11

Analysis of Traffic Congestion in a Well-Established Cellular Network in Ughelli, Delta State, Nigeria

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Ab*stract*

Evaluation of the performance of a cellular network is very necessary to judge the networks Quality of Service (QoS) standard. Percentage traffic congestion (PCONG) is one of the major metrics used by network operators to determine their QoS. In this work, we analyzed the percentage traffic congestion in the different sectors/cells of a well established network around the metropolitan area of Ughelli, Delta state, Nigeria. The result shows that most of the sectors in the different cells analyzed 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, Network, Traffic, cells.

The continuous increase of advanced services offered by modern cellular network operators require stringent Quality of Service (QoS). 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 (Osahenvemwen and Emagbeteve, 2012).

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 [Otuba and Azi, 2012; Nathaniel, Joseph and Cosmas, 2011), traffic

congestion (Adegoke and Babalola, 2011), call setup success rate (Kollar, 2008) 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.

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. In telecommunication, voice data and images in the form of electrical signals which is to be transferred from one telecom equipment to another telecom equipment through telecom network is known as telecom 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, these are;

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

Congestion can also be seen as a phenomenon in telecommunication system that occurs when more subscribers attempt simultaneously to access the network than it is able to handle. This is a situation where subscriber numbers have completely overgrown network capacity. Some reasons for network congestion as suggested by Adegoke and Babalola [2011] are;

• **Lack of Adequate Infrastructures:** To guarantee efficient network quality, there must be adequate infrastructural equipment to be able to drive the network. Also, the size of these equipment must be in tandem with the subscriber's base. When subscriber's base overgrows infrastructural equipment, then congestion is inevitable. In Nigerian, 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. Consequently, note 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) [6].

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 network

management. Some causes of traffic congestion includes; Congestion due to faulty equipment, congestion due to improper configuration of network, congestion due to generation of high traffic and sudden increase in the origination and termination of calls can cause traffic congestion. We are interested in the case of the generation occasioned by the generation of high traffic. The traffic may increase in a particular area due to various reasons. There are various ways in which high traffic may be generated, which can lead to traffic congestion in a cellular network; some of these are natural while others are manmade activities.

The natural ways include; earth quakes, floods, tsunami, land slides, tornado, typhoon etc. According to Habibur (2000), the man made generation of traffic includes; crusades for religious organizations, camp meetings for various reasons, conferences for different organizations or business, political or organizational rallies, demonstrations of any kind accidents, religious festivals such as Christmas, Salah, pilgrimage, sports festivals such as athletics competitions, nation's cup finals, world cup finals; cultural festivals like fishing, wrestling, age group, attainment of manhood, radio shows, television shows, live broadcast of events on the news etc. In such situations where people have to come to gather 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.

Materials and Methods

In this work, real data were collected using a software called network management system (NMS) for a month from one of the leading telecommunication companies in Nigeria. NMS is a programme 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 two GSM traffic cells with three sectors each for a total of six sectors. About 10,000 calls were monitored. All data came from Oghenevweta Road Ughelli Metropolis, Delta State, Nigeria. Traffic has been measured every hour of the day for the month.

In order to obtain numerically significant data, the six sectors were considered. In particular, these Sectors were chosen as representative of the whole network taking into account cell extension, number of served subscribers in the area and traffic load. We were interested in the percentage traffic congestion whereby in any given situation we expected that some calls may be rejected for one reason or another. An increase in the number of rejected calls indicates some form of problems. In our computation we used what is known as the percentage traffic congestion; this is a ratio of the number of calls rejected to the number of incoming calls multiplied by one hundred (100).

$$PCONG = \frac{No\ of\ Rejected\ Calls}{Total\ No\ of\ incoming\ Calls}\ X\ 100$$

The percentage traffic congestion is then compared with what is called the key performance indicator (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.

Result and Discussion

Table 1: Statistical Estimation of Traffic Congestion (%) in Six Sectors (two cells) in the Month of December 2015

CELL(s)	SECTOR NO	No of Call setup Cong.	No of Handover Cong.	TCONGS	Total Incoming CALLS	PCONG [%]
1	1	157	271	428	1840	23
	2	3	50	53	1529	3
	3	2	62	64	1314	5
2	4	45	221	266	2194	12
	5	15	7	22	670	3
	6	162	227	389	2158	18

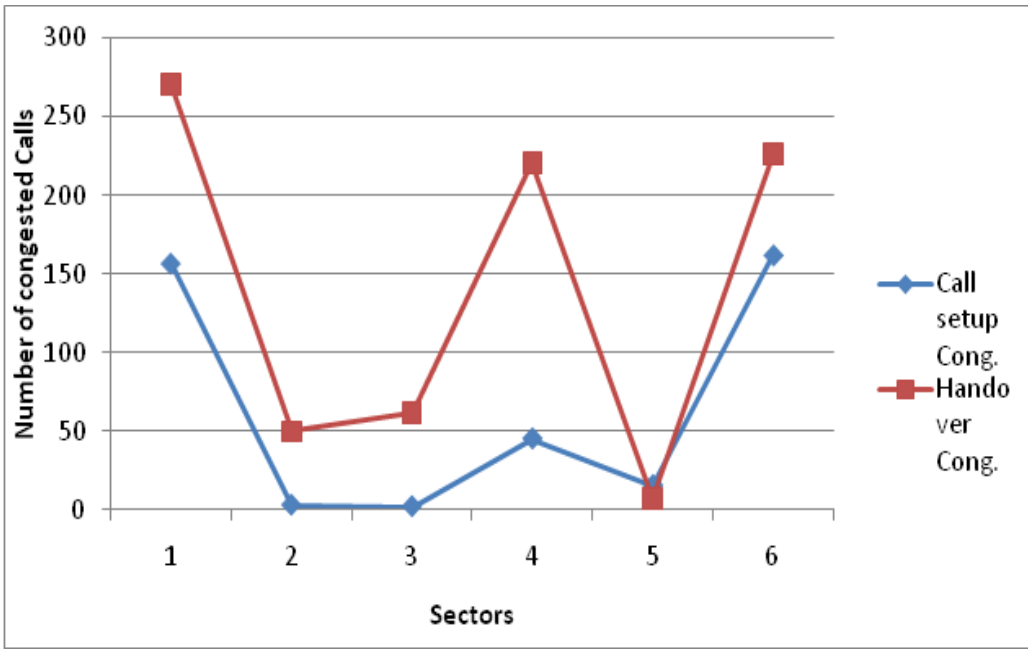

Figure 1: Total number of Congested calls based on setup and handover failure on each sector for the month of December 2015.

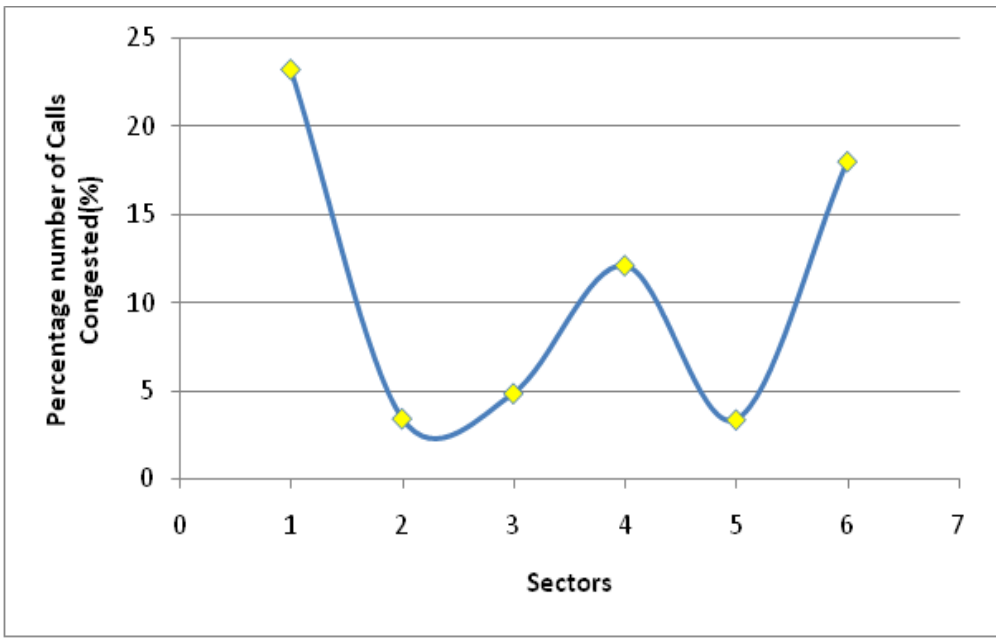

Figure 2: Graph of mean traffic congestion (%) on each sector for the month of December 2015.

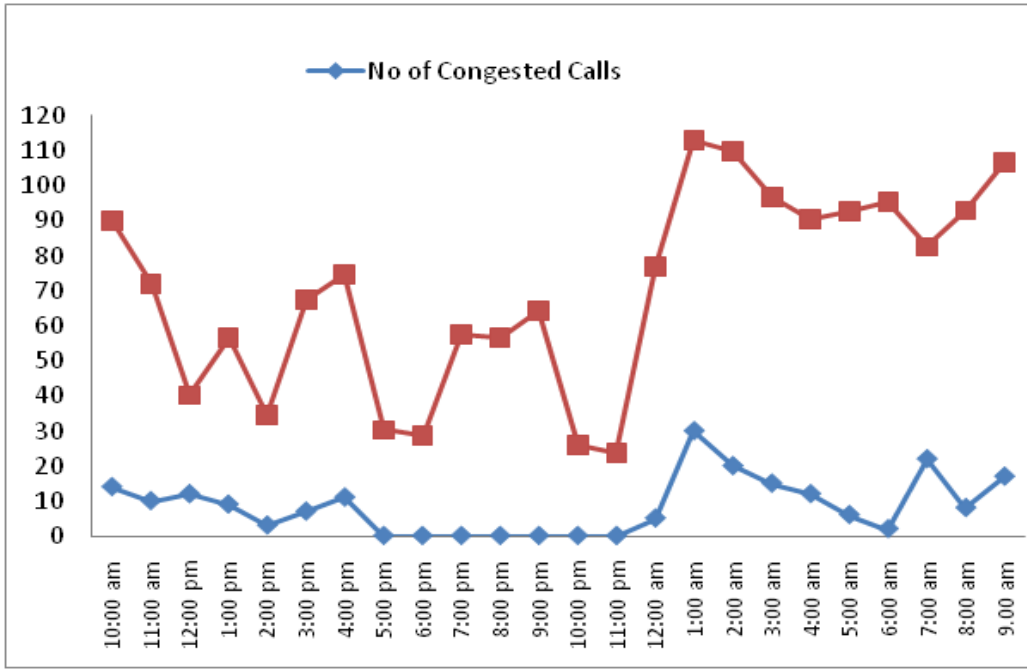

Figure 3: Daily variation of congestion on the 25th of December (Christmas Day), 2015 on sector

Figure 1 shows a plot of total number of congested calls based on set up and hand over failure an each sector for the month of December 2015. The lower curve shows an unsuccessful call set up due to congestion in a cell while upper curve shows unsuccessful hand over due to congestion in a sector or cell. This implies that more calls were dropped during hand over than set up.

Figure 2 shows a plot of mean traffic congestion (%) an each sector for the month of December 2015: From the plot, sectors 1, 4 and 6 with percentage traffic congestion values of 23%, 12%, & 18% were above the key performance index (KPI) of 5% which goes to show that they need sector specific optimization so as to save cost, time and labour. It also shows that the generated traffic for the month of December exceeded the capability of the facilities and equipment for the affected sectors (1, 4, 6).

Figure 3 shows a plot of daily variation of congestion on the 25th of December (Christmas day) 2015 on each sector. From the plot, it can be seen that more calls were made at 1:00am compared to other times which indicates that congestion was very high.

Conclusion

The results of the study shows that the studied sectors/cells cannot perform optimally when the amount of traffic 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. Consequently, we have seen that congestion is as a result of handover and setup. Furthermore, from the analysis most of the congestion related problems were as a result of calls being dropped due to handover.

Recommendation

Based on the findings of the study, the researchers recommended sectors 1, 4 and 6 for optimization to reduce the congestion value to the accepted KPI value of 5% and that future traffic congestion analysis should be sector-specific. Furthermore, more network providers should also provide raw data from their database for traffic analysis so as to enhance network performance and increase customers satisfaction and revenue for the company.

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