Received Signal Strength Measurement: Suboptimal Handing-over

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Abstract- **Reception of good quality GSM signal in any area depends on a number of factors-Received Signal Strength (RSSI), the number of TRXs in the cell sites, the quality and type of hand-overs, the call traffic in a cell etc. The impact of these factors has a direct effect on the user experience, the image and patronage of the operator, penalties from regulator etc. In many parts of the world where GSM services are operated, some of the most annoying phenomena include call setup blocking, call drops, inability to initiate calls, low signal level on the user's mobile.**

In this paper, Received Signal Strength (RSSI) levels of BTS cells from different Network Operators are measured to determine the level and quality of Received Signals, the 'dead' spots around Covenant University environment, to determine the signal strength distribution, and perform a side by side comparison of the signal strength (quality) from these Operators. There are many methods for measuring Received signal strength of GSM/LTE networks, and this include the use of Ericsson TEMS suite software and phone, using signal meters, using Spectrum Analyzers- all these methods have their draw-backs and advantages. In this paper, we have chosen to measure the Received Signal Strength using a Smart Android phone with installed software (KAI BIT Software) for measuring the Received Signal Strength from cell sites and their locations, Cell IDs and Location Area Code (LAC)

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

Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage region[21].These channels, also known as frequencies have to be optimally utilized by the process called *Frequency Reuse*. The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called *frequency reuse* or *frequency planning.*

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For efficient utilization of the radio spectrum, a frequency reuse scheme that is consistent with the objectives of increasing capacity and minimizing interference is required. There are two channel management strategy-Fixed or Dynamic.

In a fixed channel assignment management a group of predetermined voice channels is allocated to a cell; call attempts are only carried out by unused channels within the predetermined channels. If the channels are totally engaged , any call attempt is blocked. In a dynamic channel assignment serving base station request for channel(s) from the MSC each time there is a call setup request which; the MSC uses an algorithm which takes into account the probability of future blocking within the cell, the frequency reuse of the channel ,the reuse distance of the channel , and other cost functions[21]. Dynamic channel assignment increases trunk efficiency by reducing the likelihood of blocking.

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. A moving mobile is latched on to a particular cell as long as the received signal power is level is not below, $P_{minimum}$- 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

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

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

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

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

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

$into\ consideration$

III. MEASUREMENT

Covenant University is one of the top Universities in Nigeria. Over a period of time, there has been many complaints by staff and students on the quality of mobile reception, especially from staff residents. There were several reports of dropped calls and pockets of 'no service' on mobile device; internet services were at its lowest ebb.

The paper was borne out of the need to investigate the causes of the bad network in the Covenant University environment, and to proffer solution. The major mobile operators serving the environment are MTN and Etisalat. Etisalat has a better user experience (quality of reception)

Drive tests to collect network information mainly, Received Signal Strength (RSSI) were conducted over MTN and Etisalat networks; data collected were analyzed, and solutions proffered .The data collected from the drive test was based on log of one hour time interval.

IV. GRAPHS AND OBSERVATION

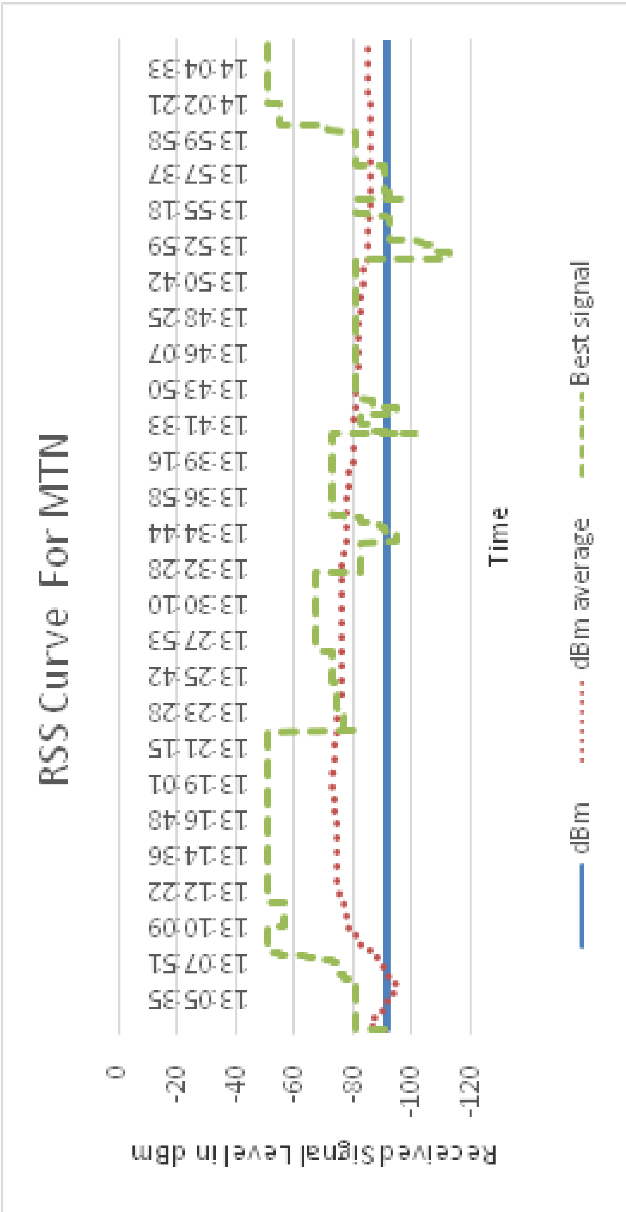

Fig 1 Received Signal Strength Curve For MTN Network

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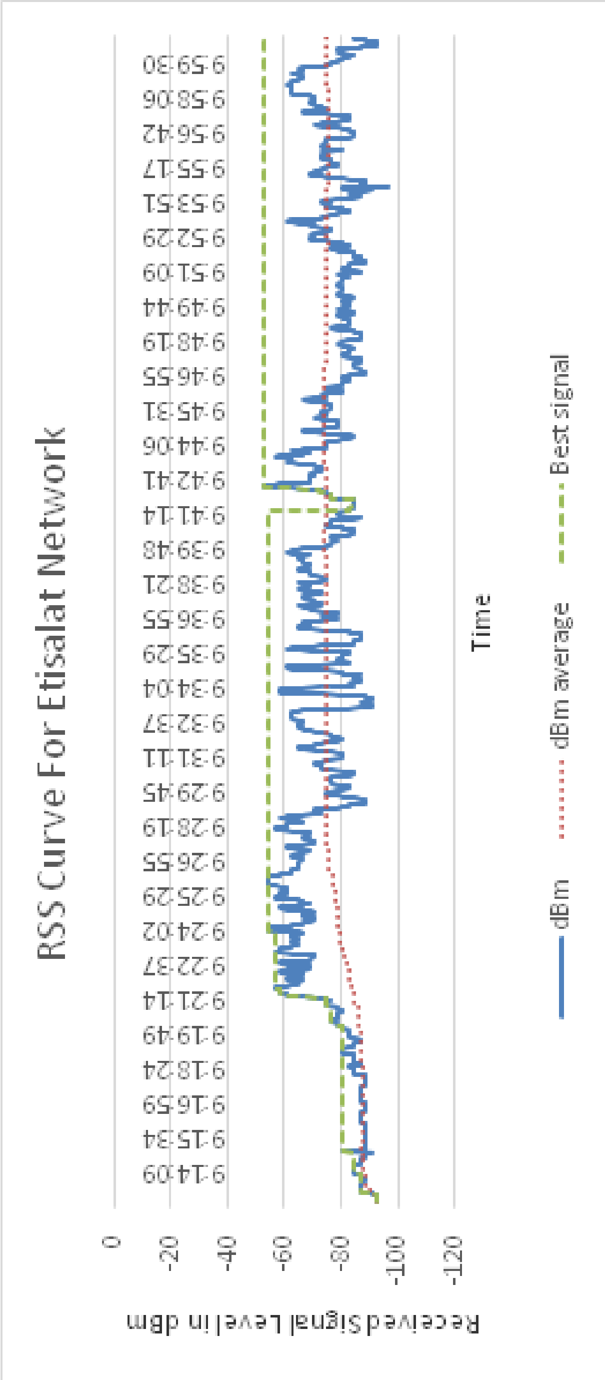

Fig.2 Received Signal Strength Curve For Etisalat Network

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
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
3. The best signal is the signal with the most optimal performance .It is represented by the dotted line.

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. 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.

From the drive test result graphs shown in Fig1 and Fig2.,each graph has three measured RSSI superimposed on each other.MTN and Etisalat have different handover policies. The unbroken line (colour blue line, 'dBm'), depict the RSSI of the cell on which the MS is connected to, the dotted line (brown colour)shows the average RSSI of the cells the MS is receiving from, while the broken line (green) represent the RSSI from the cell with the best signal.

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)

The graphs from the drive test shows tht MTN handover policy is improperly defined, and this has a detrimental effect on the quality of service. From Fig.1, we see that the MS in the MTN network is almost 'permanently' latched to just one cell (at -91dBm, from the drive test log). Even when RSSI from other neighboring cells have a very good signal strength of about -51dBm, the MS refuses to hand-over to it. This is quite a shocking scenario, and it shows the design was not optimal. The effect of this lopsided hand-over policy is that customers on the MTN network complained a lot.

Fig.2 shows the RSSI from different cells received by the MS; the handover policy of the Etisalat network is much better as the MS latches on the cell with RSSI that is close to the 'best signal'. The MS in the Etisalat network switch from one cell to the other depending on the signal strength such that RSSI trajectory of for the MS's RSSI emulates that of the average RSSI signal of all the neighboring cells. A visual inspection of Fig2. shows that the cell on which the MS is connected to (represent by the 'dBm' line) fails with 1-2 standard deviation of the average RSSI signal (dBm average line).Though at some points in Fig2, there are RSSI signals of much better quality (-55dBm from log), the MS still latches on a cell with -77dBm power, this is a better selection than that seen on MTN.

In comparison, the handover policies for Etisalat network is much better than that of MTN network in Covenant University. Though both network are not properly optimized , the MTN networks seems to have a worse handover policy despite having cell sites with better RSSI quality than Etisalat (-51dBm at best for MTN to -55dBm at best for Etisalat). The 'better user' experience observed by customers on the Etisalat network is due to this lopsided handover regime.

Both networks are sub-optimally designed, and the handover policies are not well defined. We recommend a total RF Optimization for both the MTN and Etisalat network if they want to retain their customers; with the introduction of the Number portability systems, there may be high churning from MTN and Etisalat if the user experience remains the same.

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