Performance Analysis Of Traffic Control Congestion Management In Mobile Wirelesscommunication In South West Of Nigeria

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Abstract— **Traffic Congestion of GSM has always been a major problem and challenge in Nigeria to the service provider and the subscribers. This work deals greatly with the traffic control congestion and management in mobile wireless communications with the aim of guaranteeing customer's satisfaction so as to provide very accurate and reliable throughput whenever wireless network is utilized. Also increase reliability and error free data transfer in mobile communication, so as to ensure concurrent access to users without any interference or congestion. The research was developed by exploring the use Erlang-B and critically analyzed the call data for a period of busy hour for a week that was collected, and these data are used to describe a model to estimate the maximum number of calls a channel can handle concurrently based on the number of Er1ang's channel. The data are used to determine 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 (%). This was done using correlated analysis hypothesis. In this work, from the result analysis obtained graphically, it was discovered that a lot of available channels are being underutilized especially in areas with low blocking ratio where the available channels exceeded the required channels for transmitting the effective load. Therefore, in reducing impulsive congestion in most of these cells, excess channels that are been underutilized should be converted to other cells that may be experiencing congestion. Thereby will help to reduce traffic congestion and save a lot of cost from been wasted on acquiring more cells or more channels for effective transmission on congested cells should be setting up.**

Keywords—Channels, Blocking rate, Call Data, Traffic control congestion and management, Mobile wireless Communications

I. INTRODUCTION

The advents of wireless technology have had great impact on globalization of the Nigeria economy since its inception in 2001. But the tremendous growth in subscription have brought some challenges to the operators on how to tackle the occurring congestion in the mobile wireless communication posed in their services and have caused a lot of inconveniences to the subscribers. Since its goal is to provide good quality services to the end users (subscribers) with respect to speech, effective roaming globally and lesser tariffs. GSM has become more advanced and handles more subscribers than the analog systems(6). From the finding of our research, we have well over 9 million users of GSM contending for access almost at the same time in Nigeria, making the country one of the fastest growing GSM markets in Africa and the world at large(9). It is also has that the Nigeria telecommunication market is looking forward to achieve a tele density of 100% by the year 2020 which is driven by the massive telephone and mobile communication improvements thereby requesting for a great increase in the information and communication technology (ICT). Nigeria, with the population density of over 170 million people are being serviced by five major Global System for Mobile (GSM) Telecommunication operators which are MTN, AIRTEL, GLOMOBILE, ETISALAT and MTEL. But among the various operators MTN has the greatest patronage with over 57.2 million subscribers although the competition is getting tighter as the day goes by as operates have to compete for the same potential subscribers.(1,9). Over the years after the start of the GSM era in Nigeria, the focus is now gradually shifting from providing coverage to providing quality service; and the euphoria of owning a phone set is gradually giving way to complaints of dropped calls and congestion among subscribers.

Hence, congestion simply means a state of being overcrowded, overloaded or blocked that is too full of traffic. This occurs when too many subscribers are contending or seeking for the use of the resources at almost at the same time which eventually will result to poor throughput, slow speed and poor network among the mobile wireless communication. Congestion is when too many packets are present in or a part at the subnet which results into the degradation of performance; that is when too many traffic is offered. This occurs when the incoming packets from the source node are too much for the router to handle which makes of streams of packet arriving on three or four input lines where all of them will share the same output line(6). When this happens, a queue will build up, causing congestion and finally if there is insufficient memory to hold the stream of packets, it will eventually results in the lost of some packets in the course of transmission. It can also be experience in a network when so many subscribers are contending for access simultaneously making the input traffic rate to exceed the capacity of the output line; when routers have an infinite amount of memory, congestion gets worse(9). However, congestion control is the controlling of traffic entry into a telecommunications network, in order to avoid congestive collapse. A system is said to be congested if it is being offered more traffic than its rated capacity due to too many active subscribers. System maintenance and repair actions can lead to system congestion but whatever be the cause of the overload, it will manifest as depletion of resources that are critical to the operation of the system. Also, Congestion control is differ from flow control in that a congestion is a global issue involving the behavior of all the hosts, routers, the store-and-forward processing within the routers while a flow control relates to the point-to-point traffic between a given sender and a given receiver.

Traffic is the use of given resources such as radio channels that is when a user makes a phone call, the channel is seized for communication resulting into generating traffic. Hence, traffic can be said to be proportional to the Average Call duration (6).

Network congestion can result when there is a rise in the transmission of a data thereby leading to a decrease in throughput. Also, it can occur as a result of sending more data than the network elements can accommodate thus causing the buffers on the network elements to be filled and possibly having an overflow(12). While traffic congestion is a condition on the GSM networks which occurs as the use increases and characterized by slower speeds, long trip times and queuing. This is experienced along several channels within the network architecture and occurs when the common, dedicated, traffic and pulse code modulation (PCM) channels are not available for the assignment for the incoming or outgoing service request. In summary, when backbone links fails, it shows to the available links have been over utilized (12). GSM is a cellular network, also known as mobile phones connected for cells searching in the immediate vicinity and operating in four different frequencies. There are five different cell sizes in a network namely macro, micro, Pico, femto and umbrella cells with their coverage area varying according to the implementation environment. Macro cells are regarded as cells where the base station antenna is installed on a mast or a building above average roof top level while micro cells are cells whose antenna height is under average roof top level and are typically used in urban centers (12). Hence, aimed to attempt to minimize and manage the effects of congestion on mobile wireless communication (GSM) by seeking to study critically the review and analyze the overview of the GSM network architecture, its mode of operations and the causes of traffic congestion which will provide an optimum preventive and control measure that will reduce the rate of congestion also improve the throughput of calls made. This will enhance the quality of service provided to the subscribers.

A. Network Structure

GSM architecture subsystems consists of 3 main sections which are Mobile Station (MS) consisting of 2 parts which are the Mobile Equipment (ME), serving as the portable terminal, and the Subscriber Identity Module (SIM) containing the subscription and authentication information about that particular user. The second one is the base Station System (BSS) which consists of the Base Transceiver Station (BTS) where contacts through the radio interface by MSs are done while the last which is the base Station Controller (BSC) controls a group of BTSs and network and Switching Subsystem (NSS) which houses the Mobile Switching Centre (MSC) as its main function. Also, It should be noted that the BSS connects the MS to the NSS. Figure1 below provides the overview of the GSM architectural subsystems (5)

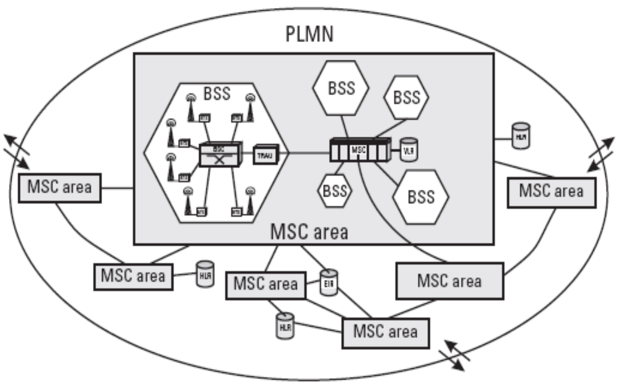

Figure1: Architecture of a Public Land Mobile Network (PLMN) (Source: Gunnar Heine 1998)

From a control theory point of view, all solutions to problems in complex systems, such as computer networks, can be divided into two groups which are open loop solutions which solves the problem by good design in order to make sure that the problem does not occur in the first place. The tools that are used here includes deciding when to accept new traffic, when to discard packets and how to schedule packets at various points in the network. In this case, decisions are made without regarding the current state of the network (5). Also, the second is the closed loop solution which is based on the concept of a feedback loop consisting of the three parts namely monitoring of the system to detect when and where congestion occurs, passing this information to places where actions can be taken and adjusting the system operation to correct the problem discovered. The main metrics for monitoring the subnet for congestion are to get the percentage of all packets discarded for lack of buffer space, average queue lengths, number of packets that time out and are retransmitted, average packet delay finally the standard deviation of packet delayed(5).

To propagate the monitored congestion information the following axioms are put in place which is a separate warning packet is sends to the traffic source by the router which detects the congestion. Also, a bit or field can be reserved in each packet when a router detects a congested state thereby filling in the field in all the outgoing packets in order to send a signal to the other packets; hosts or routers send probe packets out periodically to explicitly ask about congestion and to route traffic around problem areas. The congestion problem can be corrected when there is an increase in the resources, using of an additional line to temporarily increase the bandwidth between certain points, splitting traffic over multiple routes and using spare routers or decrease in the load by denying service to some subscribers, degrading service to some or all subscribers and having subscribers schedule their demands in a more predictable way (5). The main objective of congestion control is to keep the system running pretty close to its rated capacity, even when faced with extreme overload. This is achieved by putting the control measures in place in order to give satisfactory service to a good percentage of subscribers rather than give highly degraded service to all the subscribers. This is done by blocking some subscribers by the providers in order not to avoid overloading the main processors in the system and can be achieved by asking front end processors in the system to block the excess traffic thereby resulting in the main processors from seeing the rejected traffic; only occurs when the traffic has been accepted then the main processors will be able to handle traffic pretty close to the rated capacity (5).

B. GSM Monitoring Tools

In the monitoring tools of the GSM, different events are counted and collected by a subsystem called the statistics and traffic measurement subsystem (STS). Where in the BSC, the events can be handovers, call setups, dropped calls, allocation of different channels; also a number of status counters reporting the status of equipment within the network such as the current number of occupied channels. But by continuously supervising the results from STS, the operator can obtain a very good overview of the radio network performance which can help detect the congestion during a call set-up which affects several counters. The allocation of a Stand-alone dedicated control channel (SDCCH) can succeed or fail based on congestion or could later drop due to low signal strength. The reason for a handover decision can be normal or could be caused by conditions like bad quality and recorded by the STS which is used for further analysis. The central part in STS is a measuring database, where all measurements are collected from different blocks in the central processor. The user defines if the data should be transferred to an external system in a binary file format, or if reports should be generated as alphanumeric printouts on a terminal. STS is implemented in a support processor, which is physically located in the Input / Output group. The frequency of the collection is determined by the basic recording period parameter, which can be set to 5 or 15 minutes. The database consists of several object types which correspond to different types of equipment, logical units or functions in the BSC. Every object type contains several objects (compare with records) that have a number of counters (compare with record fields) (5).

Standard GSM Monitoring Tools

The monitoring tools is an in-built intelligence using scripts to highlight certain rows in different colors to draw attention to cells that had violated the network stipulated KPIs. A number of statistical plots like bar charts, histograms, pie charts have been incorporated to give better insights into the understanding of these parameters. With these charts, it helps to get the comparative analysis of the system for example, by plotting call drop rate against time as displayed in Figure 2 and 3 below. Also these tools helps in getting a better understanding of the network status which help in detecting the abnormalities or spotting the irregularities in the report of the measured counters are obtained; through the adopting of following research questions which are used in determining, monitoring and in getting the optimum customer's satisfactions such as can the call be made (or received), what will it sound like, will the call drop and what is happening to the network and where?

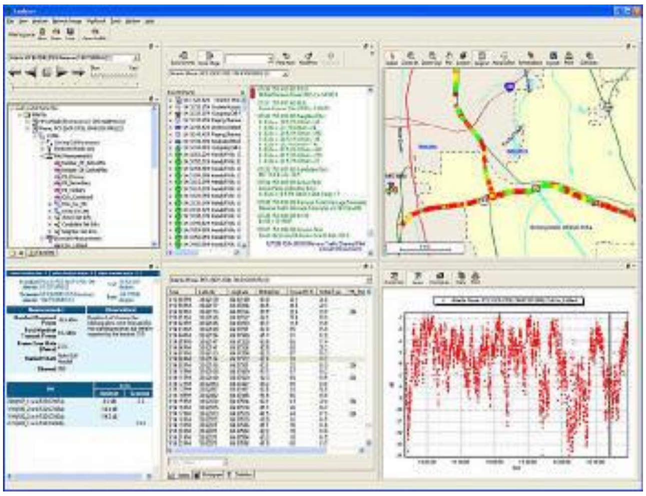

Figure 2: GSM Network Monitoring experiment.

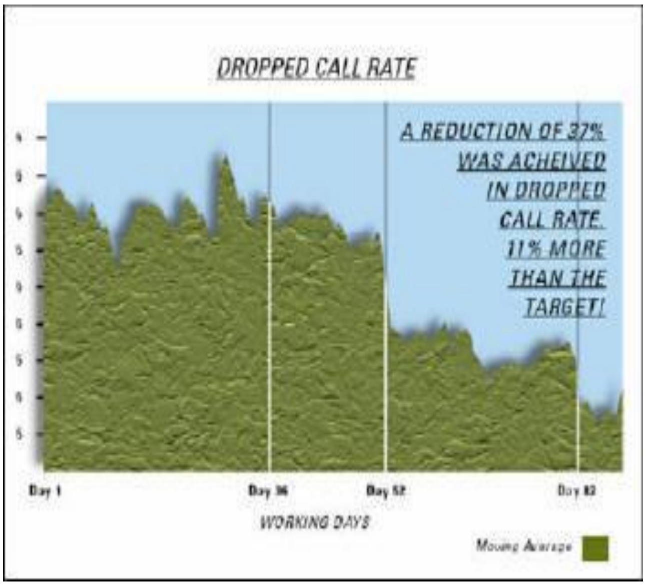

Figure 3: Statistical plotting of Drop call rate against time

II.Review of Related Works

Gunnar .H 1998 explained what GSM network is all about with its elements and their significant to the network. But Mishra A.R, 2004 describes the power control as the power that is transmitted both from the mobile equipment and from the base station has a far-reaching effect on efficient usage of the spectrum. Power control is an essential feature in mobile networks, in both the uplink and downlink directions. Chen Y. 2003 in his work describes how handover control enables the network to maintain a user's connection as the terminal continues to move across cell boundaries. In his technique, a definite decision whether to handover the call to other base station or not is made so the user is dropped from one cell before being connected to another and the user cannot have simultaneous traffic flows from two or more cells. This procedure is easy and relatively uncomplicated. But in soft handover, a mobile terminal moves into the soft handover zone it is allocated traffic channels from two (or more) base stations simultaneously. Also, Mughele 2012 study describes the carrying capacity of the MTN network and shows that there are other factors that could contributes to congestion of network while Omotoye 2014 describes the efficient way to manage the congestion during peak periods by developing a traffic-class prioritization algorithm in order to find the performance algorithm which shows that real time traffic has a better preference over non-real time traffic, also that optimum efficiency is achieved during congestion periods. Finally in 2011, Kuboye explains how the management of the congestion experienced in the GSM network in Nigeria by developing a management algorithm that explores the use of Erlang-B to determine the appropriate probability level for some range of subscribers.

III. Theoretical Framework and Methodology

In this research work, data was collected and critically analyzed by applying the Erlang-B formula which focus was on resource dimensioning through which Erlang Blocking probability, Peak Hour Traffic (PHT), Busy hour traffic (BHT), busy Hour Traffic Channel Congestion (%), Call Setup Success rate, Call Drop rate, TCH blocking rate are obtained by using the formula. The main objective of the resource dimensioning is to make sure that the system performs well during the busy hours.

Busy Hour: The load handled by a system varies a lot based on the time of day and day of the week. Most systems are heavily loaded for a few hours in a day. Thus our focus is on the load handling during the busiest hour in a day. This is obtained by calculating the Erlang (E) which is a unit of traffic measurements defined as

$$E = \frac{usage\,Time\ for\ the\ resources}{Total\,Time\ \ \mathrm{int}\,erval}$$

Hence, considering an example where a digital trunk have 31 voices circuits and each circuit has been busy for half an hour (30 minutes) during a one hour measurement interval. Calculate the number of Erlang for the usage time for resources. Hence, show the total traffic covered by Erlang.

Then the Erlang calculation will be for the Usage time for all the resources.

$let\ usage\ time\ for\ resources\ be\ represented\ as = \beta,$

$digital\ Trunk\ represented\ as = \alpha,$

$Busy\ circuit\ represented\ as = \varphi$

$Erlang\ represented\ as = \sigma$

$Then,$

$Erlang\ (\sigma)\ calculation\ for\ \beta$

$= \left(\left(\frac{1}{2}(60)\right)\varphi * 31\alpha\right) \min utes$

$= 930 \min utes$

$Hence,$

$if\ the\ total\ time = 60 \min utes$

$Then,$

$The\ Total\ Traffic\ in\ \sigma = \left(\frac{930}{60}\right) = 15.5$

$\therefore\ 15.5\sigma \cong 15.5\ Erlang$

Blocking Probability: The blocking probability defines the chance that a customer will be denied service due to lack of resources. For example, a blocking probability of 0.01 means that 1% of the customers will be denied service. Most of the time, blocking probability calculations refers to the busy hour only. Blocking probability during the busy hour can be decreased by increasing the resources in the system and Offering incentives and discounts to encourage usage during off-peak hours

Grade of Service: Grade of service is directly related to the blocking probability. A higher grade of service guarantee to the customer means ensuring a low blocking probability during the busy hours. Providing a higher grade of service requires increasing the number of resources in the system. Conversely, you can reduce the number of resources to lower the cost, but at the expense of grade of service.

Peak Hour Traffic (PHT), Busy Hour Traffic (BHT): Peak hour is the busiest one-hour period of the day, when incoming service requests are most likely to be delayed or blocked and turned away. This is the load for which resources are calculated.
Busy Hour Traffic Channel Congestion (%): This is the percentage congestion of the TCH measured at the busy hour given by

$$\frac{Busy\ Hour\ Traffic\ (Erang) - Average\ TCH\ Traffic\ (Erlang)}{Busy\ Hour\ TCH\ Traffic\ (Erlang)} * 100$$

Call Setup Success Rate: Number of the unblocked call attempts divided by the total number of call attempts. Or $(1 - Blocking\ probability) * 100\%$

Note: A call setup is an exchange of signaling information in the call process that leads to Traffic Channel (TCH) seizure.

Call Drop Rate: The Call Drop Rate is the number of dropped calls divided by the total number of call attempts. Or $(1 - call\ completion\ Ratio) * 100\%$
Note: A dropped call is a call that is prematurely terminated before being released normally by either the caller or called party.

TCH Blocking Rate: The ratio of TCH requests that were not served to the total number of TCH requests.
The model diagram shown in figure 4 below describes the congestion control analysis comprises of different subunits that are interdependent on one another. This includes the Mobile station, Base Transceiver Station (BTS), Communication link and the Radio tower. In the model diagram, the Base transceiver station takes care of the radio-related tasks and provides the connectivity between the network and the Mobile station via the Air –interface (communication link). Whenever a call is been made, it is connected to the base-station which appears to have the best path, the base station in a given area is then connected to the Mobile Switching Center from where the call proceeds to the destination

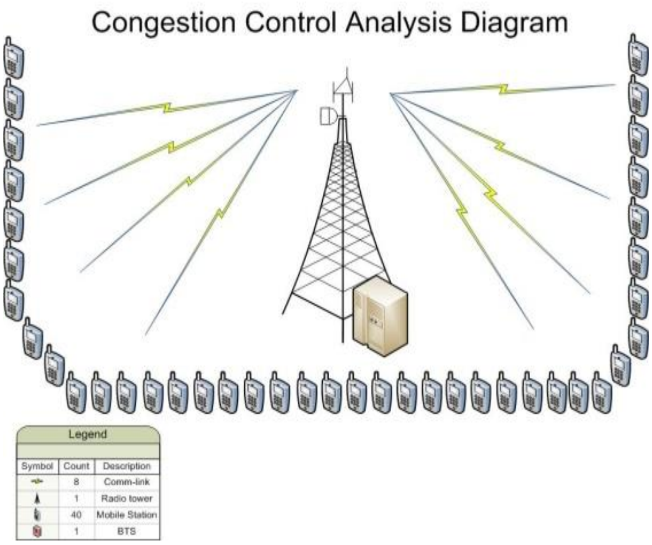

Figure 4: System Model

IV. Result and Discussion

In the course of this research work, the real traffic measurement data was for over 60 minutes between the hours of 8.00am and 9.00am over a period of a week was collected from airtel network system which is displayed in the table1, 2, 3 and 4 below. This period of one week used in the gathering of knowledge through interviewing and observation of the network data logging system of the organization. Also, help to acquire more knowledge of how network connectivity and call congestion around the environment which was mostly at the western states of the country. Interviews and data logging software were the major instruments used. This is because it was the only way to acquire an accurate data on the activity of the capacity of the network with respect to the quality of services rendered and their rate per service delivered to the subscribers.. Also, from the research, the number of calls the network receives daily, number of calls congested, calls connected, maximum number of calls the system could handle at the peak or busy periods were observed, collected and analyzed. The two methods was adopted in order to however have sufficient coverage of the research questions and to achieve the aim of the work. Correlation analysis was used for the hypotheses testing of the data. From the table analysis, we have 24 call cells for the week starting from Monday to Friday which is displayed on the table 1 below

Table 1: Traffic measurement of 24base stations during busy hour

CELL	CS Attempts-Monday	CS Attempts-Tuesday	CS Attempts-Wednesday	CS Attempts-Thursday	CS Attempts-Friday
Cell01	143	144	143	142	142
Cell02	126	122	123	126	124
Cell03	170	171	170	170	170
Cell04	460	461	460	458	459
Cell05	473	470	472	473	473
Cell06	252	250	252	248	253
Cell07	88	80	81	86	87
Cell08	266	266	265	267	267
Cell09	361	360	359	360	360
Cell10	181	180	181	182	180
Cell11	67	67	68	66	68
Cell12	956	956	950	960	957
Cell13	631	630	631	630	633
Cell14	1628	1629	1620	1622	1629
Cell15	557	550	557	554	556
Cell16	84	84	80	81	87
Cell17	140	141	142	143	141
Cell18	108	108	106	107	109
Cell19	904	904	902	900	913
Cell20	917	918	919	902	918
Cell21	243	242	243	241	244
Cell22	1501	1500	1502	1501	1500
Cell23	263	262	260	261	263
Cell24	80	80	78	79	81

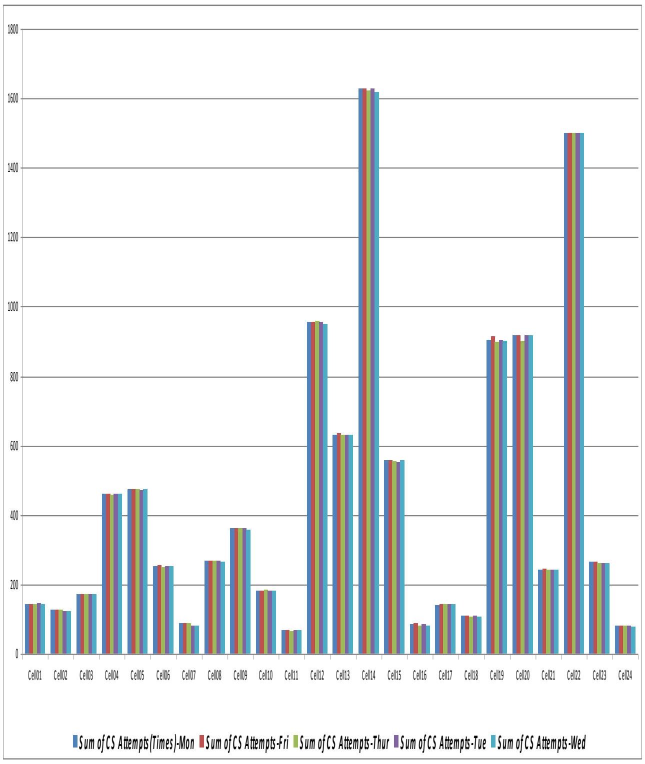

Figure 5: Erlang B Chart showing the relationship between 24 base stations.

From the analysis of table 1, a graphical profile in figure 5 showing the Erlang B chart relationships between the 24 base stations was obtained. It was observed that cell 14 has the highest recorded total congestion with a peak of 1629 Erlang on Tuesday and Friday, 1628Erlang on Monday, 1622Erlang on Thursday and 1620Erlang On Wednesday. Therefore showing that the location cell 14 is situated where there are lots of people making heavy calls especially on Tuesdays and Fridays which probably suggests that there are more business activities going on around that region than the others. Also, Cell 22 is another region that has high traffic intensity; exhibiting the highest Erlang on Wednesday to be 1502erlang, 1501 on Monday and Thursday while 1500erlang was for Tuesday and Friday. Then Cell 12 was the third highest traffic intensity recording the highest Erlang as 960 on Thursday, 957erlang on Friday, 956erlang on Monday and Tuesday while 950erlang was for Wednesday. All these occurred due to unavailable channels in the cell which is not sufficient enough to accommodate the heavy traffic in the area which can be mostly a commercial center.

Table 2: Table of computed effective load and analytical channel

CELL	Total Load/CS Attempts(Times)	Effective Load/ Successful CS Call Setups(Times)
Cell01	143	143
Cell02	126	124
Cell03	170	169
Cell04	460	458
Cell05	473	473
Cell06	252	249
Cell07	88	88
Cell08	266	265
Cell09	361	355
Cell10	181	180
Cell11	67	66
Cell12	956	951
Cell13	631	629
Cell14	1628	1615
Cell15	557	556
Cell16	84	84
Cell17	140	140
Cell18	108	106
Cell19	904	896
Cell20	917	908
Cell21	243	241
Cell22	1501	1489
Cell23	263	261
Cell24	80	80

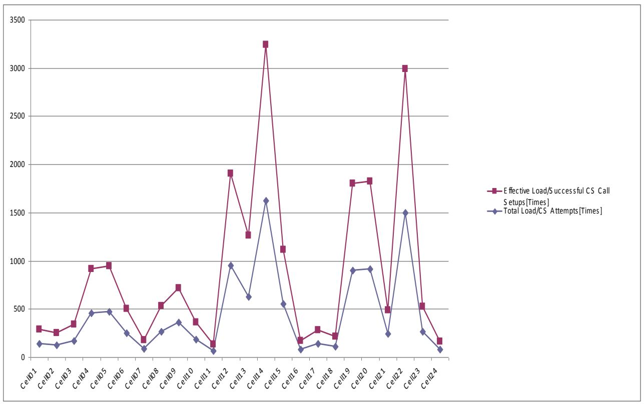

Figure 6: comparism of total load and effective load.

Hence, from table 2 above the graph of total load and effective load was obtained. The analysis shows that cell 14 carries the highest total load of 1628erlang, followed by cell 22 with 1501erlang cell 12 with 956erlang, cell 20 with 917erlang cell 19 with 904erlang due to the total traffic that comes from retrials and redials which is not part of the traffic being carried. Thus, misleads the operator thereby leading to waste of resources on areas that do not require as much resources. The resources which are the channels that are made available to those cells could be used on other cells that actually require that much. Therefore, accurate and consistent information about the Effective Load that carried by every channel should help the network operators in proper network management, prevention of congestion and proper channel utilization.

Table 3: Available channel VS Analytical channel

CELL	Analytical Channels/TCH Assignment Request[Times]	Available Channels/Successful TCH Assignments[Times]
Cell01	488	488
Cell02	682	682
Cell03	308	308
Cell04	1137	1137
Cell05	1034	1034
Cell06	1163	1163
Cell07	155	155
Cell08	579	579
Cell09	1735	1732
Cell10	761	761
Cell11	239	239
Cell12	1638	1637
Cell13	1602	1602
Cell14	2831	2827
Cell15	1007	1007
Cell16	125	125
Cell17	318	318
Cell18	146	146
Cell19	1300	1297
Cell20	2070	2070
Cell21	936	936
Cell22	1998	1991
Cell23	735	735
Cell24	373	373

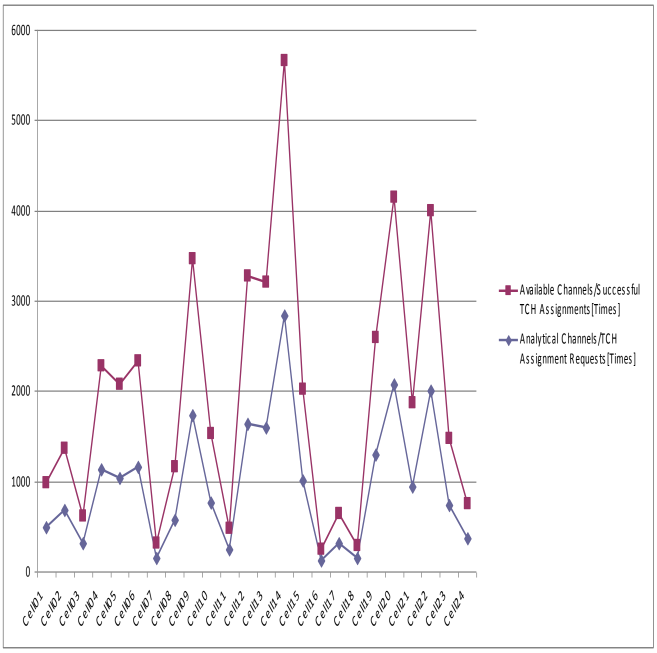

Figure 7: comparism of available channels and analytical channels chart

Also, the table 3 analyzes the output obtained for available channels versus analytical channel that is used in obtaining the graphical comparism of the available channels and analytical channels in figure 7 that shows a very clear comparism of the available channels on each cell and the analytical channels on each cell for the network operator. In the analysis, it was observed that the available channels are more than the TCH assignment requested which shows that there was no cause for congestion on the network since there are more channels available for requests but this was not so because of the mismanagement of the available channels demonstrated in the figure 7 due to the channels been distributed based on the total load and not on effective load making the channels to be utilized appropriately thereby resulting into congestion on some cells while some cells remain as a dormant in the channels that are not in use.

Table 4: Comparism of analytical channels and available channels with Blocking rate.

CELL	Analytical Channels/TCH Assign Request(Times)	Available channels /Successful TCH Assign(Times)	Blocking Rate/TCH congestion Ratio (%)
Cell01	488	488	0
Cell02	682	682	0
Cell03	308	308	0
Cell04	1137	1137	0
Cell05	1034	1034	0
Cell06	1163	1163	0
Cell07	155	155	0
Cell08	579	579	0
Cell09	1735	1732	0.1729
Cell10	761	761	0
Cell11	239	239	0
Cell12	1638	1637	0.0611
Cell13	1602	1602	0
Cell14	2831	2827	0.1413
Cell15	1007	1007	0
Cell16	125	125	0
Cell17	318	318	0
Cell18	146	146	0
Cell19	1300	1297	0.2308
Cell20	2070	2070	0
Cell21	936	936	0
Cell22	1998	1991	0.3504
Cell23	735	735	0
Cell24	373	373	0

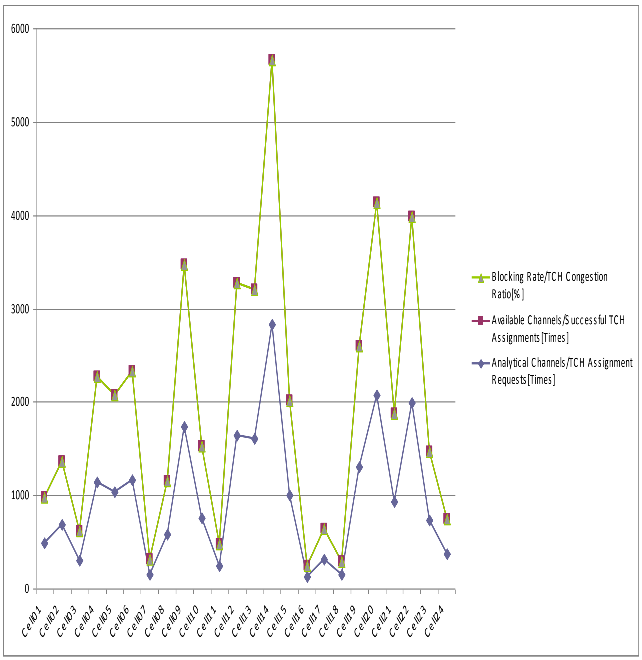

Figure 8: Comparism of channels with Blocking Rate

The table 4 is the output obtained by the program for analytical channels and available channels with blocking rate while figure 8 was from the analysis obtained from the data in table 4 showing that in most cases the number of available channels is more than the required or analytical channel needed to carry out the effective load. This depicts that the higher the rate of blocking in any cell, the more the channels that are required to carry the traffic. From the graph also, it was observed that the more the blocking rate moves towards zero, the closer the number of analytical channels which is equal to the number of the available channels.

V. Conclusion and Recommendation

In conclusion it was seem that cells with very high traffic will reduce the quality of calls made bringing about to poor quality of service and grade of service (QOS). Hence, in order to tackle this challenge, the recommendation therefore is the need to restructure and re-plan the cells in those particular geographical regions with high traffic intensity which will be achieved by increasing the number of channels in those cells (stations). Also, by provision of 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 grade of service rendered to the Subscribers resulting into congestion in the traffic.

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