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ANALYSIS OF TRAFFFIC CONGESTION IN A WELL ESTABLISHED CELLULAR NETWORK IN ASABA, DELTA STATE NIGERIA

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Abstract—*Evaluation of the performance of a cellular network is very necessary to judge the networks QoS standard. Percentage traffic congestion (PCONG) is one of the major metrics used by network operators to determine their QoS. In this work, we analysed the percentage traffic congestion in the different sectors/cells of a well established network around the metropolitan area of Asaba, Nigeria.*
Our result shows that most of the sectors in the different cells analysed cannot cope with high traffic i.e. they have mean traffic congestion values far greater than the 5% KPI standard. These sectors need further optimization to increase quality of service especially during period where high traffic is generated for the network.

Keywords: *Traffic congestion, sectors, KPI, Traffic, cells.*

1.INTRODUCTION

The continuous increase of advanced services offered by modern cellular network operators require stringent Quality of Service (QoS) guarantee, obtained as the typical result of many optimization procedures. [1]. However, the limitation to the number of transmission channels available to a mobile communication system causes great restriction in the number of subscribers that can access the mobile communication network at a particular period of time[2]. The periodic determination of the performance of a mobile network is thus paramount especially in a developing society like Nigeria where the number of subscribers increases daily. A lot of performance evaluation has been carried out on various network operators in Nigeria using different performance metrics; drop call probability [3, 4], traffic congestion [5], call setup success rate [6] etc. The main aim of all these works was to analyze and determine if the services provided by network operators equal acceptable standard and if not suggest possible ways to attain such standard.

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In our work, we aim to determine the performance of sectors in the cells (antenna-directed) of a well established network in Nigeria using traffic congestion as a metric. This is different because our analysis in this case is sector-specific unlike what have been done in the past where the cells are considered as a whole. This is very important because from research we have discovered that sometimes even when a sectorized cell seems to be performing optimally, some sectors in the cell might be performing well below acceptable limit.

1.1 Traffic congestion

Traffic congestion in a telecommunication network is a situation in a network where immediate establishment of a new connection is impossible owing to the unavailability of network elements, it may happen momentarily for an unusual high traffic. Accumulation of traffic in any portion of the network is traffic congestion. Any type of load imposed on a system which is supposed to be carried by the system is defined as the traffic. Usually the number of calls rejected from the cell due to unavailability of traffic resources, may be due to the channels allocated by network or other facilities.

There are two main types of traffic congestions;

- Time congestion, this is the ratio of time the congestion exists to the total time for calls. It is an estimate of the ability for an external observer to find the system in a state of congestion.
- Call congestion, this is the ratio of call attempts which cannot be matured immediately to the total number of call attempts.

Congestion can also be seen as a phenomenon in telecommunication system that occurs when more subscribers attempt simultaneously to access the network

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than it is able to handle. This is a situation where subscriber numbers has completely overgrown network capacity. Some reasons for network congestion as suggested by Adegoke and Babalola [5] are;

• **Lack of Adequate Infrastructures**: To guarantee efficient network quality, there must be adequate infrastructural equipments to be able to drive the network. Also, the size of these equipments must be in tandem with the subscriber's base. When subscriber's base overgrows infrastructural equipment, then congestion is inevitable. In Nigerian situation, operators have been playing down on expansion of all cell sites, which of course is the strength of call quality. The rate of service rollout in the country has never been the same with the rate of infrastructural rollout, and this often leads to network congestion and inability to recharge phones.

• **Insufficient Channels**: Since there are not enough infrastructural equipments (e.g. base stations), automatically there will be lack of adequate channels to support network functionality. Recall that channels are normally used to determine total number of subscribers that can be allowed to use the base stations. There are four areas of congestion in the GSM network. They are; Common Control Channels (CCCH), Random Access Channel Congestion (RACHC), Paging Channel Congestion (PCHC) and Grant Channel Congestion (AGCHC) [7]. Kuboye et al also gave some likely causes of congestion in Nigeria; Inadequate number of base stations, inadequate number of channels, lack of good communication terms between different Network operators, competition for subscribers among the operators, lack of end-to-end systems, lack of good quality phones, bad marketing strategies and pricing schemes.

1.2 Some general reasons for traffic congestion

Traffic congestion in telecommunication occurs for various reasons depending on switch facilities, Exchange equipment and Transmission link. Traffic congestion mainly occurs due to inadequate capacity of equipment and improper net work management.

Causes of congestion may be classified as follows;

- Congestion due to faulty equipment.
- Congestion due to improper configuration of network.
- Congestion due to generation of high traffic.

A sudden increase in the origination and termination of calls can cause traffic congestion. For a well established network like the one we are dealing with in this work, the case of the traffic congestion occasioned by the generation of high traffic is the most probable. The traffic may increase in a particular area due to various reasons. Some of the ways in which high traffic may be generated include the following;

1.2.1 Natural disasters

Natural disasters could include the following occurrences: Earth quakes, Floods, Tsunami, Landslides, Tornado, Typhoon, Bush fire etc. In this case, some base stations, cells or sectors may be affected coupled with the fact that more calls will be made by subscribers either for help, for assistance or for inquiries about friends, relations or loved ones, as the case may be. This will definitely increase the level of traffic in the affected cell generating a very unusual high amount of traffic.

1.2.2 Unusual man made situations

We have several unusual man made situations where a large number of people from different places have to come together for different reasons, some of these manmade situations include; crusades for religious organizations, camp meetings for various reasons, conferences for different organizations or business, political or organizational rallies, demonstrations of any kind, accidents etc. In such situations where people have to come together in great numbers at a particular location at a given period, we expect subscribers to make calls at different rates and this may affect the ability of the cell or sector for the net work provider in that affected area to cope with all the calls at the same time, which may lead to a traffic congestion in the cell or sector as the case may be.

1.2.3 Seasonal Factors

We also have some seasonal factors that may lead to the generation of unusual high traffic on the network (cell or sector) at some periods, such seasonal factors include; religious festivals (christmas, salah, pilgrimage), sports festivals (athletics competitions, nation's cup finals, world cup finals etc.) , cultural festivals (fishing, wrestling, age group, attainment of manhood etc.). During these seasonal festivals people are made to come together in large numbers from various parts of the country or the world to a particular location, this will cause an increased in traffic which may lead to some level of traffic congestion on sectors or cells of the network providers in that location for that period.

1.2.4 Other Activities

International Journal of Scientific and Engineering Research Volume 4, Issue 6, July-2013
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There are some other activities that can generate high traffic on the network. These activities could include the following; Radio shows, television shows, live broadcast of events on the news, etc. where the audience is expected to participate and make some contributions through calls, using communication gadgets [8].

1.3 Subscriber behaviour

In reality, only a small portion of subscribers will be using their telephones at any time, even during the busiest hour. The probability of a subscriber to make a call is completely uncertain, but the system is made always ready for response to the subscriber. It is so uncertain that sometimes a huge number of calls are accumulated. Either calls are lost or held in queue or sometimes there are no calls so that a portion of network remains idle

1.4 Network under consideration

We are considering a well established cellular network provider with well optimized facilities, where the number of subscribers is reasonably stable and the necessary optimization procedures have been done over time.

The optimization procedures in this case may be based on

- Reduced number of drop calls
- Generation of clear signals
- Adequate channel allocation in the cells or sectors within the cell.
- Adequate facilities for hand-over and roaming, etc.

1.5 Section under consideration

We are interested in the percentage traffic congestion. In any given situation we expect that some calls may be rejected for one reason or another, but an increase in the number of rejected calls indicate some form of problem. In our computation, we used the percentage traffic congestion (PCONG); this is the ratio of the number of calls rejected to the number of incoming calls multiplied by one hundred (100).

$$PCONG = \frac{No\ of\ Rejected\ Calls}{Total\ No\ of\ incoming\ Calls} \times 100 \quad (1)$$

The percentage traffic congestion is then compared to the key performance index (KPI), the KPI is given as five percent (5%) for congestion i.e. the percentage traffic congestion should be less than this key performance index, otherwise the cell or sector as the case may be is said to have a traffic congestion problem.

2. DATA COLLECTION AND ANALYSIS

In this work, real data was collected using a software called network management system (NMS) for a two months from one of the leading telecommunication companies in Nigeria. NMS is a program for providing detection and configuration for systems to automatically connect to a network. It is a set of co-operative tools that make networking simple and straight forward. The data collected were based on three GSM traffic cells with three sectors each for a total of about one million monitored calls. All data came from the main city of Asaba, Nigeria. Traffic has been measured every hour of the day for 2 months.

In order to obtain numerically significant data, three cells have been considered. In particular, these cells were chosen as representative of the whole network taking into account cell extension, number of served subscribers in the area, and traffic load. Obviously, large datasets are needed to reduce errors in probability estimation from relative frequencies [9].

Table 1: statistical estimation of traffic congestion (%) in sectors a, b, and c in the month of September 2011.

Cell	1a	1b	1c	2a	2b	2c	3a	3b	3c
Traffic Congestion (%)	6.21	3.55	3.23	16.74	0.77	5.42	9.47	22.4	5.58

International Journal of Scientific and Engineering Research Volume 4, Issue 6, July-2013
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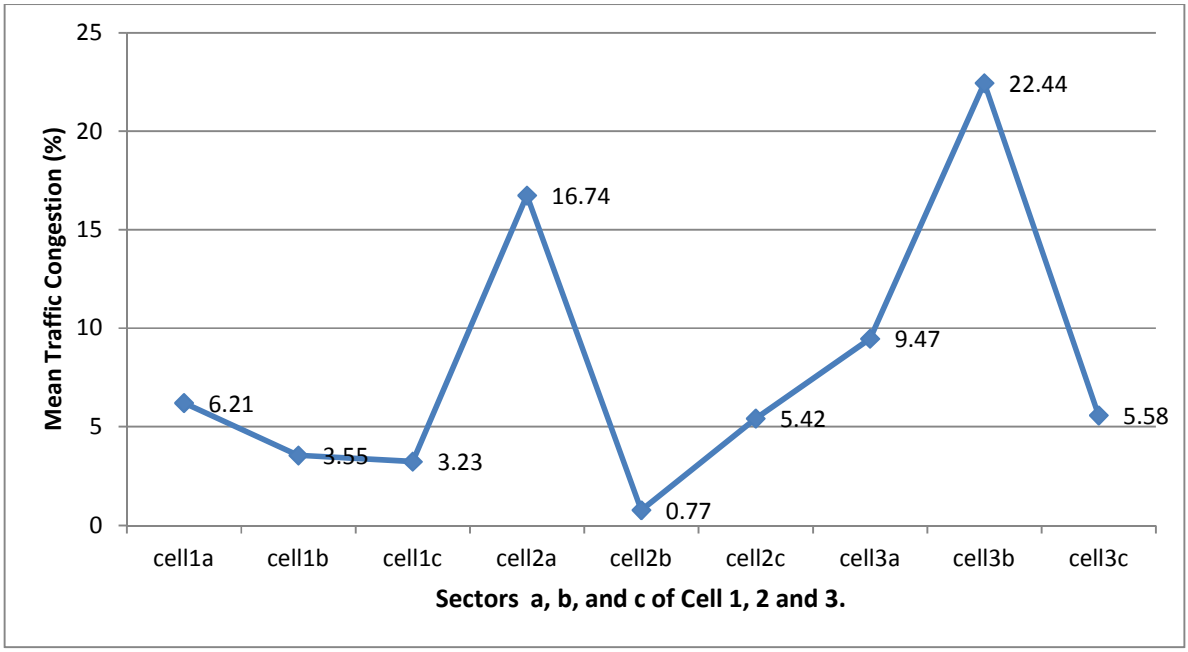

Fig 1: Graph of mean traffic congestion (%) on sectors a, b, c of cell 1, 2, 3 for the month of September 2011.

Table 2: statistical result for traffic congestion (%) in sectors a, b, and c in the month of October 2011.

Cell	1a	1b	1c	2a	2b	2c	3a	3b	3c
Traffic Congestion (%)	0.73	0.96	0.06	4.75	0.21	1.46	2.13	14.19	1.81

International Journal of Scientific and Engineering Research Volume 4, Issue 6, July-2013
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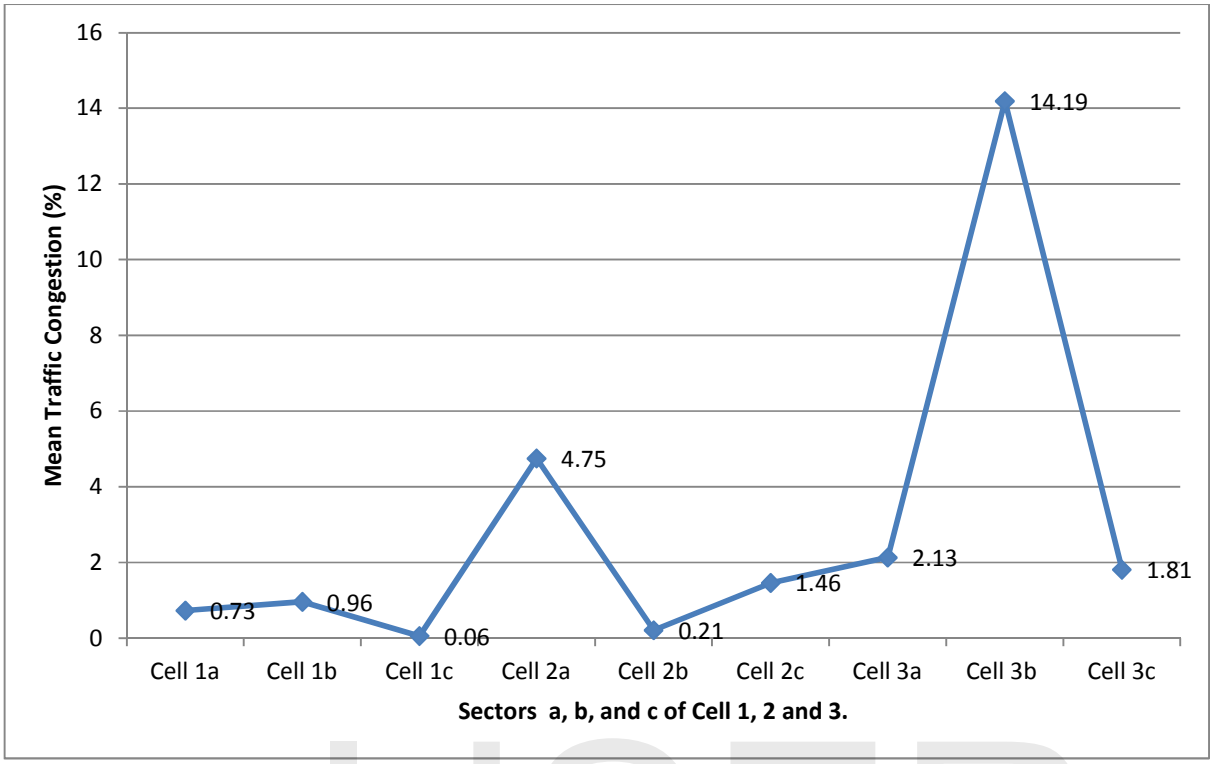

Fig 2: Graph of mean traffic congestion (%) on sectors a, b, c of cell 1, 2, 3 for the month of October 2011.

Figure 2 shows that the traffic for the month of October was managed effectively by the network provider for the sectors under the three cells, with the exception of sector b in cell 3 (Sector 3b).

Sector 3b with traffic congestion value of 14.19% was the only sector where the percentage traffic congestion was above the key performance index (KPI) of five percent (5%) for the month of October. This goes to show that the generated traffic for the month of October exceeded the capability of the facilities and equipments for that particular sector (3b).

This result is interesting because in the previous month as given by Figure 1, the month of September, it was observed that more sector seem to have encountered this problem of traffic congestion where the percentage traffic congestion was above the key performance index the (KPI).

Only sectors 1b (3.55%), 1c (3.23%) and 2b (0.77%) have values less than 5% in September. It can also be easily seen that sector 3b has the highest congestion for both months, which indicates that it probably needs more optimization.

It is also interesting to note that even if the amount of traffic differs for September and October, the shape of the traffic distribution on the sectors is similar for both months. This indicates that it is only the difference in traffic that causes the discrepancy. This difference in traffic over the two months may be associated to unusual man-made situations or seasonal factors as discussed earlier.

3. CONCLUSION

Our result shows that the studied sectors/cells cannot perform optimally when the amount of traffic unusually increases. So it is advisable for the network operator to carry out further optimization on all the sectors/cells. This will ultimately improve the QOS of the network provider, increase customer satisfaction and thereby generate more revenue for the operator.

Finally, we have been able to show that traffic analysis should not be based on cells alone, but especially on sectors because from Table 1, by calculation we have seen that for cell 1, the mean traffic congestion is 4.33% which is below the 5% KPI value, yet sector a, in cell 1, is not performing optimally since it has traffic congestion value of 6.21%. This shows that although a cell might seem to be performing optimally, some sectors of such cell might actually be too congested.

International Journal of Scientific and Engineering Research Volume 4, Issue 6, July-2013
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