Excessive Call Rejection Scheme for Congestion Control on Mobile Network

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Abstract – ***This work involved the development of a frame work for congestion control on mobile network using excessive call rejection scheme. Congestion was a situation that arose when the number of calls that emanated from or that terminated at a particular network trunk was more than the capacity that the network can effectively accommodate at a particular period of time. Inadequate radio channels and infrastructure to support the vast number of subscribers on the network, redialling by subscribers when they experienced blocking, mapping too many users on the network and use of obsolete equipment facilities are some of the factors that could lead to channel congestion. This was solved by the use of a scheme to reject excessive traffic with a known efficient and Erlang b model. The results from this work suggested that allocation of increased channel time slots resulted in reduced number of blocked calls per day; thus reducing congestion and also improving the network quality of service. Lastly, channel traffic congestion is largely transient and therefore active response time of the planned combatting scheme must be as short as possible in order to effectively mitigate congestion.***

Key Words: *Congestion, Network traffic, Network control, Teledensity, Mobile network.*

1. INTRODUCTION

Nigerian is the most populous in Africa with a population of 178.52 million people as at December 2014, according to Nigeria Bureau of Statistics, and the seventh largest in the world. Nigeria's teledensity was 99.39% as at 2014 [1]. In 1960 teledensity ratio was of 0.04 telephones per 100 persons as a result of inadequate investment in the telecommunications industry. However, before 1996 Nigeria's teledensity ratio increased to a meager 0.3 telephones per 100 persons; and with a slight to 0.4 by 1999 [2-3].

The liberalization of the telecommunication industry in 2001 with the introduction of Global System for Mobile (GSM) was responsible for a significant teledensity ratio increment within a year of operation. As at 2006 Nigeria had nearly 34 million (33,858,022) connected lines and teledensity of 24.18 the country was one of the fastest growing GSM markets in the world [3]. Presently, the ratio stands at no less than 1:1 with attendant implications of network congestion. Congestion is a serious challenge to most GSM network service providers because it negatively impacts on service level agreement since calls cannot be made or received in areas with no/weak network signals. Congestion is a situation whereby the number of calls emanating or terminating from a particular network is beyond the capacity of that network at that point in time.

When cells of higher bit rates pass through a virtual connection with a lower bandwidth, it results in congestion. Buffering of cells is said to occur when two or more conforming cells are destined to the same output at simultaneously; with cells servicing, such as dropping of cells, occurring with the arrival a non-conforming cell with the call loss probability (CLP) bit previously set to 1, resulting in network congestion [4].

Congestion is known to lead to call signals queuing on the transmission channel and this consequently manifests in reduced voice signals transfer rate or distorted received signals or both or outright unavailable service [5]. Congestions have higher possibilities of arising from traffic redirections resulting from network component failures or exceptionally high call rate to a/or some specific network node(s). Congestion inhibits the normal data flow, resulting in affected signals queuing up at already congested nodes in order to be allocated resources by the control server. Again, this put a lot of constraint on the limited network facility resulting in reduced system throughput and under-utilization of resources as a result of time wasted on the queue which could also result in data loss in critical situations (especially when it is imperative that system is refreshed).

The balance of the capacity of these interfacing devices in relations to demand from subscribers will determine the severity of resulting congestion. Except for emergency calls and power outage, calls are transmitted at the required speed.

In Nigeria, focus is now geared towards provision of quality service rather than provision coverage, as complaints of dropped calls and congestion is now rampant. Again, Nigeria is a large and highly competitive market where subscribers' satisfaction is paramount; else non-performing service providers would be pushed out of business. This is even so as network performance has a direct impact on revenues. The NCC has mandated network service operators to improve on the quality of service offered and had since commenced the conduct comparative analyses of the quality of service offered by each of the operators with a view to sanctioning non-complying operators.
Since installation costs, particularly of long distance lines, were quite expensive, wrong estimation of expected traffic and over-dimensioning of capacity could lead to economic problems. On the other hand, under-dimensioning results in economic loss and degradation of customers' satisfaction level. Dimensioning determines the amount of traffic the radio channel can capture. A good traffic model will enhance the accuracy of network dimensioning; when a network is properly dimensioned, the channels will be used more efficiently and will produce greater user satisfaction [6].
Most of the available techniques of controlling network traffic congestion were focused on either overload prevention or diversion of excess load in the event overload. Attempt had been made by [6] to use a scheme to reject excessive traffic with a known efficient and Erlang b model in order to reduce the rate of network congestion.
This research work concerns the development of a frame work for congestion control for mobile networks using excessive call rejection scheme.

2. RESEARCH METHODOLOGY

A GSM system is designed as a combination of three major subsystems. These are the network subsystem (NSS), the radio subsystem (BSS), and the operation support subsystem (OSS). To ensure that network operators have several sources of cellular infrastructure equipment, GSM specify not only the air interface, but also the main interfaces that identify different parts. There are three dominant interfaces: A interface (between Mobile service Switching Center (MSC) and Base Station Controller (BSC)), Abis interface (between BSC and Base Transceiver Station (BTS)) and an Um interface (between the BTS and MS (mobile station)). The BSS includes two types of elements. These include the BTS which handles radio interfaces towards MS and BSC which manages the radio resources and controls the handover. The MSC coordinates setup of calls between GSM mobiles and also between GSM mobiles and Phone Switched Telecommunications Network (PSTN) users, while the BSC controls several BTSs [7].

One year (January-December 2014) monthly subscriber data were gotten to examine the recent trend in mobile telephony subscriber teledensity ratio in Nigeria. Also, annual mobile network subscriber data spanning a period of three years (January 2008-December 2010) were obtained to investigate traffic channel variations, congestion, call drop and call setup characteristics. These data were procured from the NCC. Furthermore, fourteen days (6/05/2013 to 19/05/2013) data were acquired from one of the major GSM service providers in Nigeria to study the relationship between busy hour traffic, time slots and call blocking probabilities.
The Erlang b formula was then engaged. It is the probability that all channels are busy. It is used to calculate the probability that a resource request from a subscriber will be denied due to non-availability of network resources. It gives the proportion of time that no new calls can enter the system. Furthermore, it calculates the number of channels required to carry the amount of traffic with specific target grade of service. The result is used to adjust the grade of service until the appropriate one is obtained. To use this formula, the busiest hour each day is selected, the total traffic was computed; this is then averaged for the number of days considered. Furthermore, a desired target grade of service is specified where P.01 is the best target grade while P.10 is the worst allowed. A target grade of P.01 and P.10 implies that there is a 1% and 10% probability of getting a busy signal, respectively. To put succinctly, this translates to denying 1% and 10% of the total subscriber network services or resources. More so, blocking or outage probability is the probability that a call is blocked. It is therefore a measure of Grade of service [8].
The Erlang b formula is given by the expression [9]:

$$P_{bl} = \frac{L^n / n!}{\Sigma L^i / i!} \qquad (1)$$

Where L = offered traffic in Erlang, n = number of lines (or time slots). The Erlang-b formula governs the relationship between blocking probability (P_{bl}), offered traffic in Erlang (L) and the number of traffic channels (n). Equation (1) is based on analytical probability theory and is used when these two assumptions are satisfied:

1. All call attempts are Poisson distributed with exponential service time.
2 Blocked calls are cleared (BCC) in the system and that the caller tries again later.

Erlang is a measurement of telephone traffic. One Erlang is equal to one full hour of use on a (trunk) facility. To be specific, 1 Erlang = 36 centum call seconds (CCS), or 3600 seconds.

3. RESULTS AND DISCUSSIONS

Results from the-three year data (January 2008-December 2010) sourced from the NCC to investigate traffic channel variations, congestion, call drop and call setup characteristics are shown in Figures 1 to 4 respectively. It is observed that the highest data traffic is measured in the month June while the lowest is in January. Again, channel traffic due to congestion is observed to increase from year-to-year, with the worst effect measured in 2010. Similarly, traffic channel call drop increased over the years and reaching its peak also in 2010, just as channel call setup follows the same pattern. These implies that there is a direct correlation between channel congestion, call setup and call drop; therefore elucidating the inevitability of devising a technique of effectively managing and controlling channel traffic congestion, since it cannot be avoided altogether.

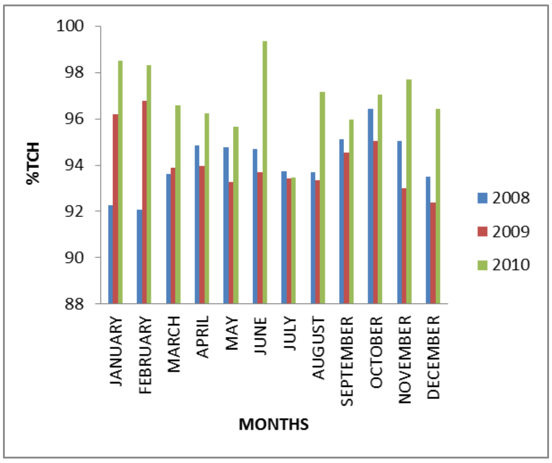

Fig -1: Traffic channel variations for an operator in Nigeria for 2008-2010

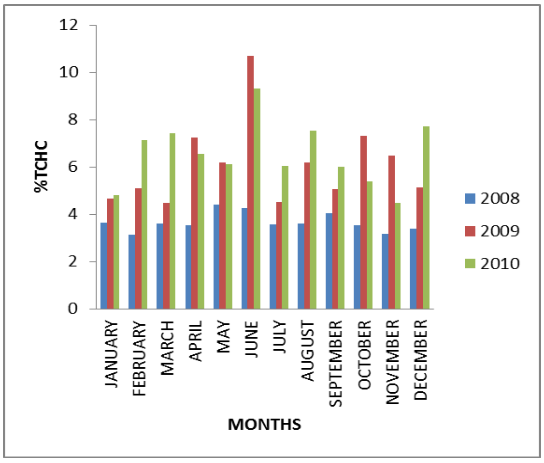

Fig -2: Traffic channel congestion for an operator in Nigeria for 2008-2010

Shown in Figure 5 is plot of busy hour traffic and blocking or outage probability for fourteen days in the month of May 2013. It should be noted that finite number of subscribers who are potential callers and not the highest number of subscribers that call during a particular hour every call is allotted equal time sharing.

Furthermore, not more than 10% of the subscribers will be ready to call at any point in time. Out of those that are ready to call, not more than 60% will be ready to spend more than one minute considering the tariff of GSM services in Nigeria. Hence, just 6% of the number of subscribers ready to make calls at any point in time would possibly spend beyond a minute. This implies that channel traffic congestion is largely transient and therefore active response time of the planned combatting scheme must be as short as possible, else congestion might not be effectively mitigated. This would put specific constraint on the microprocessor and the memory facilities if necessary provisions are not made at the design stage.

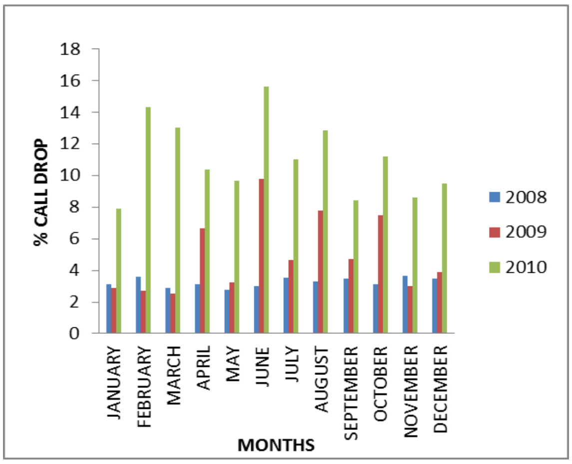

Fig -3: Traffic channel call drop for an operator in Nigeria for 2008-2010

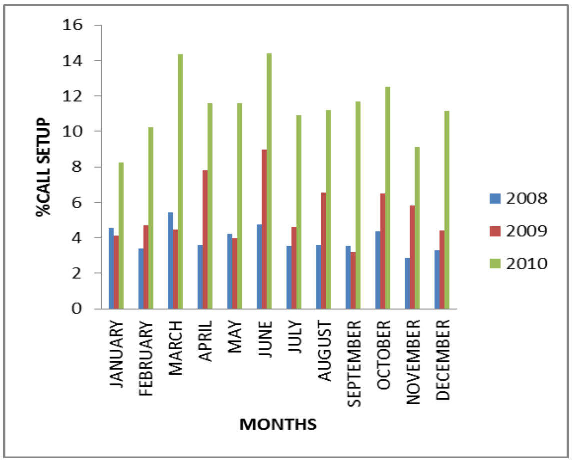

Fig -4: Traffic channel call setup for an operator in Nigeria for 2008-2010

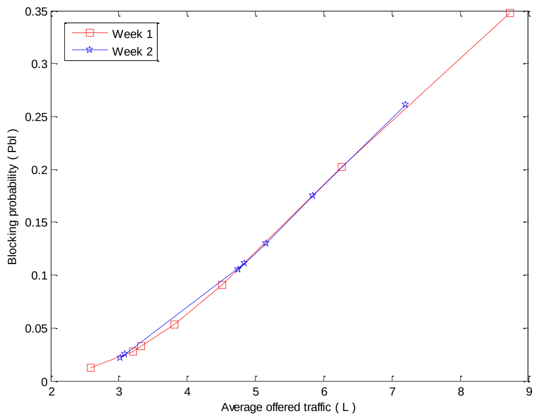

Fig -5: Relationship between busy hour traffic and call blocking probability for 6/05/2013 to 19/05/2013

From Figures 6 and 7, it is observed that increased number of time slots results in reduced number of calls blocked in any given day. Again, for 7 time slots, 20.2% of the subscribers will be denied access to the congested resource; for 8 and 9 time slots, 13% and 8.7% of the subscribers would be denied access respectively. Again, increased time slots leads to a reduction in the call blocking probability, a consequence of which is reduced network maintenance cost, minimal congestion and good profit returns for service operators.

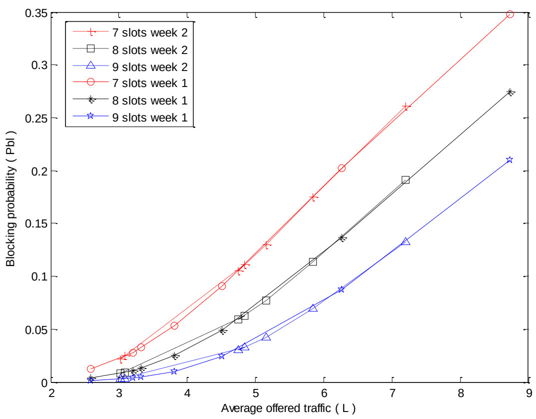

Fig -6: Relationship between time slots and call blocking probability for 6/05/2013 to 19/05/2013

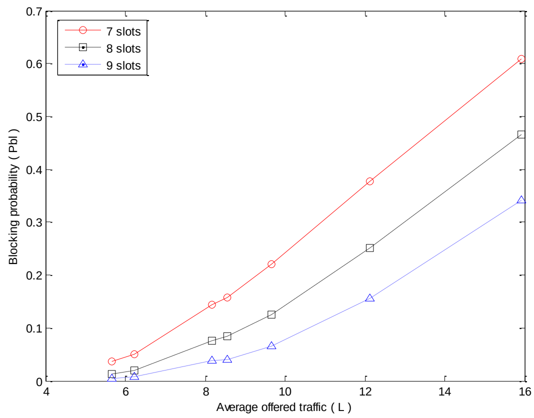

Fig -7: Mean time slots and call blocking probability for 14 days

Since it is virtually impossible to completely prevent network congestion, which may be due to some unforeseen propagation impairments (such as natural or human-prompted disasters or adverse weather conditions), which can generate abnormally high traffic, it is imperative to evolve an effective scheme that will adequately accommodate this undesirable occurrence.

4. CONCLUSIONS

This paper presented a study on excessive call rejection scheme for congestion control on GSM network. Network traffic congestion cannot be avoided; hence a practical and effective method of managing and controlling it is crucial. One such technique is appropriate implementation of a balanced combination of call blocking and time slots to moderate and stem the adverse consequences of excessively high channel traffic, especially at busy hours. Moreover, when users experience congestion, they aggravate the problem by continuously trying to make the calls again. This attitude significantly exacerbates the already congested network, and violates the assumption that blocked calls by the system would not reemerge on the network. This scenario is however not accommodated by the Erlang B model. To conclude, channel traffic congestion is largely transient and therefore active response time of the planned combatting scheme must be as short as possible in order to effectively mitigate congestion.

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