Performance Evaluation of Well-Established Cellular Network Using Drop Call Probability Analysis

Osunkwor E.O., Atuba S.O., Azi S.O.

Abstract— There are various performance determinant applied to cellular networks. One of the most important of these is the drop call probability. With the rapid increase of GSM users in Nigeria, it becomes imperative that Network operators pay close attention to the Quality of Service (QoS) with a view of improving it. Minimization of call drop is usually the result of many optimization procedures implemented by network operators. In this work, the phenomenon of dropped calls, one of the most important indices of QoS in a large scale well-established cellular network, has been analyzed. We verified from measured traffic data that in a well-established cellular network, handover failure as a cause of dropped calls available in some literature are in reality negligible so not the most relevant in service optimization: phenomena like propagation conditions and irrational user behavior heavily influence call termination. The obtained results, validated by statistical evaluation of measured traffic data taken from a real network, can allow the network operator to optimize system performance, improving the offered Quality of Service and their revenue.

Keywords: Drop Call, Optimization, Signal Strength, K.P.I

1 INTRODUCTION

When the call set-up phase is successfully completed, the actual service (usually speech in GSM networks) begins. However, the service may be abnormally interrupted or terminated (dropped) due to several reasons. This phenomenon is known as call dropping and the probability of such an event is known as drop call probability [1]. Drop call probability is one of the most important quality of service (QoS) determinant for monitoring the performance of cellular networks. Most service optimization procedures like increase of coverage area and network usage, congestion and interference minimization and traffic balancing carried out on cellular networks are geared towards minimization of this phenomenon.

In the past, drop call probability has been a subject of several studies [2]-[9] resulting in the design of various models under well established enviroments that have satisfied the necessary propagation conditions with appropraite cell and system planning assumption.

- *Osunkwor E.O. is a lecturer with the Dept of Physics, University of Benin, Nigeria. +2347060470621.Email: offormata.osunkwor@uniben.edu*
- *Atuba S. O. is a lecturer with the Dept. of Physics, University of Benin, Nigeria.*
- *Azi S. O. (Dr.) is a lecturer with the Dept. of Physics, University of Benin, Nigeria.*

Moreover, the fundamental hypothesis that calls are terminated only due to handover failure is also considered in [2, 5] that is, an active user can change cell several times and during one of these transitions between cells, his connection can be dropped.

Call termination caused by handover failure depends, apart from system characteristics, on user behaviour too; therefore, it is an event non directly predictable by system planners.

Although there are vast literature on this subject involving the analysis of measured traffic data. The data used in this work was supplied by one of the leading telecommunication company in Nigeria and covering the region of Asaba, Nigeria, allowed us to verify that, in a well-established cellular network, previous models are inadequate to pursue the objective of service optimization. In fact, by observing the behavior of actual wireless cellular networks, we realized that handover failure is usually a negligible event in a well-established network unlike the works of [2, 5], so that, many other phenomena become much more relevant in influencing the call dropping; in particular, call termination is mainly due to propagation conditions (Bad signal strength interms of the uplink and downlink signals, interference or bad quality), irregular user behavior, internal failure of network elements and sometimes for reasons unaccounted for by the network providers.

A cellular network is said to be well established if the number of customers is stable, assuming that the system planning phase has been completed. In this work, we performed our analysis of already measured data, supplied by one of the leading network operators in Nigeria across three cells during a period of three months; June, July and August. We analysed the real data for total call drops and its causes for each cell in the three months period to see if its less than the 2% K.P.I (Key Performance Indicator) standard. This could ultimately help in optimizing the network performance and increase revenue.

2 DISCUSSIONS OF RESULT

In this work, real data was collected for the month of June, July and August from one of the top telecommunication companies in Nigeria. These data were based on three GSM traffic cells with three sectors each for a total of 35,826,100 monitored calls that were successfully set-up. All data came from the main city of Asaba, Nigeria. Traffic has been measured every hour of the day for these months.

In order to obtain numerically significant data, Three cells for 3 different months 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 [10]. This is especially true when considering the call-dropping phenomenon which is a rare event in well-established networks [7].

2.1 Classification of Drop Call Causes

Data obtained from the network operator consist of several time-stamps about the temporal evolution of the calls, such as the call start and end times. In the database a *counter* is associated to each call reporting the cause of call termination. By using these *counters*, calls are classified in Dropped calls due to Sudden Loss (TSUDLOS), Dropped calls due to insufficient signal strength on the Uplink (TDISSUL), Dropped calls due to insufficient signal strength on the Downlink (TDISSDL), Dropped calls due to insufficient signal strength on Bothlink (TDISSBL), Dropped calls due to Bad quality on the Uplink (TDISQAUL), Dropped calls due to Bad quality on the Downlink (TDISQADL), dropped calls due to Bad quality on Bothlink (TDISQABL), and finally dropped calls due to excessive Timing Advance (TDISTA), distinguishing causes of drop calls and Total dropped calls TNDROP which is the summation of the values on each of these *counters.*

A statistical analysis of the measured data was carried out, allowing us to estimate the mean (μ) and varaince (σ^2) of each process by using the well known polarized estimators for these parameters [10].

$$\hat{\mu} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{n} (x_i - \mu)^2}{n-1} \quad (2)$$

Where $(x_1, x_2, \ldots\ldots\ldots\ldots, x_n)$ is a sample vector of n elements.

Equations (1) and (2) was the mathematical estimator used by the program. The result gotten suggests the choice of the pdf (probability density function) to represent the process. In particular we made the hypothesis, validated by the following statistical analysis that drop calls have lognormal probability density function with different parameters. Since this gave a better fit compared to other probability distribution functions.

The analytical expression of lognormal distribution is given by [10].

$$f_T(t) = \frac{1}{t\sqrt{2\pi\sigma^2}} e^{-(lnt-\mu)^2/2\sigma^2} \sigma, \mu > 0, t \geq 0. \quad (3)$$

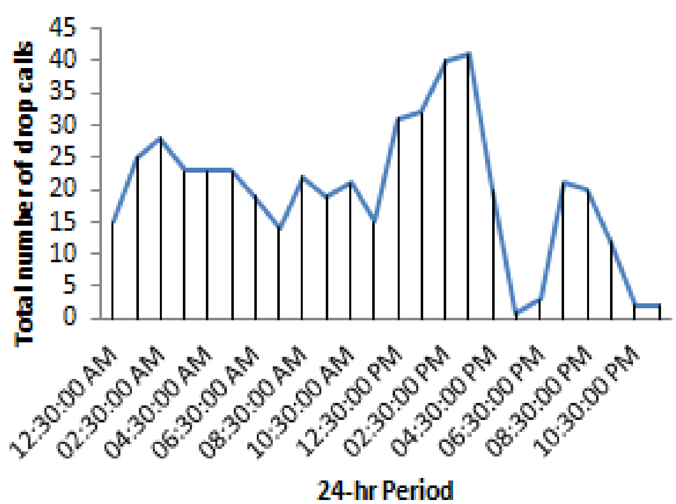

Figure 1. Daily variation of drop calls in the month of June cell 1.

Figure 1 above shows a very interesting result that suggest that drop calls are highest during the so called busy hour. During a 24-hr period drop calls were monitored and from the figure above around the period of 12.30pm to 3.30pm there was a sharp increase of drop calls. Also looking at figure 2 below which shows the variation of traffic in erlang for the same period, it confirms our suggestion that 12.30pm to 3.30pm is indeed a busy period

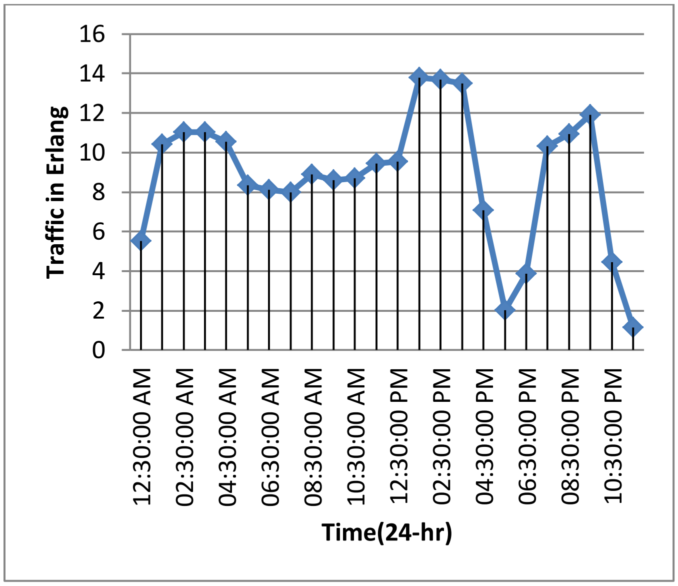

Figure 2. Daily variation of traffic in erlang unit in month of june, cell 1.

In analysing our traffic data we observed that the causes of dropped call by means of the *counter* tables and their relative occurrence follows the pattern as shown in Table 1. This represents the result for a single cell.

Table1: OCCURRENCE OF CALL-DROPPING CAUSES IN CELL 1

Drop Causes	Occurrence [%]
Drop due to sudden loss. i.e. system does not really know they dropped.	43.62
Drop due to insufficient signal strength on the uplink.	11.70
Drop due to insufficient signal strength on the downlink.	3.19
Drop due to insufficient signal strength on bothlink. i.e signal level was low on both links when call dropped.	5.32
Drop due to bad quality on the uplink	2.13
Drop due to bad quality on the downlink	30.85
Drop due to bad quality on bothlink. i.e bad quality was experienced on both links when call dropped.	2.13
Drop due to excessive timing advance	1.06

In Table 1 above, It can be observed that call drop is mainly due to electromagnetic causes (e.g., power attenuation, deep fading, multipath fading, shadowing and so on) which has a total sum of 55.32%. Although these causes are represented in our work as uplink, downlink, bad quality or interference but they are all due to electromagnetic propagation issues. Sudden loss which is the first term in Table 1, has an occurrence of 43.62% and is due to irregular user behavior which includes; mobile equipment failure, phones switched off after ringing, subscriber charging capacity exceeded during the call.

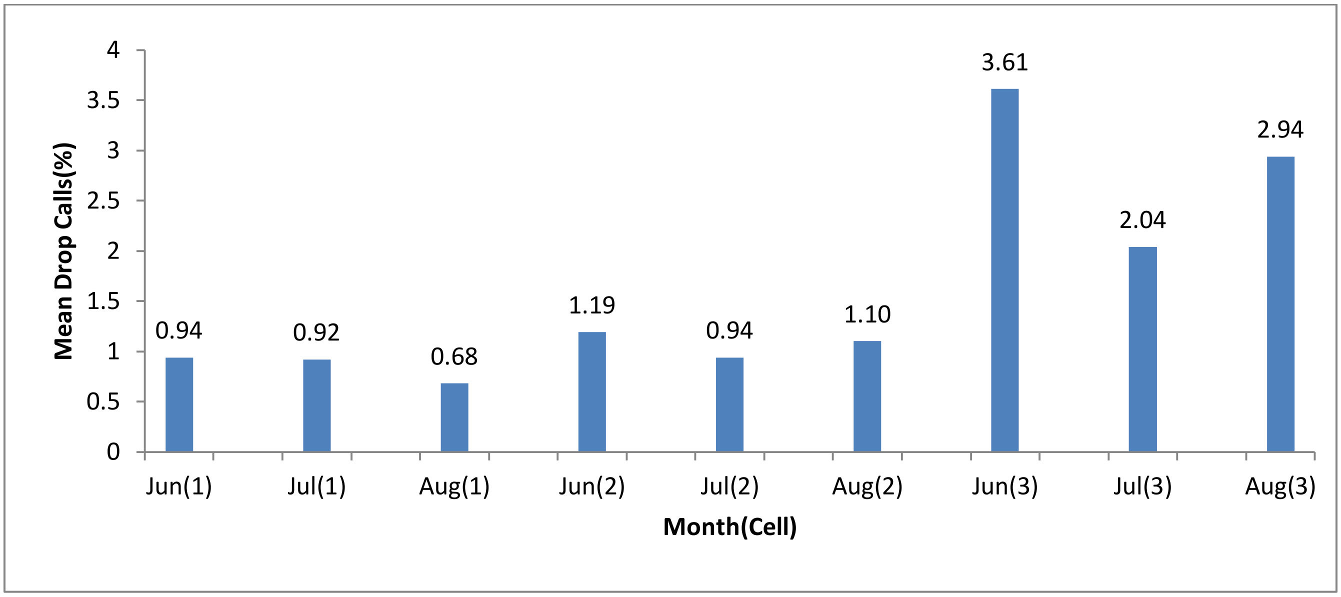

Figure 3. Percentage mean drop calls per cell for the month June, July and August.

From the Three(3) cells analysed, we noticed that call drops for this network is mostly due to sudden loss, possible causes under sudden loss are phone switched off after ringing, mobile equipment failure, subscriber charging chapacity exceeded during the call, abnormal networking response and disconnection due to wavy speech service. The next highest cause is bad quality on the downlink which is basically due to interference, followed by insufficient signal strength on the uplink, which is as a result of poor propagation condition.

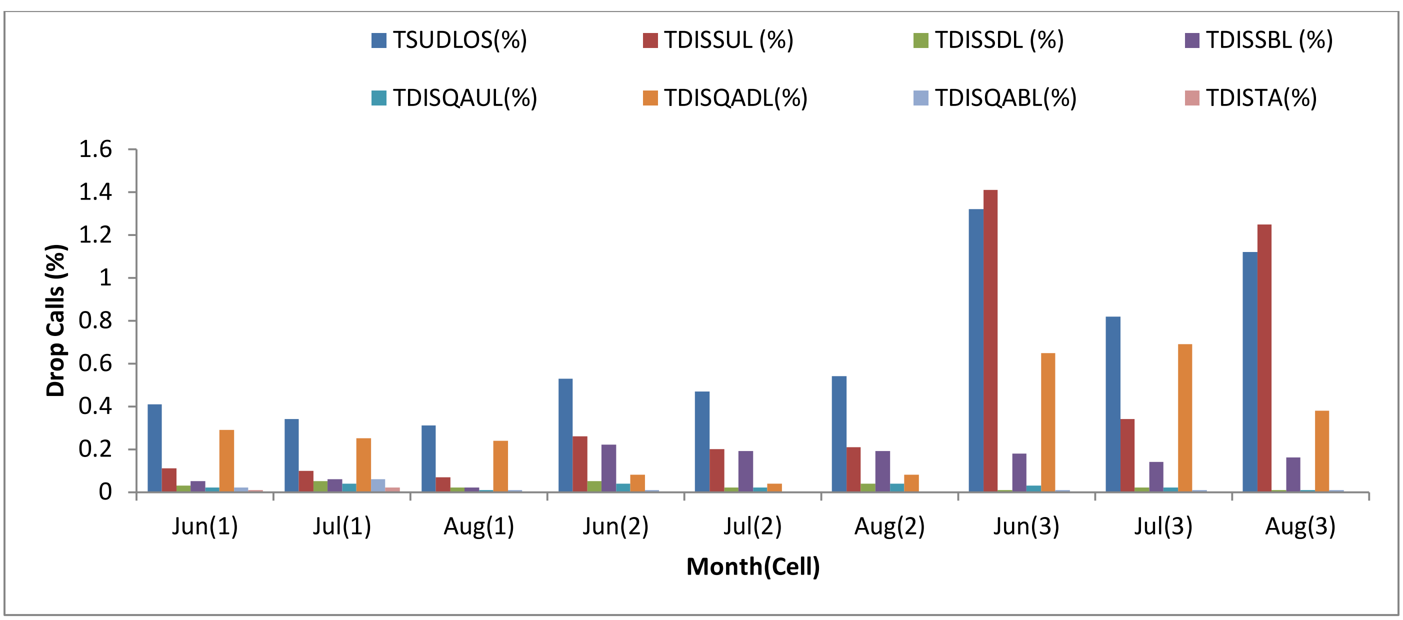

Figure 4. Percentage drop calls per cell in the month of June, July and August in terms of causes.

In figure 4, it can be easily seen that in June, July and August for cell 1 and 2, drop calls due to sudden loss was the highest. But in cell 3, for June and August, insufficient signal strength was higher. Conclusively, we can say that the major causes of call drop for this particular network operator is sudden loss, insufficient signal strength on the uplink and bad quality on the downlink. Excessive timing advance recorded the lowest value, in some cases like in cell 2 and 3, its value is zero i.e. neglible. In the case of Cell 3, it's quite obvious that this problem is not from the user end but from the network providers. They need to improve on their service delivery i.e. strong signal strength which will reduce call drop.

Considering figure 3, the mean drop call percentage are plotted against cell 1, cell 2, and cell 3, for the three months June, July and August. For cell 1and 2, we see that the drop call is well less than the standard 2% which simply indicate that cell 1 and 2 are performing within standard. However, in cell 3, optimization needs to be carried out to keep the call drop down within acceptable limits, specifically less than 2% in order to satisfy customer needs which will definitely lead to increase in revenue.

3 CONCLUSIONS

In a well-established cellular network, it was not possible to find a prevailing cause of call termination, rather a heterogeneous independent mix of causes ranging from sudden loss (Irregular user behaviour and mobile equipment failure) [9], insufficient signal strength on the uplink and downlink, bad quality (interference) on the uplink and downlink and excessive timing advance.

In a well-established network in particular, the handover failure is almost an unknown event, thanks to the reliabiilty and effectiveness of the deployed handover control procedure which is evident statistically by the mean Handover Success Rate (HOSR) for example in cell 1 which has an outstanding value of 99.6%.

Also in this work it was neccessary to filter data samples which showed anomalous relative frequency, but, whereas in [11], 26% of sample data was discarded, in [6], 5% of sample data discarded. In our analysis we discarded close to 4%.

Finally, the results obtained agrees with [6, 7], we higlight however, that the analysis of dropped calls interms of its basic causes as treated here has not appeared in previous scientific work to the best of our knowledge. Furthermore, our opinion is that the obtained results are not limited to the analyzed cells but generally valid on the whole network

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