Analysis of Mobile Networks Signal Strength for GSM Networks

Nsikan Nkordeh, Johnson.O.Olatunbosun, Ibinabo Bob-Manuel, Oluyinka Oni, *Members IAENG*

Abstract- **GSM Network performance and service quality evaluation are essential steps for mobile operators as the income generated and customer satisfaction is directly linked to network performance and quality. Mobile Network Service Satisfaction assessment, most importantly from the consumer's perception is necessary to evaluate the network performance and maintain service quality standards. In this project, based on the end user satisfaction stand**
Point, we consider the service quality offered by mobile telephone operators in Nigeria using the four (4) core GSM networks i.e. MTN, ETISALAT, AIRTEL and GLO as case study. A Drive test report is conducted within Canaan land with the help of the (Network Signal Info Professional) application which would be used to make proposals on how network operators can

Improve radio resources as well as provide the requisite QoS (Quality of Service) to subscribers within the Canaan land environs to subscribers within the Canaan land environs.
This study would help Network Operators to improve quality, ensure improved network coverage and increase capacity in future. [2]

Index Terms-- **Received Signal Strength Indicator (RSSI), Mobile Subscriber (MS), Best Signal, Average signal**
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I. INTRODUCTION

People want to communicate with their family and friends and to be communicated with. This desire makes it all the more frustrating when the network is poor or doesn't go through at all. There have been serious complains raised by GSM subscribers regarding poor quality of services (QoS) rendered by the GSM operators in this study area. The most annoying aspect of this is the fact that all the GSM subscribers irrespective of the operator are being affected. [1] Based on these customer complains, this study was embarked upon to examine the causes of this problem and find ways of proffering solutions. This paper therefore measures signal strength of GSM networks (MTN, AIRTEL, GLO and ETISALAT) in Canaan Land and Covenant University with the view to address the complaint of the subscribers. This study would help operators to enhance coverage, improve quality and increase capacity in the days to come.

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Planning of network quality is vital if operators wish to make full use of the existing investments and keep existing mobile subscribers (MS).

II. `HAND-OVER PROCEDURE

In a mobile network hand-over strategy is prioritized over call initiation requests. When a mobile in a conversation moves around, it moves from one cell to the other, cells which may be within the same base station or outside the base station. Hand-over involves transferring both the voice and control signals of a mobile from a particular channel in a cell to another channel in another cell. Hand-over must be performed successfully and infrequently. In performing hand-over a minimum usable signal level for acceptable voice quality $P_{minimum}$ is defined (it's normally between -85dBm and -105dBm).A stronger signal level, $P_{Threshold}$ is used to defined the threshold at which hand-over is initiated. A differential $\Delta_{handover} = P_{Threshold} - P_{minimum}$ is used by the MSC to control hand-over procedure. If $\Delta_{handover}$ is too large, too many hand-overs occur and the MSC is over engaged. If $\Delta_{handover}$ is too small, there may be insufficient time to complete a hand-over before a call is lost due to weak signal level.
- the *dwell time.* The dwell time is defined as the time over which a call may be maintained within a cell without hand-over. The dwell time of a mobile is governed by: propagation, interference, distance between subscriber and base station.

In first and second generation systems, hand-over is controlled by the MSC, while in subsequent generations; hand-over is controlled by the Mobile and/or base station.

The main objective of optimal power control is to enable the transmission of the needed power to support a given data rate or sustain a call in a mobile communication link. If the power transmitted is too high, it causes unnecessary interference but if the power is low, it increases the error rate which causes the call to drop, or requires retransmission – which invariably causes large transmission delays and lower throughputs.
Four units of measurement are used to represent RF signal strength in 802.11. These are: mW(Milliwatts), dBm ("dB"-milliwatts), RSSII (Received Signal Strength Indicator), and a percentage measurement [1]. "Signal strength" is defined as Received Signal Strength Indicator(RSSI). Received Signal Strength of Mobile Subscribers (MS) from the base station determines the quality of reception .The Received Signal Strength depends on a number of factors: the quality of Radio Frequency planning, the number of base stations.

Indoor radio propagation is difficult to predict because of the dense multipath environment and propagation effects such as reflection, diffraction, and scattering [9]. Multipath fading causes the received signal to fluctuate around a mean value at particular locations. The received signal is usually modeled by the combined effects of large-scale fading and small-scale fading. As the Mobile Station (MS) moves away from the serving base station, the Received Signal Strength (RSSI) drops according to the inverse square law. Propagation measurements in a mobile radio channel show that the average received signal strength at any point decays as the square of the power law of the distance of separation between a transmitter and receiver. The average received power $P\ r$ at a distance d from the transmitting antenna is approximated by

$$P_r = P_0 \left(\frac{d}{d_0}\right)^{-n} \qquad (1)$$

$$P_r(dBm) = P_0(dBm) - 10n\log\left(\frac{d}{d_0}\right) \qquad (2)$$

P_0 is Power received at close-in reference point in the far field region of the antenna at a small distance d_0 from the transmitting antenna, and n is the path loss exponent.

The problem of estimating spatial – coordinates of the node is referred as localization

Through a RF drive test, a RSSI-based localization of the network can be computed from data collected: a computation which involves measurement of the RSSI at different, i.e the RSSI is mapped to an estimated distance,d.The distance, d is computed as

$$d = k10^{(P_t - RSS + X_0)} \qquad (3)$$

$$k \text{ is a constant which takes } P_L(d_0), \alpha log_{10}\left(\frac{d}{d_0}\right) \text{ into consideration}$$

III. MEASUREMENT

Drive tests were made at different time intervals. The first series of tests were taken during Shiloh, annual program that takes place in Canaan Land, Ogun State, where about 250,000 people converge for a religious exercise, and an estimated 125,000 would have mobile phones. The Shiloh ground spans over 500 hectares of land space. The measurement was taken at such a event to test the resilience of the network when at full utilization

The drive were planned and taken immediately after the end of each meeting session. The was done to ensure that the network resources were subjected to the 'highest load' from users. It is common phenomenon that after the end of a religious service like Shiloh, people tend to make simultaneous calls to reach out to friends, keep abreast of happenings at work place and locate family members that may be at different section of church. An estimated 100,000 simultaneous calls could have been made at the peak of the program, and measurements were taken at such times so that performance comparison could be made among the four major GSM providers (which are MTN, GLO, AIRTEL and ETISALAT)

The primary data obtained were analyzed graphically to see the performance of each of the GSM vis-à-vis the others in the Canaan land area.

IV. GRAPHS AND OBSERVATION

Table 1: Comparison of RSS For the Four GSM Network

	dBm MS RSS (dBm)	dBm average Mean RSS (dBm)	Best signal Best RSS (dBm)	RSS M.D (dBm)	RSS S.D (dBm)
MTN	-50	-80	-49	30	5.48
Airtel	-84	-90	-70	6	2.45
Etisalat	-58	-80	-57	22	4.69
Glo	-53	-80	-52	27	5.20

M.D = Mean Deviation,
S.D= Standard Deviation
MS=Mobile Subscriber

Fig1 and Fig2 show the graphs of the Received Signal Strength from MTN and Etisalat collected over 60mins period. Each graph is a superposition of three signal quality

1. The signal to which the Mobile Subscriber(MS) is presently latched on(connected to).This is represented by the unbroken line
   dBm
2. The average signal: this is the average of signals from different base stations, radio, captured by the MS. The average signal is the mean of all these signals. The average signal is depicted by the broken line
   Best signal
3. The best signal is the signal with the most optimal performance .It is represented by the dotted line.
   dBm average

The process through which handover is achieved in a mobile Network is determined by many factors other than the Received Signal Strength (RSSI), though the RSSI should be the main factor.[4] The MS should normally be latched on to the cell with the 'best signal' at any time. For an MS coming from a cell of low signal quality (low RSSI) to cells of higher RSSI, the usual thing to do is for the MS to be transferred to the next cell of higher RSSI, subject to other conditions. If RSSI is the only factor considered in handover, a ping-pong scenario occurs where the MS switches intermittently to different cells at the slightest increase.

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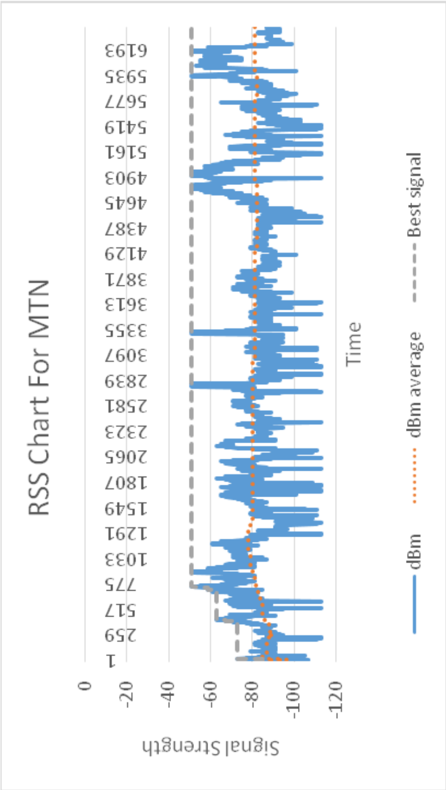

Fig. 1 Received Signal Strength Profile of a Mobile In MTN Network

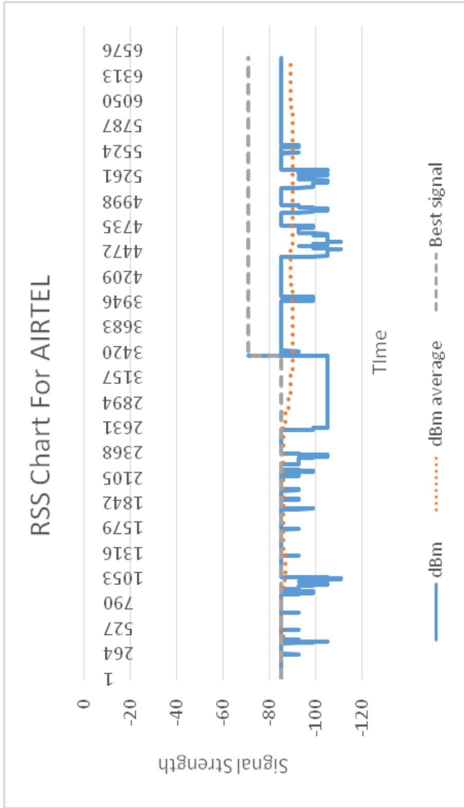

Fig. 2 Received Signal Strength Profile of a Mobile in Airtel Network

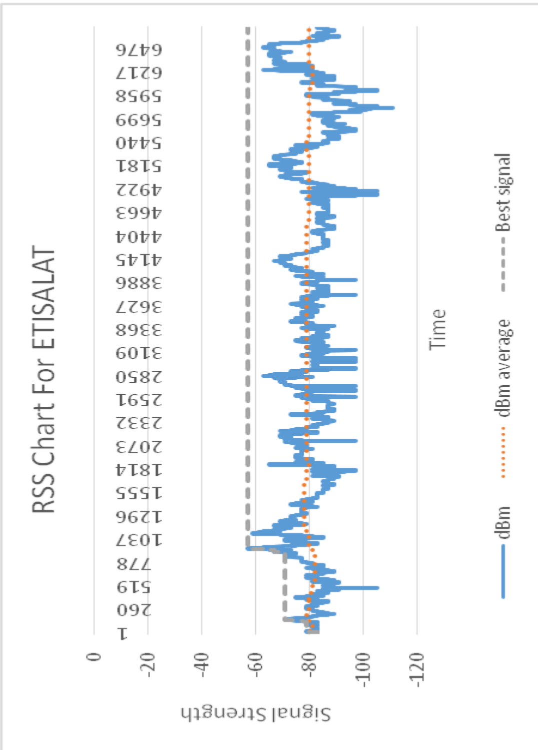

Fig.3 Received Signal Strength Profile of a Mobile in ETISALAT Network

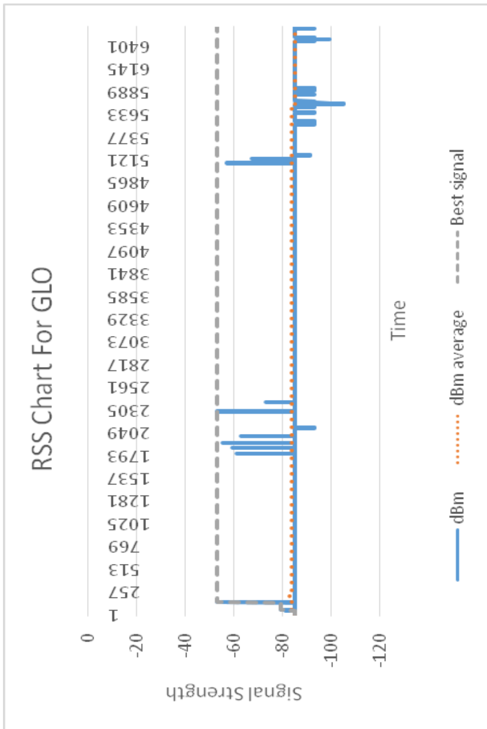

Fig.4 Received Signal Strength Profile of a Mobile in GLO Network

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Table 1 shows a comparison of the various Received Signal Strength (RSS) for the four networks under study. The table gives an insight into the performance of these networks, how efficient the RF planning by the companies was done. The table gives us idea of which network is better designed and which network needs optimization. It is a summary of the important milestones of the graphs of Fig.1 through to Fig.4. From the table it can be seen that MTN has the "Best MS RSS to Best RSS ratio(1.0204)" - i.e. the cell on which the MS is latched on has as close an RSS as the cell with the best RSS(-50dB to -49dBm). On the other hand, Airtel has the most disperse "Best MS RSS to Best RSS ratio (1.2)"

The result from Table 1 apparently shows MTN and Glo as having better RSS than Etisalat and Airtel but a closely and more analytic observation shows that Airtel and Etisalat are better designed .Airtel and Glo has the best Mean Deviation (M.D) and Standard Deviation (S.D) RSS- indicators which show that the signal variation from neighbor cells are low. This ensures that handover is well defined, and a 'ping-pong' scenario is avoided

Figures 1,2,3,4 gives a plot of three superimposed RSS for each network. It is observed that the MS RSS values during the drive test were not always the Best RSS values available. While the 'best signal' received by a MS may not be the most optimal vis-à-vis other handover factors, it is empirically noted, and statistically implied, that the RSSI of the cell on which the MS is connected should be at most two standard deviation from the average RSSI (taking the 'average dBm' as the Centre of the normal distribution curve, for good quality reception, the MS should be latched on the signal that is $\pm$ *the standard deviation* of the cell with the average dBm signal) [2].The network providers should configure the BSS and RF air interface such that the MS should be latched on to the cell with the best RSS signal for better reception and user experience. From the data collected during the drive test, it was observed that for Glo, the MS watched latched onto a particular cell for so long, even when the RSS was low, and did not hand over to the next cell with a better RSS.This is a bad configuration policy which the provider to correct.

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