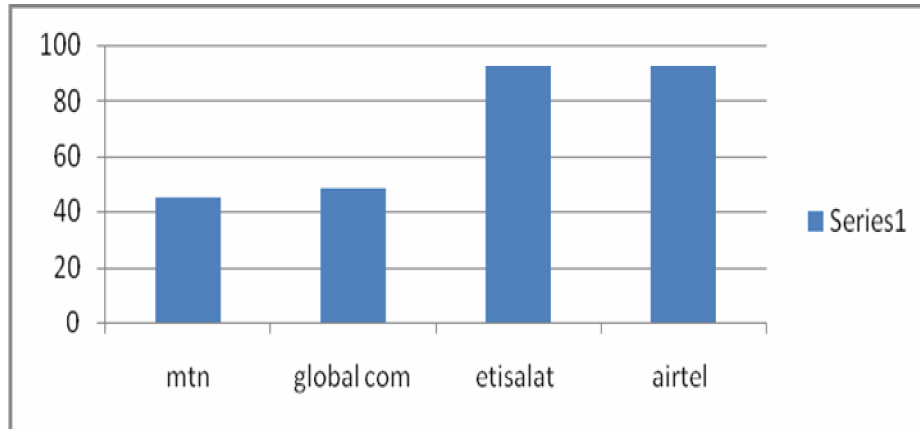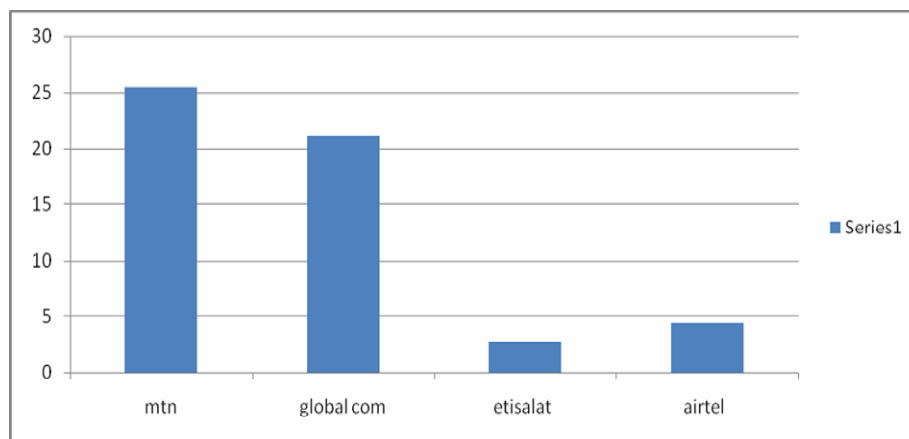

Figure.4 Average call set up failure rate (%) ratio for operators

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