

# ASSESSMENT OF CALL VOICE QUALITY OF GSM NETWORK OPERATORS IN 5 CITIES IN KWARA STATE

## 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 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.

## 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

37 system, which was analog system, was impelled in 1960s before digital  
38 communication became prevailing (Goldsmith, 2005; Popoola et al., 2009).

39 It was the advent of this analog system that birthed the second generation digital  
40 system called Global System for Mobile (GSM) Communication, originally stood  
41 for Group Speciale Mobile, but later renamed as Global Systems for Mobile  
42 communication (Popoola et al., 2009). This development of GSM in the world was  
43 prompted by the need to provide unified telecommunications throughout  
44 Europeans countries.

45 Hence, the first unveiling of GSM was called Phase 1, which is known as 1G or  
46 first generation (Ajiboye et al., 2007). The services offered by this unveiling  
47 include provision for the basic voice, short message service (SMS) and circuit  
48 switched data (CSD).

49 Early 1990s, the lack of a common mobile system was discovered to be globally  
50 challenging, and it led to the initiation of the second generation GSM, known as  
51 phase 2 or simply 2G as it came to existence in 1995 with improved additional  
52 facilities. Sequel to this, obviously nowadays, GSM system can be seen in the  
53 Eastern European countries, Africa, Asia and Australia (NOKIA, 2002; popoola et  
54 al., 2009). In fact, it has spread to most part of the world.

55 Nevertheless, as the quantity of services and GSM users in Nigeria rises, the  
56 demand for good quality of service (QoS) has become issue of concern in the  
57 country. The clamor for good QoS has become a national concern and was tabled  
58 before the country House of Representative and the Nigerian Communication  
59 Commission (NCC) on July 18, 2007 (popoola et al., 2009; Adegoke et al., 2008).  
60 Meanwhile, in the quest for providing lasting and salient solution to this menace,  
61 the NCC, body responsible for the regulation of GSM in Nigeria, on 6thJuly, 2007  
62 issue out the threshold levels on the key performance indicators (KPIs) for  
63 ascertaining QoS of all the GSM networks in the country (popoola et al., 2009) .  
64 The KPIs on which the GSM networks were tested include call set-up success rates  
65 (CSSR), call drop rate (CDR), call completion success rates (CCSR), handover  
66 success rates (HSR) and traffic channel congestion rate (TCHR) (Kollár 2008;  
67 Popoola et al., 2009).

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

71 According to Audin and Lodge, 2006, Mean Opinion Score (MOS) is the Public  
72 Switched Telephone Network (PSTN) standard numeric value used to quantify

73 voice quality. This ranges from a maximum of 5 to a minimum of 1; the maximum  
74 value of 5 is considered to be basically the same as communicating unswervingly  
75 into the person's ear, while the minimum value of 1 is considered to be an  
76 unacceptable voice quality to all users. A MOS of 4.4 to 4.5 is attributed to be the  
77 same as a toll quality call experienced on the PSTN; with this, users will be very  
78 satisfied. Meanwhile, MOS of 4.0 is still considered acceptable to the most users,  
79 but MOS of 3.5 will make some users to find the call voice quality unacceptable.

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

84 According to Audin and Lodge, 2006, voice quality alone does not account for  
85 other elements—such as delay to dial tone, connection success and service  
86 availability—that make up a satisfactory call. The caller's experience includes four  
87 key elements, which are voice quality, call quality, service quality and usability of  
88 additional services that may also be employed. All this are experienced during calls  
89 (Audin and Lodge, 2006).

## 90 **Methodology**

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

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

## 106 **Presentation of Data**

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

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

112 Table 1: Questionnaires Distribution

	<b>SELECTED GSM NETWORK PROVIDERS</b>			
<b>CITY</b>	<b>MTN</b>	<b>AITEL</b>	<b>ETISALAT</b>	<b>GLOBACOM</b>
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
<b>Total</b>	<b>1693</b>	<b>1295</b>	<b>872</b>	<b>1008</b>
<b>Overall Total</b>	<b>4868</b>			

113

## 114 **Results and Discussion**

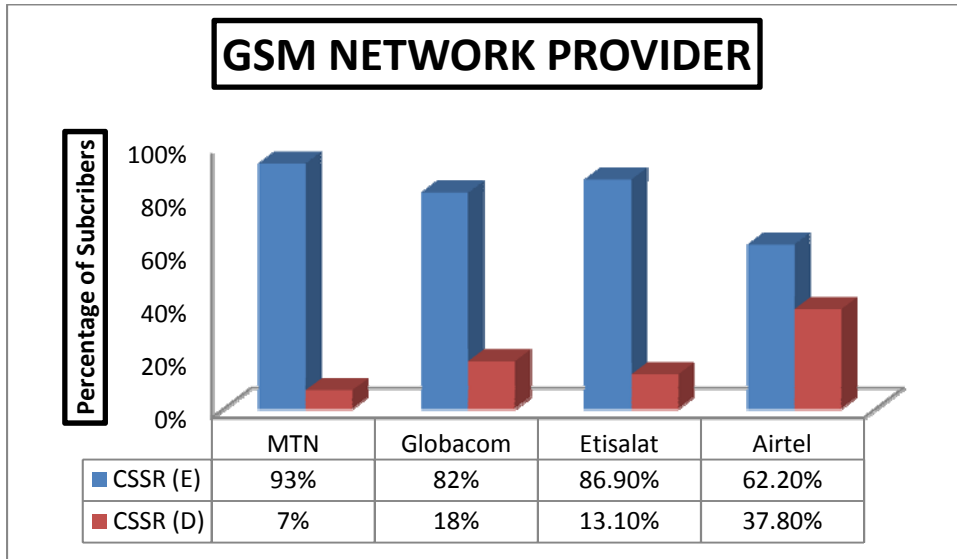
115 The analysis of the results obtained from this research work is as explicated below:

### 116 *Network Accessibility*

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

121 However, from the areas under study, the result of the responses on the call set-up  
122 rate of GSM Users shows that among all the four GSM network providers studied,  
123 As represented in figure 1 below, MTN has the highest easy call set-up success rate  
124 with CSSR (E) of 93.00%, while Airtel has the lowest easy call set-up success rate,  
125 CSSR (E), of 62.20%. This implies that the accessibility into MTN network is the  
126 easiest follow by Etisalat with CSSR (E) of 86.90%. Correspondingly, the

127 accessibility to Globacom with 82.00% CSSR (E) is easier when compare with that  
 128 of Airtel with 62.20% CSSR (E). Meanwhile, CSSR (E) connotes easy call set-up  
 129 rate and CSSR (D) connotes difficult call set-up rate.



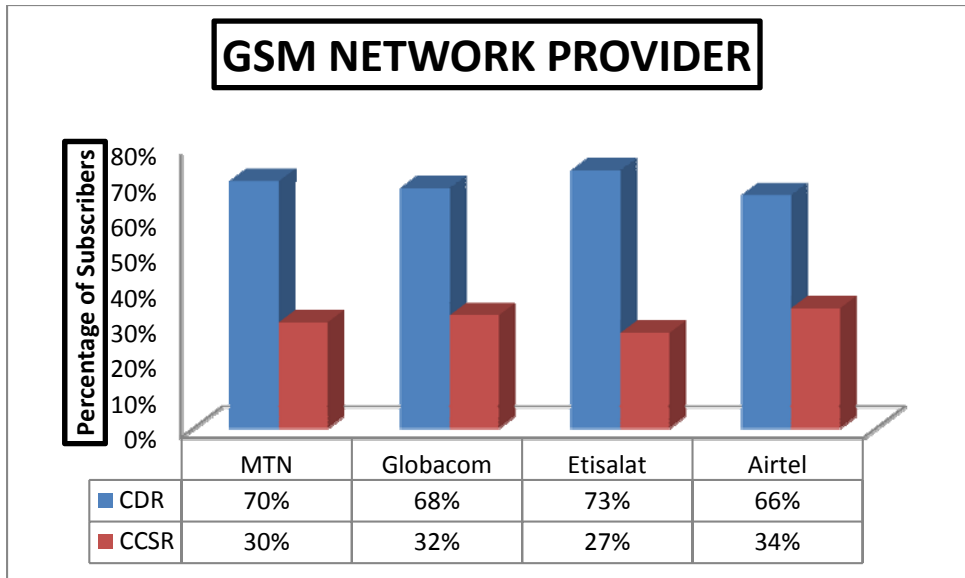
130

131 *Figure 1: Call Set up Success Rate (Easy/Difficult)*

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

139 *Service Retainability*

140 As the name implies service retainability reveals the extents to which a subscriber  
 141 remains on a network when the call has been launched or set-up. It is an evaluation  
 142 of possibility that an already launched call will not cut off while communication is  
 143 ongoing. Mainly, the Key performance indicators (KPIs) for estimating the service  
 144 retainability on a network are referred to as the CDR and the CCSR. However, the  
 145 reply from subscribers on the retainability question from the survey area shows  
 146 that sizable numbers of the subscribers experience call drop while talking is still  
 147 ongoing. Sequel to this, the information gathered shows that Etisalat has the  
 148 highest CDR of 73%, follow by MTN with 70%, Globacom with 68% and Airtel  
 149 with 66%. Meanwhile, the CCSR and CDR are contrariwise correlated. Then,  
 150 taking for instance, Etisalat that has the highest CDR value will have CCSR 27%  
 151 as the lowest. This is represented in figure 2 below:



152

153 *Figure 2: Call Drop and Call completion Success Rates*

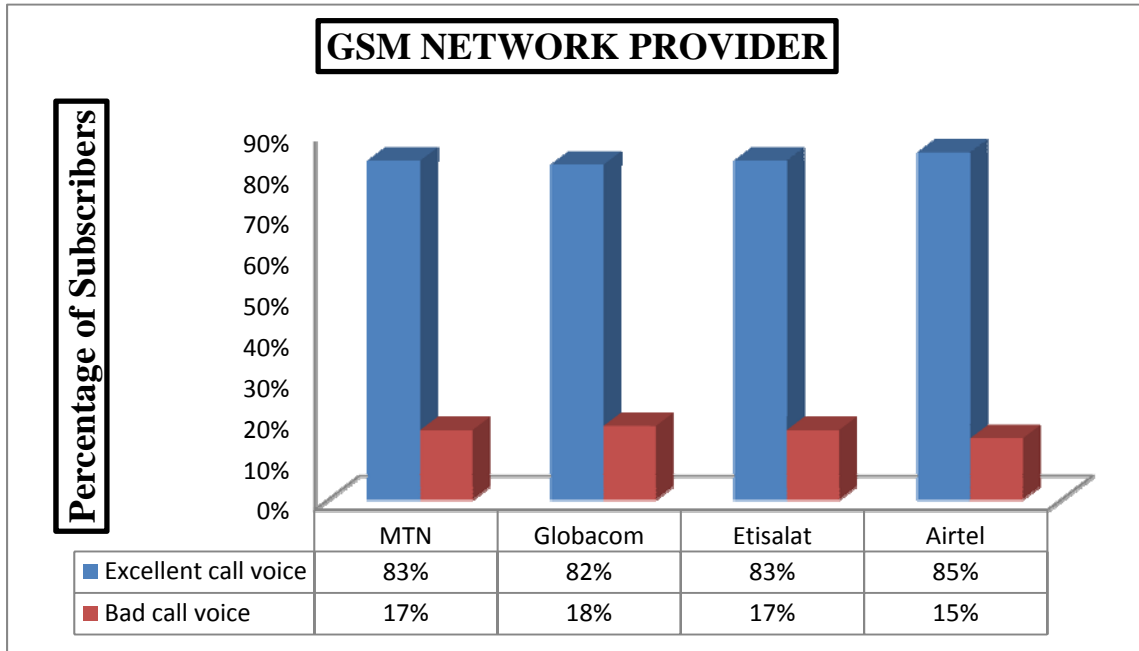
154 In this case, for Airtel with lowest CDR, the CCSR are the highest. The  
 155 interpretation is that Airtel subscribers have higher possibility of completing their  
 156 conversation when compare with subscribers on Etisalat, MTN and Globacom  
 157 networks.

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

166 *Connection (Call Voice) Quality*

167 The service integrity that is termed as connection quality is another assessment  
 168 parameters that is normally used in measuring the performance of the network that  
 169 is being subjected to constantly changes in response to increasing coverage and  
 170 capacity. This has to do with having a good or better service experience while  
 171 using the network. On a GSM network, voice quality or call voice quality is an  
 172 indicator of end-to-end speech communication or linking quality. According to  
 173 Kuboye *et al.*, 2009, connection quality was computed using the mean opinion  
 174 scores (MOS) which estimate the overall acceptability of quality of call voice  
 175 communication base on rating. For this research work, GSM network users were

176 asked to specify if they normally hear other party perceptibly during conversion on  
 177 their GSM networks. The response gathered on this is depicted that over 80% of all  
 178 the subscribers in each of the network respond that the voice quality on all the  
 179 GSM networks was excellent while less than 20% respond the voice quality on all  
 180 the GSM bad. Therefore, figure 3 below shows the audio quality of the GSM  
 181 network providers covered in this research work.



182

183 *Figure 3: Audio Quality of the GSM Network Providers*

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

190 Table 2: Measurement results obtained from applying PESQ, to a Voice over IP  
 191 network

	<b>PESQ</b>	<b>Delay PESQ</b>
<b>G.711 No Load</b>	3.65	60..100ms
<b>G.711 Load</b>	1.40	180..700ms

<b>G.723 No Load</b>	3.24	150ms
<b>G.723 Load</b>	1.27	230..400ms

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

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

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

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

## 214 **Conclusion**

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

218 With this finding, and considering the areas under study, none of the GSM network  
219 providers has up to 90% call completion success rate (CCSR). This is an indication  
220 that the service retainability of all GSM networks in the selected areas is very low.  
221 Observation shows that the call drop rates on the networks are high. Also, the  
222 network accessibility on all these network providers studied is low. Hence, the  
223 congestion rates on the networks are high. Meanwhile, the network providers in the

224 selected area have more subscribers, but lack sufficient equipment to support their  
225 daily increasing customer base.

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

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

### 235 **Recommendation**

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

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

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