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Analysis of Drop Call Probability in Well Established Cellular Networks In Asaba, Delta State, Nigeria.

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Abstract

Technology in Africa has increased over the past decade. The increase in modern cellular networks requires stringent quality of service (QoS). Drop call probability is one of the most important indices of QoS evaluation in a large scale well-established cellular network. In this work we started from an accurate statistical analysis of real data collected from one of the leading telecommunication companies in Nigeria. We analysed the total percentage drop call for six cells located in Asaba, Nigeria. Our result show a lognormal distribution with $\sigma = 5\times 10^{-5}$, m=7, $\theta = 0.65$, and with a mean square error (MSE) of 2.133×10^{-5} for the total drop calls. The drop calls due to other factors was found to exceed that due to handover except for cell two. The obtained results can allow the network provider to optimize system performance, forecast, and improve quality of service and revenue.

Keywords: Drop call, call holding time, Handover.

1.0Introduction

During the life of a call, a mobile user may cross several cell boundaries and hence may require several handoffs. Failure to get a successful handoff at any cell in the path forces the network to discontinue service to the user. This is known as call dropping or force termination of the call and the probability of such an event is known as call dropping probability.

Call drop is defined as a call that is disconnected prematurely during the sixty (60) second holding time [1]. This is one of the most important factors considered in quality of service (QoS) used in monitoring the performance of a cellular network. For this reason, mobile network providers try as much as possible to optimize service delivery by maximizing service coverage area, and of network usage, the minimization of interference and congestion, the optimum traffic balancing among the different frequency layers [2, 3].

There are quite a number of publications on call drop, and on how it affects network performance and some other traffic parameters. Performance analysis of mobile radio systems has been studied by Orlik and Rappaport [4] with the assumption that the drop call probability follows an exponential distribution for the call holding time, although handover is considered the main cause for call dropping. It has been observed by Fang *et al* [5] that handover is the cause for call dropping but made emphasis on user mobility of different patterns. More general statistical distributions have been considered in [5, 6] for the call and the channel holding times, while the authors in [5, 7] gave a more realistic assumption on call drop which also involve system behaviour.

All these works consider a wireless network with an infinite number of users. Boggia and Co-workers [2, 3] describe what happens when a finite user population is taken into consideration noting that call termination could also arise due to propagation conditions and irregular user behaviour. The common factor of all the previous work is that the termination calls are caused by handover failure. That is the case where the connection of an active user changing cell several times is terminated only due to lack of communication resources in the new cell. Although this sounds interesting and holds true for an established network it lacks so much ground when considered for a well established network like the one considered in this work. In such a network the lack of communication resources in new cell is extremely very low i.e. negligible, and so other factors such as electromagnetic ones (e.g. power attenuation), abnormal network response (e.g. radio and signalling protocols error), irregular user behaviour (e.g. mobile equipment failure, phone switched off after ringing, subscriber charging capacity exceeded during call), congestion etc, become significant and have to be considered.

Therefore in this work, such behaviours have been confirmed by analysing real telephone traffic data measured in the

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cellular network of the leading telecommunication company in Nigeria across six cells in Asaba, Nigeria. In practice, we found that this behaviour also accounted for call drops. Hence we analysed real data for total call drops and that due to handover and other factors for each of the six cells to see if it is less than 2% which is the Key Performance Indicator (KPI) Standard. We also used lognormal distribution to fit our probability distribution which gave a better fit than other distributions [8]. This could help network providers forecast, optimize the network and generate high revenue.

The rest of the paper is organised as follows. In Section II the measured data is statistically analysed and our results are presented in Section III. Finally, some conclusions are drawn in Section IV.

2.0 Data Collection And Analysis.

In this work, real data was collected for the month of April 2011 from one of the leading telecommunication companies in Nigeria. These data was related to six GSM traffic cells; for a total of 12,303 monitored calls in Asaba, Nigeria. In order to obtain numerically significant data, several days have been considered. In particular, these cells were chosen as a representative of the whole network, a large number of data set is needed to account for drop calls because a well established network is being considered. In the database collected from the network operator, total dropped calls are classified as handover and that due to other factors. The data was analysed to see if it agrees with the KPI (Key Performance Indicator) standard of 2% for call drops per cell.

First of all the mean percentage,$\hat{\mu}$ and the variance,$\hat{\sigma}^2$ of drop calls were carried out for each process by using the well known estimators for these parameters [8]

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

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

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

We also evaluated the coefficient of variation, C, defined as the ratio between standard deviation and mean; this parameter is an index of data dispersion around the mean value.

We tried to fit our data with several statistical distributions to examine the best distribution for drop calls. The obtained results show that lognormal distribution gave the best fit. The analytical expression of lognormal distribution is given by [8]:

$$f_T(x)=\frac{1}{(x-\theta)\sigma\sqrt{(2\pi)}}e^{\frac{-In\{\left(\frac{x-\theta}{m}\right)\}}{2\sigma^2}}\quad ,\sigma,\theta>0,\ x\geq 0 \qquad (3)$$

3.0 Results And Discussion

From Table 1, the results from the six cells show that drop call are not entirely due to handover calls as noted earlier in section I.

Table 1: ESTIMATED STATISTICAL PARAMETERS.

		Number of Calls	$\hat{\mu}$ Mean	$\hat{\sigma}$ Standard Deviation	C Coefficient of Variation
CELL 1	Drop call Percentage	2049	1.66	1.38	0.83
	Drop call Percentage due to Handover		0.69	0.45	0.65
	Drop call Percentage due to other Factors		0.97	0.93	0.96
CELL 2	Drop call Percentage	2083	1.11	4.05	3.64
	Drop call Percentage due to Handover		0.58	1.34	2.32
	Drop call Percentage due to other Factors		0.53	2.72	5.11
CELL 3	Drop call Percentage	2070	2.71	17.61	6.49
	Drop call Percentage due to Handover		0.97	1.66	1.71
	Drop call Percentage due to other Factors		1.74	15.97	9.16
CELL 4	Drop call Percentage	2085	4.23	3.94	0.93
	Drop call Percentage due to Handover		2.37	1.48	0.63
	Drop call Percentage due to other Factors		1.86	2.80	1.50
CELL 5	Drop call Percentage	1981	4.17	4.75	1.14
	Drop call Percentage due to Handover		1.17	1.11	0.95
	Drop call Percentage due to other Factors		3.00	3.95	1.32
CELL 6	Drop call Percentage	2035	0.83	1.03	1.24
	Drop call Percentage due to Handover		0.30	0.30	1.00
	Drop call Percentage due to other Factors		0.53	0.78	1.48

Looking at Figure 1, it can be noticed the figure has six cells with percentage (%) drop of 1.66, 1.11, 2.71, 4.23, 4.17 and 0.83 which is the call drop rate for six cells respectively. This indicator measures the network ability to retain call conversion when it has been established or setup. A value of 3% means that out of every 100 calls established only 3 will drop before any of the calling parties voluntarily terminate the call. The acceptable Key Performance Indicator (KPI) for call drops should always be less than 2%. Cells 3, 4 and 5 in Figure 1 clearly exceeded the KPI. Network operators should optimize these cells and keep the call drop within acceptable limits in order to satisfy consumers need which will definitely lead to increase in revenue.

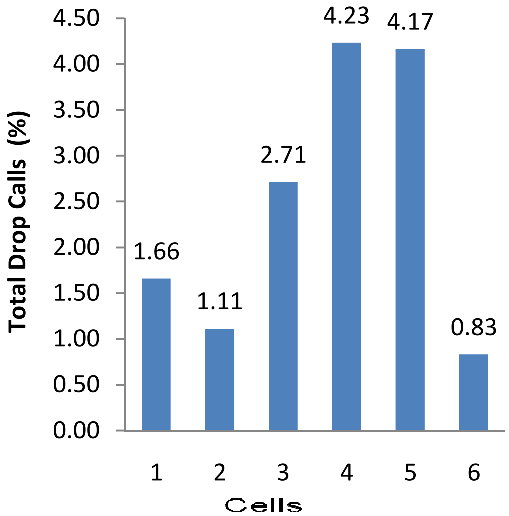

Figure 1: Drop Calls per cell (%)

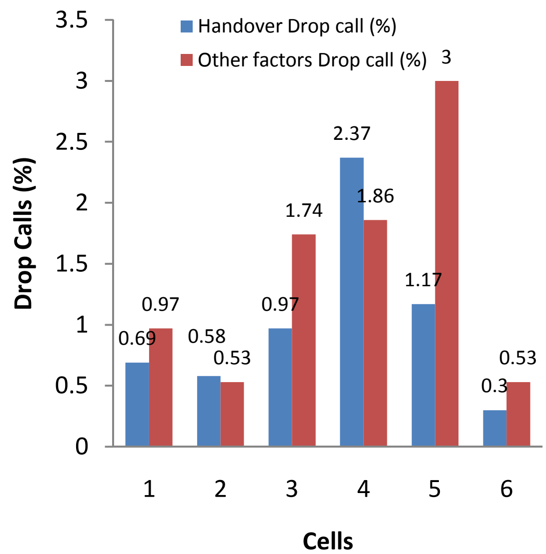

Figure 2: Causes of Drop Calls per cell (%)

From Figure 2, it can also be noticed that the handover drop calls percentage vary significantly from the total percentage drop call in Figure 1 for each cell. This shows that not all drop call is due to handover, other factors such as irrational behaviour of the user, mobile equipment failure, subscriber charging capacity exceeded during call, congestion during ceremonies, political party and religious conventions - all these factors are due to the mobile users. Other causes due to the network operators include; abnormal networking response, weak signal strength arising from propagation conditions, interference, etc. All these combined are referred to call drops due to other factors. Figure 2 shows that call drops due to these other factors can be significant and can even exceed that due to handover as shown by cells 1, 3, 5 and 6. As reported by Boggia et al [2], many other phenomena other than handover become more relevant in influencing drop calls in well established networks. This result disagrees with Hong and Rappaport [9] that handover drop is the main cause for call dropping but it is now known that total call drop is rather a heterogeneous mix of independent causes.

It is commonly assumed that Call Holding Time (the duration of the requested call connection) and Cell Residence Times (the amount of time a mobile user spends in a cell) in cellular networks is exponentially distributed. Although, exponential distributions are not accurate in practice but the models based on the exponential assumption are typically tractable and do provide mean value analysis which indicates the system performance trend by Hang *et al* [10]. Using real measurements, Jedrzycki and Leung [11] showed that a lognormal distribution is a more accurate model for cell residency time. Based on simulations, Guerin [12] showed that for some cases the channel occupancy time distribution is quite close to exponential distribution but for the low rate of change of direction the channel occupancy time distribution shows rather a poor agreement with the exponential distribution. Using detailed simulations based on cell geometries, Zonoozi and Dassanayake [13] concluded that the residency time is well described by a generalized gamma distribution but channel holding time remains exponential. Boggia *et al* [2] using real measurements also showed that drop calls follow a lognormal distribution.

The results obtained in Figure 3 agrees totally with Boggia *et al* [2] and Jedrzycki and Leung [11] and follows a lognormal distribution with 5 , m=7, and we obtained a Mean Square Error (MSE) of 2.133 for real measurements taking in Asaba, Nigeria. This result obtained can help network operators forecast the performance and drop call variations of each cell for other months.

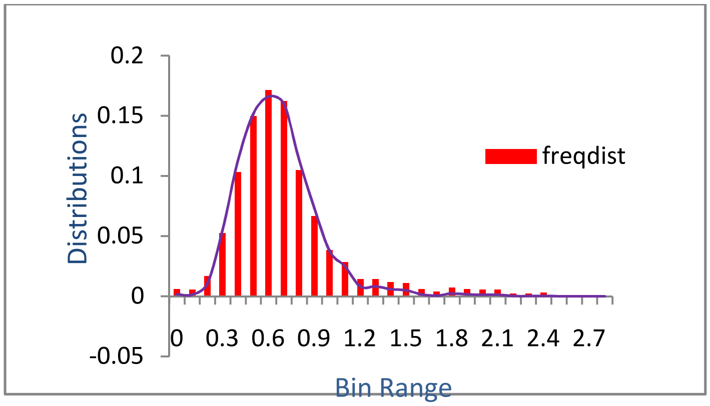

Figure 3: Histogram of the Drop calls in a cell along with the best fit pdf.

4.0 Conclusion

In this work, we started from the statistical analysis of data measured in a large well-established cellular network, taking real measurement from Asaba, Nigeria and evaluating six cells for the month of April 2011, we were able to show that three of such cells were performing below the K.P.I standard. Network operators working on those cell sites need to upgrade their facilities to meet consumers need.

From our measured results, we also found out that drop calls are not entirely due to handover drops alone as stated by Hang and Rappaport [9] but a heterogeneous independent mix of causes. Handover failure become negligible with both planning optimization, fine tuning of network parameters, reliability and the effectiveness of the deployed handover control procedure. Several secondary phenomena (irregular users behaviours, abnormal network response, power attenuation, and so on) become non-negligible.

We also showed that drop calls follow a lognormal distribution which agrees with Boggia *et al* [2], and Jedrzycki and Leung [11].

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