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Assessment of Call Voice Quality of GSM Network Operators in 5 Cities in Kwara State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This paper evaluates voice quality of four Global System for Mobile (GSM) Communication providers in five selected cities in Kwara State with thoughtfulness of network performance evaluation and the quality of service (QoS) improvement of GSM network system. Three assessment components/parameters which are network accessibility, service retainability and connection quality for evaluating QoS on the network were mainly adopted. The parameters were applied on four GSM networks in the studied areas using customers' complaints method. Also, a standard method known as Perceptual Evaluation of Speech Quality (PESQ) — (International Telecommunication Union-Telecommunication Standardization Sector) ITU-T standard P.862, used for measuring call voice quality and Mean Opinion Score (MOS) is adopted. The two methods were

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therefore compared to assess call voice quality of the four GSM networks. The Key Performance Indicators (KPIs) on which the GSM networks were tested include call set-up success rates (CSSR), call drop rate (CDR), call completion success rates (CCSR), handover success rates (HSR) and traffic channel congestion rate (TCHR). The result of the study shows that the Quality of Service of GSM system in the selected cities is unreliable. The study also shows that the GSM network accessibility and retainability in the country are unsatisfactory. However, the call voice quality was observed to be on the peak in these cities across the four network providers. At the end of this manuscript, suggestions are given on how to advance both the Quality of Service and the positive impact of GSM network in the selected areas and the country as a whole.

Keywords: Call voice quality; GSM network providers; key performance indicators (KPIs); PESQ; algorithm.

1. INTRODUCTION

As it has been long proven, information and communication have shaped the basis of human survival globally. The aspiration to reach others and also be reached has been a powerful and driving force behind encouraging men to perpetually seek for a new and effective means of disseminating information to one another on real time basis regardless of expanse or region. Sequel to this, the rapid development in technology accompanied this aspiration with introduction of the first generation cellular telephone systems that give people the chances of communicating with one another heedlessly of time and location. This first generation cellular telephone system, which was analog system, was impelled in 1960s before digital communication became prevailing [1,2].

It was the advent of this analog system that birthed the second generation digital system called Global System for Mobile (GSM) Communication, originally stood for Group Speciale Mobile, but later renamed as Global Systems for Mobile communication [2]. This development of GSM in the world was prompted by the need to provide unified telecommunications throughout Europeans countries.

Hence, the first unveiling of GSM was called Phase 1, which is known as 1G or first generation [3]. The services offered by this unveiling include provision for the basic voice, short message service (SMS) and circuit switched data (CSD).

Early 1990s, the lack of a common mobile system was discovered to be globally challenging, and it led to the initiation of the second generation GSM, known as phase 2 or simply 2G as it came to existence in 1995 with improved additional facilities. Sequel to this, obviously nowadays, GSM system can be seen in the Eastern European countries, Africa, Asia and Australia [2,4]. In fact, it has spread to most part of the world.

Nevertheless, as the quantity of services and GSM users in Nigeria rises, the demand for good quality of service (QoS) has become issue of concern in the country. The clamor for good QoS has become a national concern and was tabled before the country House of Representative and the Nigerian Communication Commission (NCC) on July 18, 2007 [2,5]. Meanwhile, in the quest for providing lasting and salient solution to this menace, the NCC, body responsible for the regulation of GSM in Nigeria, on 6th July, 2007 issue out the threshold levels on the key performance indicators (KPIs) for ascertaining QoS of all the GSM networks in the country [2]. The KPIs on which the GSM networks were tested include call set-up success rates (CSSR), call drop rate (CDR), call completion success rates (CCSR), handover success rates (HSR) and traffic channel congestion rate (TCHR) [2,6].

Measuring the call voice quality and MOS in this research work, a standard method known as Perceptual Evaluation of Speech Quality (PESQ)—ITU-T standard P.862, which was approved in December 2003 is adopted.

According to [7], Mean Opinion Score (MOS) is the Public Switched Telephone Network (PSTN) standard numeric value used to quantify voice quality. This ranges from a maximum of 5 to a minimum of 1; the maximum value of 5 is considered to be basically the same as communicating unswervingly into the person's ear, while the minimum value of 1 is considered to be an unacceptable voice quality to all users. A MOS of 4.4 to 4.5 is attributed to be the same as a toll quality call experienced on the PSTN;

with this, users will be very satisfied. Meanwhile, MOS of 4.0 is still considered acceptable to the most users, but MOS of 3.5 will make some users to find the call voice quality unacceptable.

Observation shows that most GSM calls have a MOS rating of 3.8, where speaker and word recognition may be weakened. Factually, users will be discontented and hang up when the MOS drops below 3.5. Also, MOS below 2.6 is considered to be an awful call.

According to [7], voice quality alone does not account for other elements—such as delay to dial tone, connection success and service availability—that make up a satisfactory call. The caller's experience includes four key elements, which are voice quality, call quality, service quality and usability of additional services that may also be employed. All this are experienced during calls [7].

2. METHODOLOGY

This research work was carried out in five (5) selected cities in Kwara state, Nigeria. The period covered by the study is three (3) months. The study was carried out using a well-designed questionnaire. The selected cities are Offa, Ilorin, Omu-Aran, Oro and Idofian, where GSM network providers are considered to be highly operative. The GSM networks studied are MTN, Airtel, Glo and Etisalat. Thereafter, the obtained data correlation was then compared with the PESQ Measurement values in order to strike balance in the assessment. This was possible with the time alignment algorithm implemented in the OPERA™ system.

In analyzing call voice quality in the areas under study, we also give proper consideration to the five components that define the elements of sound quality for one direction of a call, which as well represent part of the overall call voice quality. These five components include loudness, distortion, noise, crosstalk and fading. Also, network accessibility, service retainability and connection quality were also considered for an in-depth study of call voice quality in the selected area across the four network providers.

2.1 Presentation of Data

This research work was carried out in the selected areas in Kwara State where the four GSM communication network providers are unwaveringly operating.

Table 1 shows details on the recovered questionnaires from each of the areas under study. The responses gathered were converted to percentage so that the result analysis could be on the corresponding basis.

3. RESULTS AND DISCUSSION

The analysis of the results obtained from this research work is as explicated below:

3.1 Network Accessibility

For this research work, the evaluation of the accessibility to services made available by GSM network providers is known as the call set-up rate. The call set-up rate is here referred to as the rate by which a subscriber who initiates a call gets his/her calls through or established.

However, from the areas under study, the result of the responses on the call set-up rate of GSM Users shows that among all the four GSM network providers studied, As represented in Fig. 1, MTN has the highest easy call set-up success rate with CSSR (E) of 93.00%, while Airtel has the lowest easy call set-up success rate, CSSR (E), of 62.20%. This implies that the accessibility into MTN network is the easiest follow by Etisalat with CSSR (E) of 86.90%. Correspondingly, the accessibility to Globacom with 82.00% CSSR (E) is easier when compare with that of Airtel with 62.20% CSSR (E). Meanwhile, CSSR (E) connotes easy call set-up rate and CSSR (D) connotes difficult call set-up rate.

Also, study revealed that the degree of accessibility is better in these selected cities. It was being observed that for every 100 calls made on MTN network, 58 of them occur after 3 or more attempts while only 40 of such calls are set-up with one or two attempts. Whereas on the Airtel network, it is obvious that for every 100 calls attempt, 44 of them were successful with the first or second dials while 52% of those successful calls only occurred with three or more numbers of attempts on the same Airtel network.

3.2 Service Retainability

As the name implies service retainability reveals the extents to which a subscriber remains on a network when the call has been launched or set-up. It is an evaluation of possibility that an already launched call will not cut off while communication is ongoing. Mainly, the Key performance indicators (KPIs) for estimating the

Table 1. Questionnaires distribution

City	Selected GSM network providers			
	MTN	Airtel	Etisalat	Globacom
Offa	400	380	200	250
Ilorin	565	392	358	300
Omu-Aran	200	183	105	180
Oro	230	158	120	118
Idofian	298	182	89	160
Total	1693	1295	872	1008
Overall Total	4868			

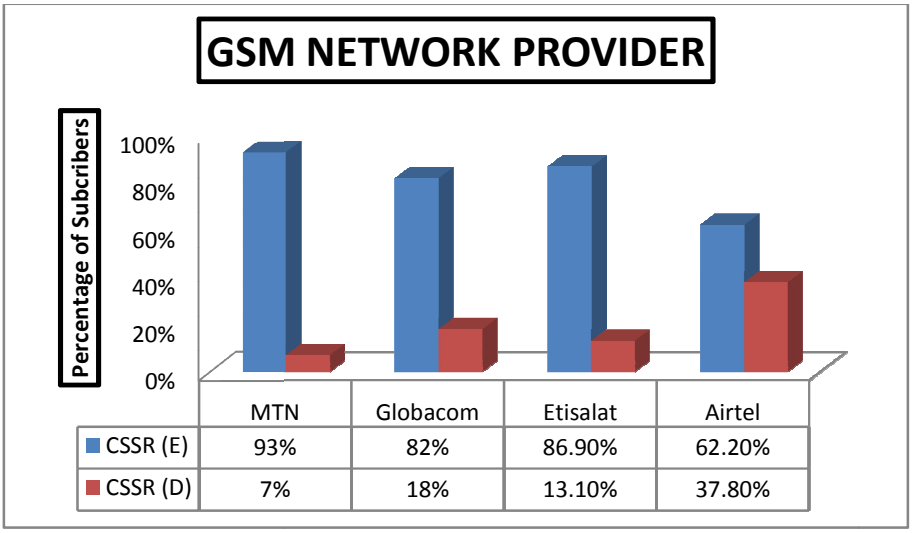

Fig. 1. Call set up success rate (Easy/difficult)

service retainability on a network are referred to as the CDR and the CCSR. However, the reply from subscribers on the retainability question from the survey area shows that sizable numbers of the subscribers experience call drop while talking is still ongoing. Sequel to this, the information gathered shows that Etisalat has the highest CDR of 73%, follow by MTN with 70%, Globacom with 68% and Airtel with 66%. Meanwhile, the CCSR and CDR are contrariwise correlated. Then, taking for instance, Etisalat that has the highest CDR value will have CCSR 27% as the lowest. This is represented in Fig. 2.

In this case, for Airtel with lowest CDR, the CCSR are the highest. The interpretation is that Airtel subscribers have higher possibility of completing their conversation when compare with subscribers on Etisalat, MTN and Globacom networks.

Looking through the networks considered in these five cities, observation revealed that the maximum or highest CCSR value the subscribers do experience is 34%. It means that for every 100 successful call set-up, only 34 of them will not drop before the parties involve completed their conversation. The interpretation is that retainability on all the four national GSM networks in the selected cities is low. This is an indication that their service is unreliable and needs improvement. However, when the service is not to satisfaction, then call voice quality will be impaired and distorted.

3.3 Connection (Call Voice) Quality

The service integrity that is termed as connection quality is another assessment parameters that is normally used in measuring the performance of the network that is being subjected to constantly changes in response to increasing coverage and capacity. This has to do with having a good or better service experience while using the network. On a GSM network, voice quality or call voice quality is an indicator of end-to-end speech communication or linking quality. According to [8], connection quality was computed using the mean opinion scores (MOS) which estimate the overall acceptability of quality of call voice communication base on rating. For this research work, GSM network users were asked to specify

if they normally hear other party perceptibly during conversation on their GSM networks. The response gathered on this is depicted that over 80% of all the subscribers in each of the network respond that the voice quality on all the GSM networks was excellent while less than 20% respond the voice quality on all the GSM bad. Therefore, Fig. 3 shows the audio quality of the GSM network providers covered in this research work.

Table 2 shows the result obtained from applying PESQ to a Voice over IP network. An application known as OPERA™ was also attached to this IP network through two VoIP Gateways. Two codecs specified as G.711 (64 Kbit) and G.723 (6.3 Kbit) were used. Moreover, the measurement was taken on the network without any load and later on loaded in order to monitor the impact of the network congestion on the speech quality.

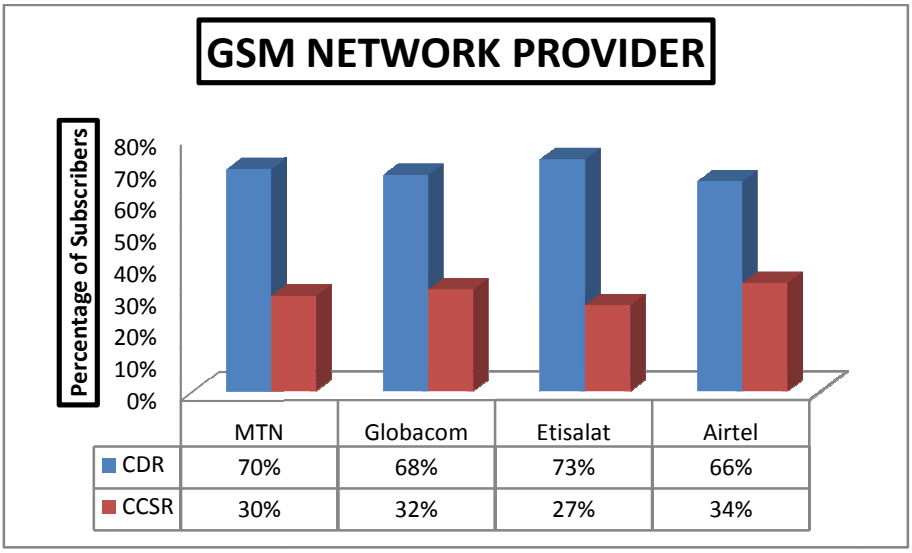

Fig. 2. Call drop and call completion success rates

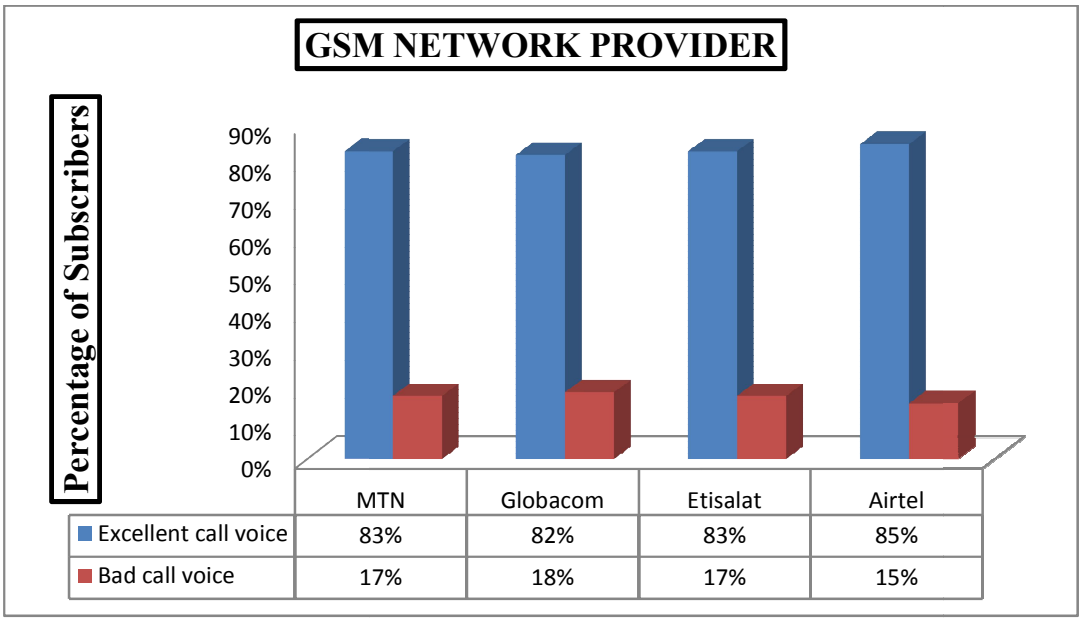

Fig. 3. Audio quality of the GSM network providers

Table 2. Measurement results obtained from applying PESQ, to a Voice over IP network

	PESQ	Delay PESQ
G.711 No Load	3.65	60..100ms
G.711 Load	1.40	180..700ms
G.723 No Load	3.24	150ms
G.723 Load	1.27	230..400ms

The PESQ measurement taken is therefore compared with the people-generated value. This is to see whether the people-generated value and machine-calculated MOS are exactly equal.

By looking at the PESQ values only, it becomes obvious that the network load has a significant impact on the speech quality. For the G.711 codec the quality drops from 3.65 to only 1.40 for the busy network. While for the G.723 codec, the quality drops to 1.27. However, due to the higher compression rate one could transfer ten times as many calls on the same network compared to G.711 without any significant loss of speech quality.

Looking at the effect of the network load, it is obvious that the speech quality is at lower limit and it has a significant influence on the delay of the line. Most especially when combined with G.711. Although G.723 shows a much higher minimum delay, meaning that the delay variation is much less than it appears to be with G.711. The latter shows a delay of 380ms ±89%(!), whereas G.723 varies just ±37% around and average of 275ms.

If these results are now compared to those obtained from people-generated value, it appears that both measures may surprisingly well be used for the assessment of the unloaded network, as well. This is possible with the time alignment algorithm implemented in the OPERA™ system. The correlation of the PESQ measurement to that of people-generated value is approximately one. Hence, it shows that both techniques are the same for the overall determination of call voice quality of a network.

4. CONCLUSION

Observation shows that a call begins when the user picks up the phone and ends when the call cut off. Calling experience is express as the quality experienced by the user for the entire call, including but not limited to call voice quality.

With this finding, and considering the areas under study, none of the GSM network providers has up to 90% call completion success rate (CCSR). This is an indication that the service retainability of all GSM networks in the selected areas is very low. Observation shows that the call drop rates on the networks are high. Also, the network accessibility on all these network providers studied is low. Hence, the congestion rates on the networks are high. Meanwhile, the network providers in the selected area have more subscribers, but lack sufficient equipment to support their daily increasing customer base.

Furthermore, the result shows that there is better performance of all the networks in terms of service integrity, most especially in call voice quality. Nevertheless, the overall evaluation is assign of poor performance as the customers express satisfaction in only one of the four parameters used in assessing the four GSM networks.

Finally, as far as this research work is concern, it can be concluded that the QoS and overall performance of the GSM network operation in the selected cities is poor, undependable and displeased, though the call voice quality is considered to be good.

5. RECOMMENDATION

Base on the above hypothesis and conclusion, it is highly recommended that:

1. The GSM network providers in these areas and the nation as a whole should focus more on providing Mobile Service Switching Center (MSC), Base Station Controller and base station site in order to minimize congestion and improve quality of service. Also, logistics such as detailed network planning are to be made available for coverage prediction, interference analysis, frequency planning and microwave link planning.
2. The Nigerian Communication Commission (NCC) is also enjoined to imbibe periodical inspection of the GSM network providers in the country so that they can give optimum attention to increasing their networks base across the country, and most especially in the five selected cities.
3. Government is advised to be moderate in the area of tax levying network providers in the country in order to enjoy congestion

free and good communication system in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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