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# Mobility Effects on Handovers In MBB Networks Within Kaduna Metropolis

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***Abstract:*** *Mobile Broadband MBB networks under mobility are evaluated with regards to connectivity, packet loss and throughput and compared with static performance. Handover, signal strength, RRC mode and sub mode were studied. The four operating networks which represent more than 90% mobile broadband market share in Nigeria were compared. These networks were characterized in different locations within Kaduna metropolis with measurements conducted in peak hours and off-peak hours. Packets were collected mostly in 3G and few in 2G.* A GPS equipped *G-NetTrack Pro net-monitor and drive test tool application for UMTS/GSM/LTE/CDMA/EVDO network which allows monitoring and logging of mobile network serving and neighbor cells information is used for these measurements. Different performance metrics were affected differently in mobility. Connectivity seems significantly affected under mobility. Almost all packets were received without loss in static scenario, whereas significant connection losses were observed in mobility. Measurements were carried out during handover to monitor the rate at which the amount of packet loss due to handover events and the total number of dropped calls in the mobile system.*

***Key words:*** *mobile broadband, handover, QoS, call drops rates, signal strength, mobility.*

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## I. Introduction

Consumer demands of the mobile networks is on the increase, from voice and SMS to Web browsing, then higher-speed data and video streaming. The Ericson annual report 2017 indicates such a huge growth of global mobile data traffic, eight times the current demands in less than a decade projection.[1] The search for more efficient technology, higher data rates and improved spectrum utilization is a necessity. Applications requiring higher bandwidth, greater capacity, lower latency and stringent demands are already surfacing. In all these services, the QoS must be maintained for customer experience and satisfaction. A prominent feature affecting the QoS of the mobile networks is the handover mechanism, that is, the ability to transfer an ongoing call or data session from one channel to another in a mobile network seamlessly. The handover is horizontal when it is performed in one network of the same radio access technology, and vertical where at any given time the call is handled by only one connection, this is the type used in GSM (Global System for Mobile Communication), and the default in LTE.

One of the main reasons behind the huge success of wireless communication is its support of mobility. UMTS being one of the most successful and deployed cellular technologies handles mobility very well. There are two scenarios for the MBB network to manage mobility. Firstly, when the mobile station is in the idle mode, when there is no call in progress or it is switched off. In this case the network keeps track of the MS (Mobile Station) by a means of location management [2, 3].

Secondly, when an active mobile station moves within the coverage area of a network, this leads to situations where the MS leaves the coverage area of a single cell, in this case there is a need for a feature to transfer an ongoing call from a physical channel to another without dropping the call.

The handover mechanism switches the user’s connection from one cell to another with the requirements of minimizing service interruption and providing seamless handover. When user equipment (UE) moves towards an area where signal strengths it receives from cell associated with it is marginally lower than neighbor cell or base station, then handover is triggered [4]. This becomes more critical with the additional applications like Skype, Facebook, MSN Messenger etc.

Handovers increase as such applications send periodic keep alive messages to the UE making active data transfers even the applications are not in active use [5]. The Main functions during handover procedure are: handover measurement and handover decision-execution [6]. Handover measurement deals with measuring service quality of serving cell with signal strength and discovering appropriate cell when handover is necessary. Handover decision-execution evaluates if handover is necessary or not and if it is required, it coordinates multi-party handshaking among users and cells for transparent and smooth handover. In mobile-assisted network-

controlled handover, mobile assists to make handover decision by measuring the signal quality of its neighbor cells and report the results to the network system followed by synchronization with neighbor cell and calculation of the signal quality of the cell such as Signal to interference plus noise ratio (SINR) [7].
3G permits that adjacent cells can operate in same frequency band which enables the mobile node to detect several such neighbor cells that is also refereed as intra-frequency cells [8]. The number of cells the mobile can scan per measurement period is called mobile's measurement capability. The higher the measurement capability, the higher will be the handover measurement and Handover [9].

Handover can be hard handover or soft handover. Soft handover implements make-before-break strategy, that is, the mobile node communicates with several base stations or cells and makes a new connection to a cell before breaking connection to old cell whereas in hard handover, the mobile node changes cells trying to minimize interruption [10, 11].

In HSDPA, mobile node can be connected to only single serving cell or Node B which leads to hard handover procedure but the associated DCH itself can be soft handover and maintain DCH active set [12]. Handover procedure is initiated when a link in DCH active set is maintained in higher strength for certain period, also called time-to-trigger followed by measurement report sent from UE to Node B and then forwards to RNC. Then UE is consented by RNC to make handover by sending signaling radio bearer (SRB) message if admission control requirements are satisfied. In case of Intra Node B handover, there is minimal interruption of data flow by maintaining Node B buffers where as in inter Node B handover, Node B buffers are flushed. In HSUPA, mobile node can transmit to two or more cells simultaneously leading to soft handover procedure similar to WCDMA Rel'99 [13]. HSPA+ supports both soft and hard handover.

## II. Methodology

Four network providers MTN, GLO, Etisalat and Airtel were considered for this study. These also represent over 90% of the market share available within Kaduna metropolis. Different measurements obtained in the four network providers within Kaduna metropolis were carried out on speed and throughput in kbit/s and the success ratio evaluated to determine their performance under mobility. The effects of mobility on the performance of the Mobile Broadband (MBB) networks were done using G-netTrack PRO equipped with GPS. The measurement set up is shown in Fig.1

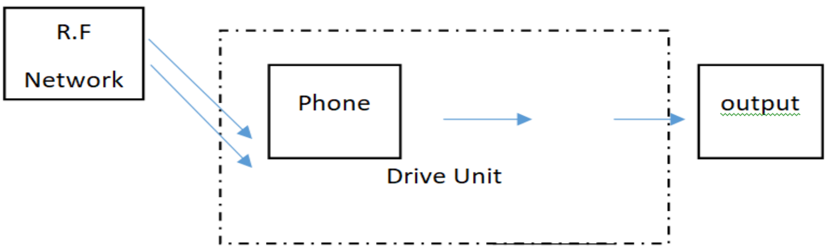



Figure 1: Measurement setup

Figure 1 shows how the data were collected during the drive test. The radio frequency signal from the network is received by the user equipment (phone), the software starts collecting data on the required test subject and a log file is collected during this process, where it is analyzed and processed to get the result on various test carried out.

**G-NetTrack Pro** is a wireless network monitor and drive test tool for Android OS devices. It allows monitoring and logging of mobile network parameters without using specialized equipment. Fig. 2a is
a screenshot of the Gnet-Track pro while Fig. 2b is the route followed in the drive test.

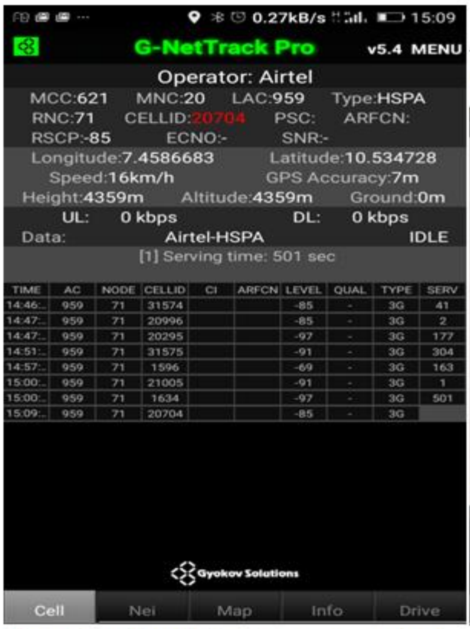
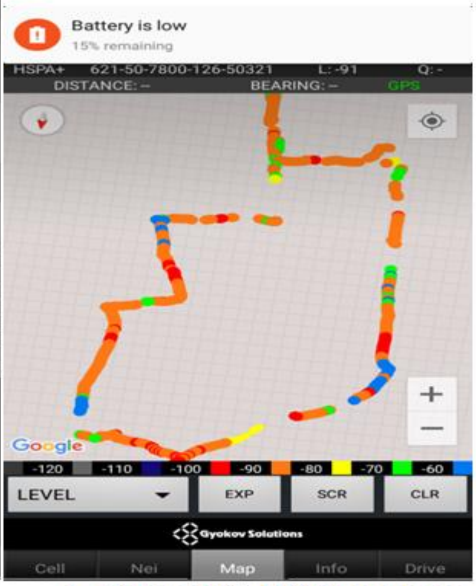



Figure 2a: Gnet-Track pro screenshot




b. Drive route by Google map

**QoS STATISTICAL EVALUATION**

The monitoring equipment (Andriod device) is installed with a software tool which supports the storage and organization of information as well as the generation of statistics on the data obtained by the measuring unit. The software tool makes it possible to generate different reports on single or multiple monitoring sessions. The equipment also incorporates a GPS receiver which makes it possible to georeference all measurements, localize significant events, detect the cause of the events, and in conjunction withG-NetDiag and G-NetEarth tool, makes it possible to visualize statistics in the form of a digitally generated geographic map.

**KPI ASSESSMENTAND QOS ESTIMATION**

In order to understand how the behavior of traffic channels (TCH) and control channels (SDCCH) affects the network‟s performance, one has to analyze TCH and SDCCH blocking when congestion in the network increases. The above mentioned KPIs are frequently used in performance judgment and QoS estimation of the network.

**(a) CALL SET-UP SUCCESS RATE (CSSR) Indicator CSSR Definition:** Rate of call attempts until TCH successfulassignment. The number of successful seizure of SD channel by Total number of requests for seizure of SDchannel.

CSSR = $\frac{\boldsymbol{CT01-CT02}}{\boldsymbol{CT03}} \times 100$ [1]

**Condition Applied** Where counter CT01 counts SD channels successfully seized for Call termination & CT02 counts SD channels successfully seized for Call origination.CT03 counts SD seizure requests.Where SD (usually called SDCCH stands for Stand-alone dedicated control channel) and TCH stands for Traffic channel.

**(b) CALL DROP RATE (CDR) Indicator CDR** Definition Rate of calls not completed successfully.The number of TCH drops after assignment by Total number of TCH assignments.

CDR = $\frac{\boldsymbol{CT04-CT05}}{\boldsymbol{CT06}} \times 100$ [2]

**Condition Applied** Where CT04 counts TCH drops due to radio interface problems and CT05 counts TCH drops due to BSS problems. CT06 counts numbers of TCH successfully seized/assigned.

**(c) HANDOVER SUCCESS RATE (HSR) Indicator HSR Definition** Rate of successful handovers (intracell +intracell). Number of successful [intercell + intracell] HA1 by Total number of handover requests.

**HSR**= $\frac{\boldsymbol{CT07+CT08}}{\boldsymbol{CT09+CT10}} \times 100$ [3]

Where CT07 counts number of incoming successful handovers and CT08 counts number of outgoing successful handovers. CT09 counts number of outgoing HO requests while CT10counts number of incoming handover requests.

## III. Results And Discussion

**Connectivity**

Connectivity was measured as consecutive number of packets received without loss for each MBB networks under mobility. This parameter shows stable and reliable a network is, especially in case of sensitive applications. Connectivity for file up and file down loads are presented in Figs.3 and 4 respectively.

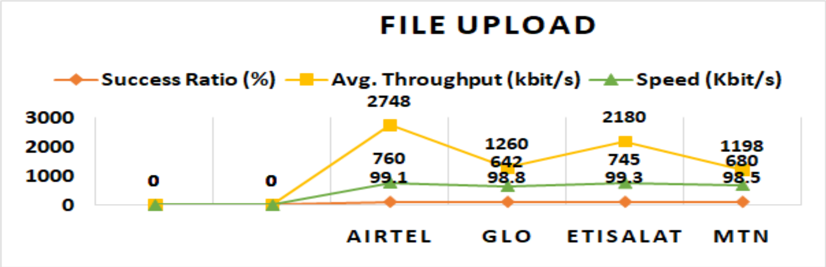



Fig 3: Connectivity on file uploads

This shows the success ratio in percentage, the average throughput in Kbit/s and the speed of each network in Kbit/s. It is clear that both Airtel and Etisalat are slightly better in these categories of measurement as can be seen from their success ratio with GLO and MTN having a success ratio slightly behind the leading pack.

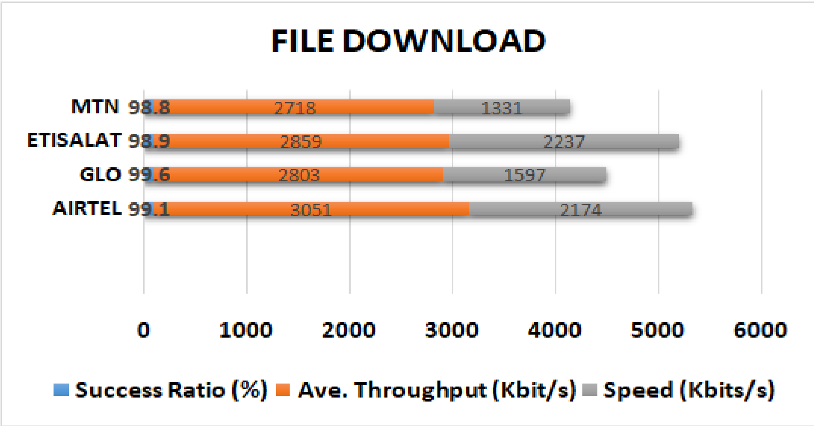



**Fig 4** Connectivity on file downloads

Video streaming is shown in Fig. 5. The performance of all the networks is good and competitive in ranking.

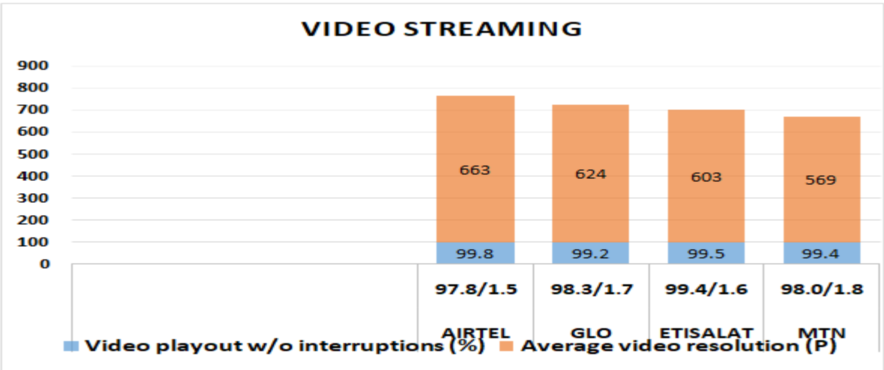



Fig 5 Video streaming analysis

During the SMS sequence measurement test, SMS attempt, SMS sent, SMS failure, and SMS delivered in percentage was measured to determine the best network when it comes to SMS file. All the networks performed brilliantly, but Airtel and Etisalat network got a 100% sore in this category as in Fig.6.

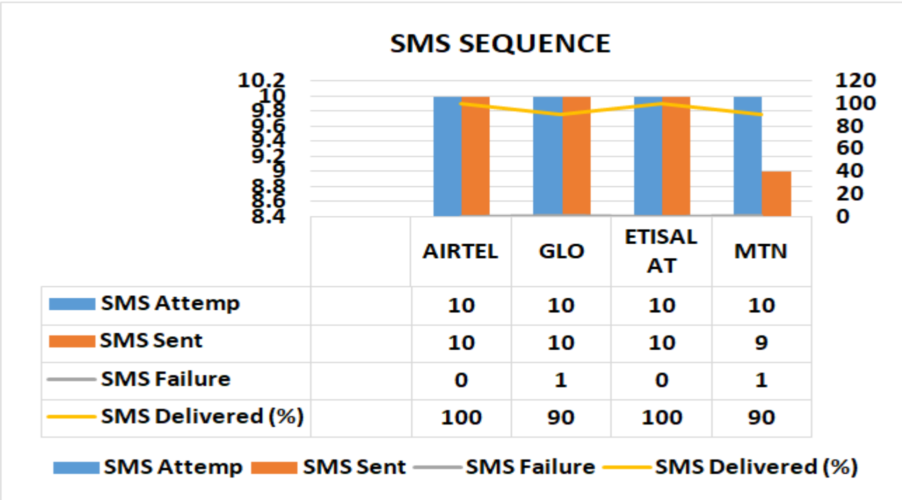



**Fig.6:** SMS sequence analysis.

**PACKET LOSS**

Loss was measured as packet(s) that is sent but not received. Total number of packet loss was computed using **Gnet-world software and analysis tools** and percentage total loss was calculated for whole data set, that is, 90 plus packets sent for each networks. It was observed that negligible packet loss, about 0.05 percent or less, in static scenario. While the study on packet loss under mobilityshowed that packets were lost either randomly or caused by mobility event(s). Under mobility events, it was observed that packets were lost by mode change (WCDMA in 3G and GSM in 2G), submode change (HSPA+, HSDPA, HSUPA, HSDPA+HSUPA and WCDMA within 3G) and LAC & cell change.During LAC and cell change, the node was reselecting cells/base stations (Node Bs in UMTS) which was also studied in handovers.

Percentage total loss and losses contributed by different events depicted in charts for all MBB networks and compared. Then, total number of handovers and number of handovers that caused packet loss are examined with charts.

Fig. 7 shows overview of packet loss. In total percentage packet loss for all operators are presented in comparative bar-chart. From this bar-chart, Airtel and Etisalat have the lowest percent i.e. 17% percent and considered good. MTN has the comparatively more packet loss i.e. about 32 percent. On the basis of total percent loss performance, GLO also performed well with less than 30% i.e. slightly higher than MTN. GLO can be said to have performed averagely with total loss about 28%.

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**Table 1:** Table of KPI values for each service providers

| KPI | | AIRTEL | GLO | ETISALAT | MTN |
|---|---|---|---|---|---|
| **CSSR (%)** | | 97.8 | 95.2 | 98 | 95.3 |
| **HSR (%)** | | 99.92 | 98.23 | 99.62 | 97.12 |
| **DCR (%)** | | 1.02 | 3.51 | 0 | 3.51 |
| Handover | | 25 | 30 | 27 | 32 |
| Handover | Failure | 1 | 4 | 1 | 2 |

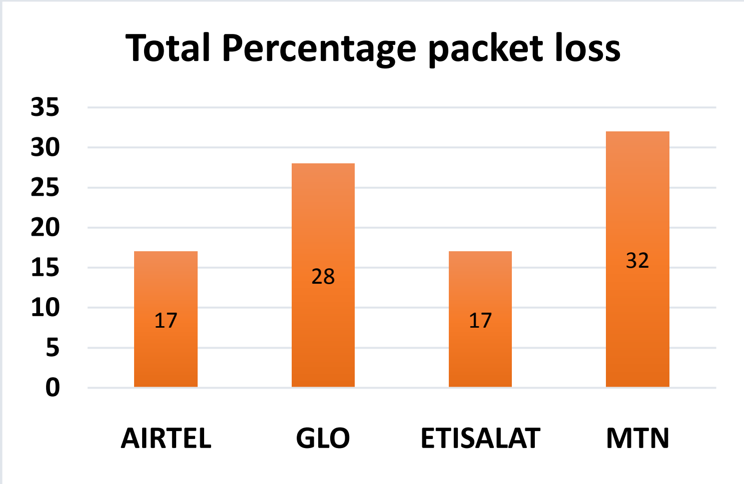


**Figure 7:** Total percentage losses

Total percentage packet loss for all operators are presented in comparative bar-chart in Fig.7. From this bar-chart, Airtel and Etisalat has the lowest percent i.e. 17% percent and considered good. MTN has comparatively more packet loss i.e. about 32 percent. On the basis of total percent loss performance, GLO also performed well with less than 30% i.e. slightly higher than MTN. GLO can be said to have performed averagely with total loss about 28%.

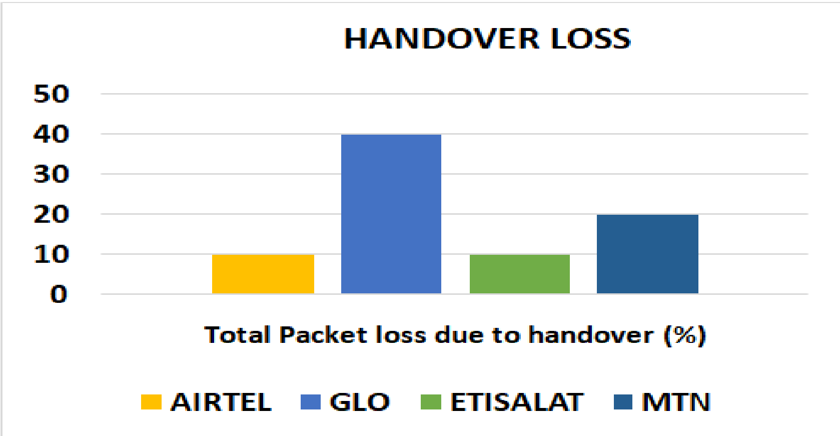


**Figure 8:** Handover loss

Handover in mobility and packet loss contributed by those handovers are depicted in Fig 8. As per those results in Fig 8 more than 20 percent losses are due to handovers except Airtel and Etisalat where only about 10 percent losses are contributed by handovers. Even though, there is considerably high losses due to handover, all handovers didn't cause packet loss. Handovers that caused packet loss are more than 30 percent in case of GLO.

## IV. Conclusion

The performance of mobile broadband networks was carried out while observing handovers and radio conditions to characterize operational MBB networks under mobility. MBB performance metrics were measured in peak and off-peak performance using public transport available in Kaduna, Nigeria. Frequency of handover is different and unpredictable in different networks. It is noticed that in an average packet losses and connection failures are more in downlink than uplink. Under mobility, noticeable losses were observed with the more in MTN, i.e. about 32 %, followed by GLO. Packet loss in Airtel and Etisalat was quite low, which can be arguably negligible. Additionally, more packets were lost in downlink than uplink, though the difference was not significant. More frequent handovers were noticed in GLO as compared to other networks and 1/3rd of them caused packet loss, giving the highest number of loss among all four operators. This may also be because GLO has more clustered base stations in city area that caused more handovers as compared to other networks.

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