Experimental Assessment of Cellular Mobile Performance along the Railway Corridor

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Abstract: With the ongoing rehabilitation of the railway transportation sector in Nigeria, improvement in the quality and reliability of the services deliverable becomes crucial. Reliable railway communication infrastructure guarantees effective operation and also ensures connectivity for security, safety, maintenance and passenger communication. This work describes today's network scenario by assessing current cellular performance as it affects a passenger's experience along the railway corridor. A drive test was conducted on the 6th of July, 2014 between 12:58pm and 07:14pm along the railroad linking Oshogbo and Lagos, Nigeria. The measurement setup consists of four TEMS Mobile Sony Ericsson W995 phones, a Personal Computer, a GPS receiver, and a power bank. The measurement was useful in the assessment of coverage, capacity and Quality of Service (QoS) of four mobile radio networks namely: Airtel, Globacom, Etisalat and MTN in the GSM 900 MHz and 1800 bands. Results reveal that no single mobile network service operator consistently serviced the train throughout the 6-hour trip. Also, the results obtained from the drive test represents a true picture of mobile network condition and can be useful in decision making in several areas - from planning and design through optimization and maintenance of the system, with the goal of maximizing quality, capacity and coverage for all mobile networks for improved service delivery on our railway infrastructure.

Keywords: Railway communication; GSM; Performance of Cellular mobile

I. Introduction

Globally, trains remain a dependable mode of transportation for both freight and passengers. It is safe and has been proven to be relatively more reliable than other means of

transportation over the years. Although the on-going railway projects in Nigeria are targeted at increasing capacity and expanding the national railroad net-work, the medium is currently underutilized and patronage dwindles significantly.

In order to improve capacity through the provision of secure, safe and attractive railway systems, it is important to explore the use of a reliable railway communication system. Indeed, such systems will serve as the backbone for a converged railway operation and it should ensure connectivity at a good percentage of operation time.

to the 4G broadband multiservice systems (LTE) remains one of the phenomenal advancements in communications in the last decade (Bertout & Bernard, 2012). Typical applications in railway systems as shown in Figure 1 indicates the provision of a two-way continuous communication for safety control, speed control and other vital communication purposes (Aguado et al., 2005; Yan, Chang-Young, Jeong-min, Jin-ho, & Young-Jae, 2013). Common passenger experience range from the inconsistent waiting time at the train station to network connectivity issues while on the

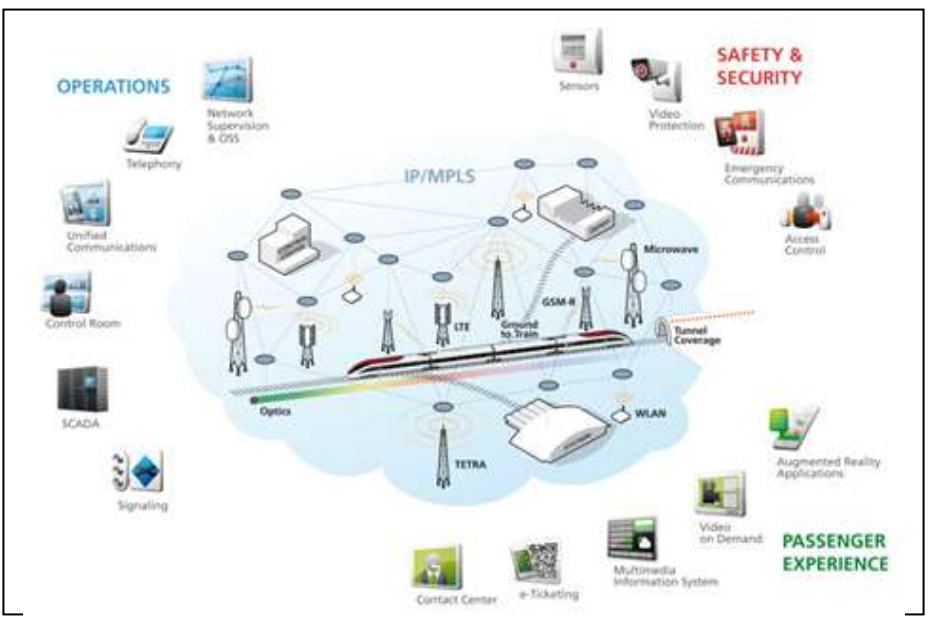

Figure 1. Communication as the backbone for converged rail operations (Bertout & Bernard, 2012)

Interestingly, the evolution of wireless technologies from the 2G centric systems – (e.g. GSM) with limited data transmission capabilities

railway corridor. Seemingly, most of the passengers on board are mobile subscribers and they need to enjoy connectivity to their respective

operators. Hence, a reliable communication will enhance passenger experience, providing stable voice and data services and retaining connectivity to the diverse social network platforms, which could define the passengers' experience and perhaps compensate for the long hours spent on the railroad. Figure 2 (a) shows existing railway network across Nigeria, while the rail corridor linking Osogbo and Lagos is shown in Figure 2 (b).

This study aims to assess the quality and coverage of the 4 predominant mobile networks on the Lagos-Osogbo railroad. Results obtained provide useful information on the quality of service delivered by MTN, Airtel, Globacom and Etisalat. These results will guide the decisions of mobile network service operators as well as policy formation by the National Communications Commission (NCC), and particularly on the need to adopt dedicated standards such as GSM-R for improved mobile network connectivity along railroads in Nigeria.

II. Related Work

The Global System for Mobile Communication (GSM) standard has been successfully deployed in Nigeria and the performance is frequently assessed in order to guarantee optimal service delivery over respective coverage areas. Interestingly, efforts to sustain connectivity on the highways have yielded positive results and the situation is still improving with the several optimization efforts by the mobile operators.

The situation is however different for the railway corridor. The railway medium of transportation has been abandoned for some time and

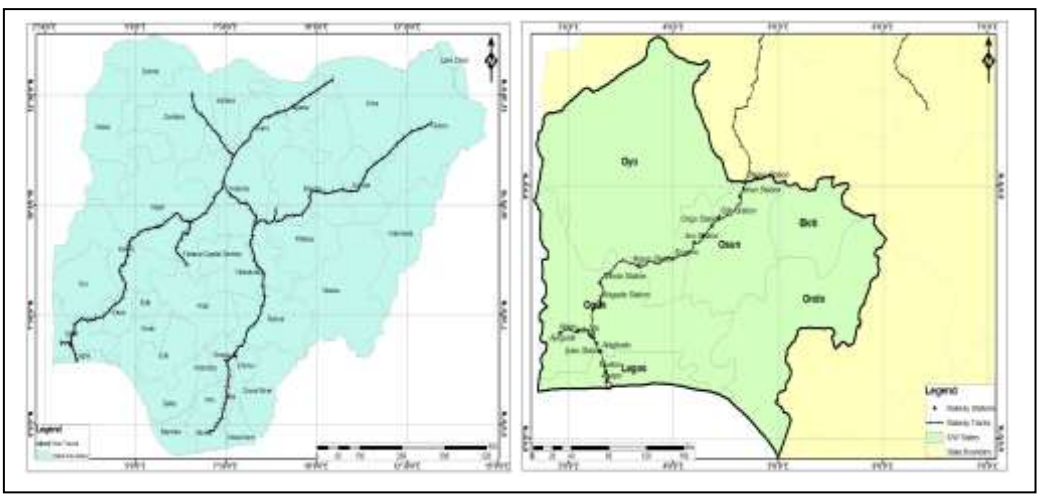

Figure 2. (a) Existing railway network across Nigeria, (b) The railway corridor between Osogbo and Lagos terminal

passengers have lost confidence in the services of the Nigerian Railway Cooperation (NRC). However, patronage has improved recently owing to the ongoing rehabilitation effort by the government. There is the need for the mobile operators and relevant regulatory agencies of the government to work out sustainable train-to-ground communication solutions. Seemingly, GSM remains the main communication infrastructure for both passengers and the train drivers.

Although the performance of GSM has not been evaluated on the railway networks in Nigeria, some related works involving the GSM performance could be mentioned. In (Adegoke & Babalola, 2011; Adegoke, Babalola, & Balogun, 2008), a report on the experiences of mobile subscribers is presented based on the perceived performance of three mobile operators (MTN, GLO and Zain/Airtel) over fourteen states across Nigeria. The quality of service offered was evaluated based on the performance of the selected networks.

Considering the advancement in the telecommunication industry, which is premised on the increase in the number of operators and the subscribers, a review on the performance of the four GSM operators is presented in (Adekitan, 2014). Frequent upgrade and optimization of the existing infrastructure were recommended as solutions to the fickle and unsatisfactory services offered to Nigerians. In a similar approach, the impact of GSM on rural economies in Nigeria was evaluated based on the stakeholders' perceptions (Ajiboye, Adu, & Wojuade, 2007). In their findings, GSM is considered to have sizeable impact on the rural settlements in Nigeria. However, they submitted that the impact on rural dwellers is still marginally poor, hence, confirming the obvious digital divide between the urban and rural settlements. A similar evaluation of the performance of existing GSM services in Nigeria is presented in (Olatokun & Bodunwa, 2006; Popoola, Megbowon, & Adeloye, 2009). In their findings, the limitations of the GSM services were identified and presented, and they are: unreliable QoS, poor network accessibility and retain-ability, and poor network coverage.

In order to enhance services to travelers by train, there is the need to develop an accessible passengers' information system, which can be built on modern networking technologies for the railway. The provision of reliable infrastructure for on-board applications can be built on a mobile telephone network for railways (B3.2, 2001). This of course will also be useful to the train operator(s) on-board, as well as the ground staff. Ultimately, this will also improve operations, safety and the security of the railway system.

Other important train communication solutions have been successfully deployed globally. Some of these standards are demonstrated in

(Bertout & Bernard, 2012), where the Long Term Evolution (LTE) was presented as the next generation of railways and metros wireless communication systems. In their work, the optimal wireless communication system for railways and metro needs were evaluated based on selected performance parameters and service attributes such as voice support, vital traffic, priority, availability, frequency and commercial maturity.

Although GSM-R is presented as the only approved world telecommunication standard for the railway communications (Aldred & Gorasia, 2005; Bibac, 2007; Hofestadt, 1995; Mohamed, 2014), perhaps it has not been deployed on the Nigerian railway system and communication is still based on the conventional GSM for railway communication. However, the need to effectively manage railway operations, ensure passengers' safety and security during their journey, improve travel comfort for passengers, provide real time multimedia information and grant access to social networks in stations or in motion now remains very crucial for modern railway operations.

In this paper, the performance of the four predominant GSM service providers in Nigeria is evaluated experimentally along the busy Osogbo-Lagos railway corridor using five key performance indicators namely; coverage, capacity, accessibility, retain-ability and mobility.

III. Methodology

An experimental measurement campaign was conducted through a drive test which was carried out in a train en route Lagos from Osogbo. The measurement was useful in assessment of the coverage, capacity

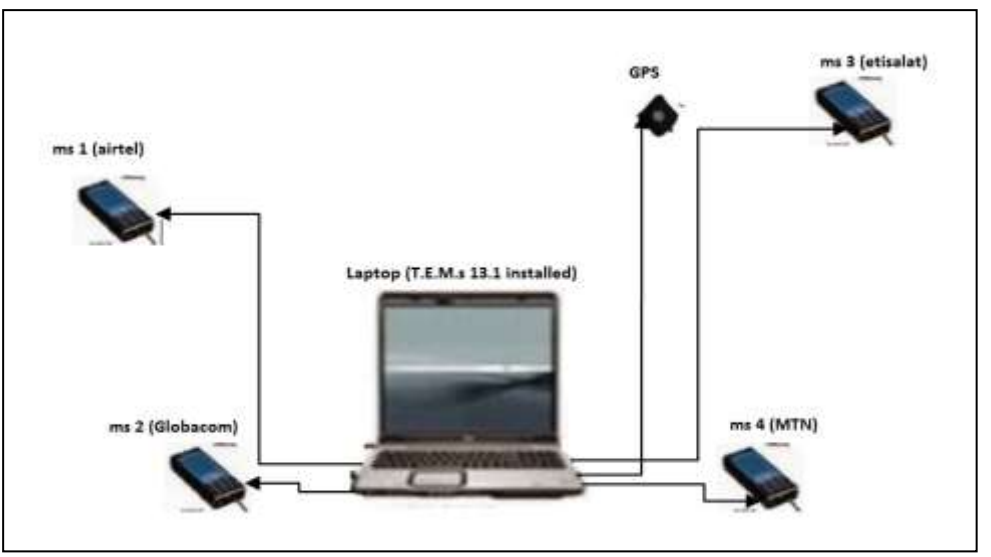

Figure 3. Experimental measurement setup

and QoS of the mobile radio networks.

The measurement setup consists of highly specialized electronic devices, interfaced to mobile handsets. This was used in order to ensure that measurements are realistic and comparable to actual user experiences. The drive test was carried out along the railroad from Oshogbo to Lagos and was conducted on the 6th of July 2014 between the hours of 12:58 Pm to 07:14 Pm. **T**he setup consists of TEMS Mobile Sony Ericsson W995, personal computer (PC) with TEMS Investigation 13.1v installed on it with the TEMS dongle, Global Positioning System (GPS) receiver, power bank. This is as shown in Figure 3.

The drive test equipment was used to collect data relating to the network, especially for services running on the network such as voice or data, radio frequency scanner information and GPS information. The data set collected during the drive testing field measurements include: signal intensity, signal quality, interference, dropped calls, blocked calls, Anomalous events, Call statistics,

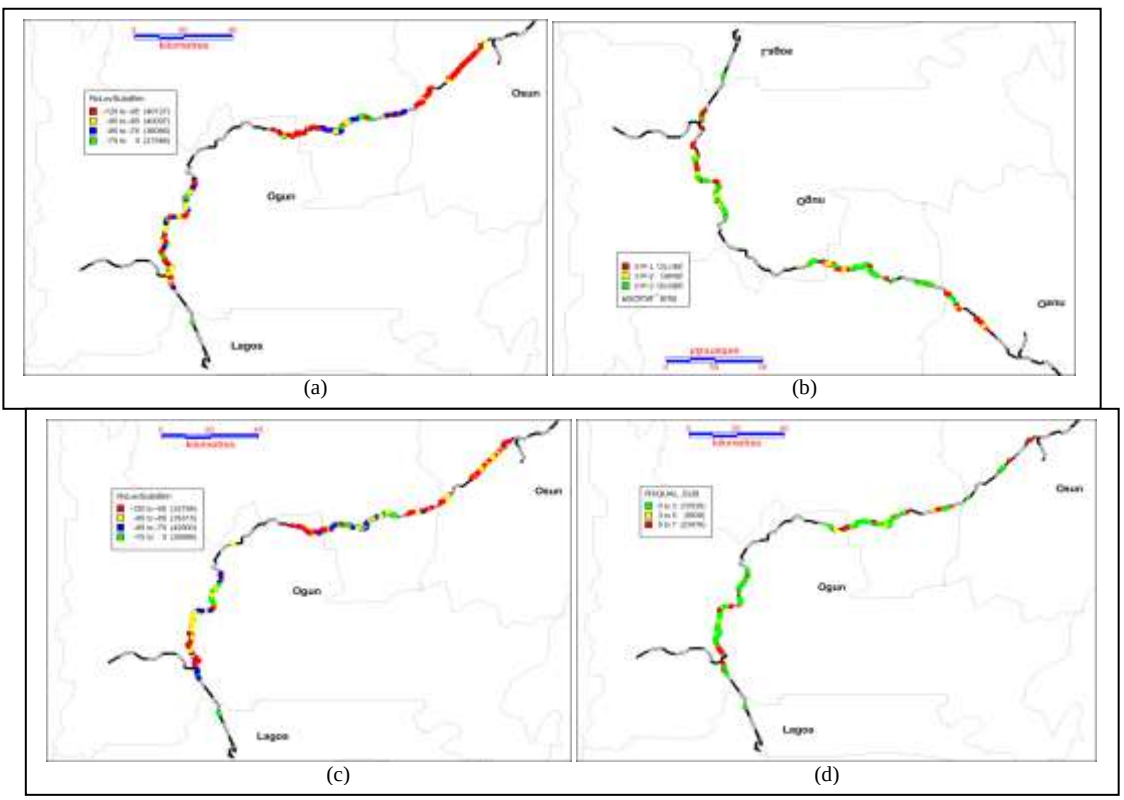

Figure 4. (a) Rx-lev for Airtel along Osogbo-Lagos rail road, (b) Rx-Qual for Airtel along Osogbo-Lagos rail road, (c) Rx-lev for Globacom along Osogbo-Lagos rail road, (d) Rx-Qual for Globacom along Osogbo-Lagos rail road

Service level statistics, Quality of Service information, Handover information, Neighboring cell information and GPS location co-ordinates.

IV. Results and Discussion

The performance of the four GSM services is described according to different radio frequency measurements namely: Mobile station (MS) Receive-Level (RxLev), MS Receive-Quality (RxQual), MS Speech Quality (SQI). Other Key Performance Indicators (KPIs) for Radio Access Network (RAN) were estimated to assess performance along the railroad. Data collection was possible using TEMs investigation 13.1v and four Mobile Stations (MSs): MS1 – Airtel, MS2 – Globacom, MS3 – Etisalat, MS4 – MTN, all in dedicated mode.

The results obtained were used to present the coverage plot on the route's map using Map Info Professional and the corresponding plots are shown in Figures 5 (a-d).

The KPIs employed in this study are the Call Setup Success Rate (CSSR), Call drop rate (CDR), Handover Success Rate (HOSR), Coverage and Quality.

CSSR is a measure of the MS's accessibility to the GSM network and it is estimated as the ratio of call setup to call attempt (Haider, Zafrullah, & Islam, 2009). Results indicate that MTN records the best accessibility with a CSSR of 84.38% while Airtel had the least with 55.56%. The performance of Globacom was fair with 75.61% while the 83.87% recorded for Etisalat did not do badly, using on this metric.

The CDR is another important KPI, which is a measure of calls that are prematurely disconnected before the end of conversation, against the number of all successfully established calls (Haider et al., 2009). From the results obtained, Airtel records the poorest retain-ability with a large call drop rate of 74.29%,

TABLE 1. STATISTICS FOR THE NETWORK EVENTS FOR THE FOUR MOBILE OPERATORS

Events	MS1 (Airtel)	MS2 (Globacom)	MS3 (Etisalat)	MS4 (MTN)
Blocked Call	21	11	8	9
Call Attempt	63	41	31	32
Call End	19	14	10	13
Call Established	35	31	26	24
Cell Reselection	87	92	66	88
Dropped Call	26	15	13	11
Handover	110	217	299	181
Handover Failure	1	12	10	3

while MTN shows the best retain-ability with a CDR of 45.83%, Globacom (48.39%) and Etisalat (50%) also exhibit an average performance based on this metric. Statistics for the network events for the four mobile operators is presented in Table 1.

The HOSR measures the ability of a customer to talk on the cell phone over a long distance without getting disconnected. It is the ability of a call connection to be handed over from one cell to another without losing the connection (Haider et al., 2009). This KPI is directly linked to call drop rate because a handover failure normally results into a dropped call. The target for this KPI is 90%, meaning only 10% percent of the calls may experience handover failure beyond which the grade of service will decline. All the operators record excellent mobility in this regard. However, Airtel shows the highest mobility with a HOSR of 99.10%, the least is recorded on MTN with 93.78%, Globacom has 94.76%, while Etisalat records 96.76%. This is also shown in Figure 5.

Result obtained on the coverage estimate for the four GSM services is also as presented in Figure 5. It is however indicates that MTN records the highest coverage of 77.61% over the Osogbo-Lagos railway corridor. Airtel has the lowest coverage with 70.89%, while Etisalat records fair coverage with 76.27% and then Globacom, with 74.97% coverage.

Since the quality of the mobile radio network is dependent on its coverage, capacity and frequency allocation, MTN records the best quality throughout the measurement with 78.02% while Airtel records a relatively poor quality with 65.51%.

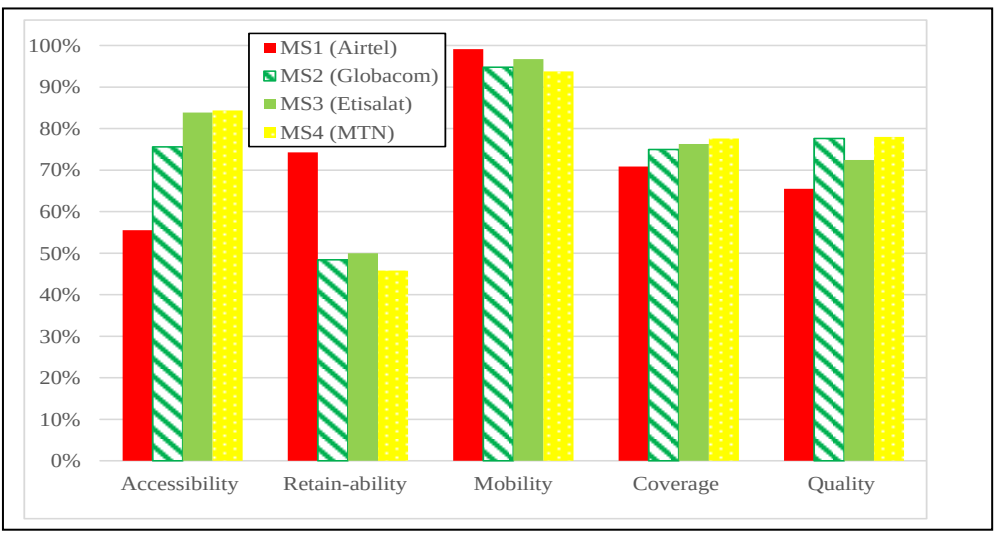

Figure 5. . Key performance indicators for the four mobile operators

Globacom and Etisalat performed averagely well with quality of 77.63% and 72.47% respectively.

V. Conclusions

As patronage increases with the continuous governmental intervention for enhanced capacity, existing railway transport service definitely needs an intelligent train tracking and management system. Moreover, accessibility of railroad travelers to good mobile network could motivate Nigerians to patronize the railway. This is one of the connectivity issues that defines effective operation and maintenance of the entire rail network. There is the need to consider wireless connectivity in the current restructuring and rehabilitation. This therefore calls for the attention of the government, NCC, as well as the mobile network service providers.

The experimental measurement has been conducted on the railroad between Osogbo and Lagos. GSM (2G) coverage and quality along the rail route is fair around locations where Base Transceiver Station (BTS) sites exist. A number of dark spots were observed experimentally as a result of poor coverage gaps.

However, the direct optimization of GSM coverage along the railway routes would be difficult if not impractical as the railway routes are mainly across areas not inhabited by people. Hence the installation of new sites - either 2G or 3G along such routes would not be a good investment for the mobile network service operators concerned.

This situation can be improved by the direct effort of the government to industrialize areas around the railway routes, which would make it reasonable for network operators to install at least a 2G site along such routes as it would serve both the passengers as the train passes and the workers in the industries.

The authors hereby present results based on this experimental campaign. It is considered as a vital tool, which could guide the decision of the mobile network operators and the National Communications Commission (NCC) alike, particularly in the formation of policies in this regard and on the need to adopt dedicated standards such as GSM-R for improved mobile network connectivity along railroads in Nigeria.

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