

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

Abstract

This paper evaluate voice quality of four GSM provider in five selected cities in Kwara State with consideration of network performance evaluation and quality of service (QoS) improvement of GSM network system. Three assessment parameters which are network accessibility, service retainability, and connection quality for evaluating QoS on the network were 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)—ITU-T standard P.862, used for measuring call voice quality and MOS is adopted. The two methods were therefore compared to assess call voice quality of the four GSM networks. The result of the study shows that the QoS 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 is discovered to be better in these cities across the four network providers.

At the end of the paper, recommendations are given on how to advance both the QoS and the positive impact of GSM network in the selected areas and the country as a whole in the country.

Keywords: Call voice quality; GSM network providers; Key performance indicators (KPIs); PESQ; Algorithm

Introduction

As it has been long established, information and communication have formed the basis of human survival globally. The desire to reach others and also be reached has been a driving force behind motivating men to unceasingly seek for a new and effective means of spreading information to one another on real time basis regardless of expanse. Sequel to this, the outburst in technology accompanied this desire with initiation 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 dominant (Goldsmith, 2005; Popoola et al., 2009).

It was the advent of this analog system that birthed the second generation digital system called GSM, originally stood for Group Speciale Mobile, but later renamed

36 as Global Systems for Mobile communication (popoola et al.,2009). This
37 development of GSM in the world was prompted by the need to provide unified
38 telecommunications throughout Europeans countries.

39 Hence, the first release of GSM was called Phase 1, which is referred to as the 1G
40 or first generation (Ajiboyeet *al.*, 2007). The services offered by this release
41 include provision for the basic voice, short message service (SMS) and circuit
42 switched data (CSD).

43 Early 1990s, the lack of a common mobile system was seen to be globally
44 challenging, and it led to the initiation of the second generation GSM, known as
45 phase 2 or simply 2G as it came to existence in 1995 with improved additional
46 facilities.As a result of this, today, GSM system can be seen in the Eastern
47 European countries, Africa, Asia and Australia (NOKIA, 2002; popoola et al.,
48 2009). In fact, it has spread to most part of the world.

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

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

64 According to Audin and Lodge, 2006, Mean Opinion Score (MOS) is the PSTN
65 standard numeric value used to quantify voice quality. This ranges from a
66 maximum of 5 to a minimum of 1; the maximum value of 5 is considered to be
67 basically the same as communicating unswervingly into the person's ear, while the
68 minimum value of I is considered to be an unacceptable voice quality to all users.
69 A MOS of 4.4 to 4.5 is attributed to be the same as a toll quality call experienced
70 on the PSTN; with this users will be very satisfied. Meanwhile, MOS of 4.0 is still
71 considered acceptable to the most users, but MOS of 3.5 will make some users to
72 find the call voice quality unacceptable.

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

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

83 **Methodology**

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

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

100 **Presentation of Data**

101 This research work was carried out in the selected areas in Kwara State where the
102 four GSM communication network providers are unwaveringly operating. The
103 network providers that the questionnaires cut across as earlier mentioned are MTN,
104 GLOBACOM, ETISALAT and AIRTEL. The questionnaires were ensured to be
105 evenly distributed among the four network providers.

106 Table 1 below shows the detail on the recovered questionnaires from each of the
 107 studied areas. The responses gather were converted to percentage so that the result
 108 analysis can be on the equivalent basis.

109 Table 1: Questionnaires Distribution

| | SELECTED GSM NETWORK PROVIDERS | | | |
|----------------------|---------------------------------------|--------------|-----------------|-----------------|
| CITY | MTN | AITEL | 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 | | | |

110

111 **Results and Discussion**

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

113 *Network Accessibility*

114 For this research work, the evaluation of the accessibility to services made
 115 available by GSM network providers is known as the call set-up rate. This
 116 investigates mobile station's ability to launch and sustain calls. It also examines the
 117 capability to magnificently create voice communications between two ends (i.e. a
 118 mobile network terminal and a fixed network terminal), and the ability of networks
 119 to maintain this call during a pre-established period of time. Provided
 120 communication does not exist or it eventually dropped during calls, then there is
 121 need for consideration of both call set-up rate and call drop rate on the network.

122 The call set-up rate is here referred to as the rate by which a subscriber who
 123 initiates a call gets his/her calls through or established.

124 When a subscriber has to make more than one attempts before getting his/her call
125 connected or established, this means that the call setup failure rate of the network is
126 high.

127 However, from the area under study, the result of the response on the call set-up
128 rate of GSM Users shows that among all the four GSM network providers studied,
129 MTN has the highest easy call set-up success rate with CSSR (E) of 93.00%, while
130 Airtel has the lowest easy call set-up success rate, CSSR (E), of 62.20%. This
131 implies that the accessibility into MTN network is the easiest followed by Etisalat
132 with CSSR (E) of 86.90%. Correspondingly, the accessibility to Globacom with
133 82.00% CSSR (E) is easier when compared with that of Airtel with 57.30% CSSR
134 (E). Meanwhile, CSSR (E) connotes easy call set-up rate and CSSR (D) connotes
135 difficult call set-up rate.

136 Also, study revealed that the degree of accessibility is better in these selected
137 cities. It was being observed that for every 100 calls made on MTN network, 58 of
138 them occur after 3 or more attempts while only 40 of such calls are set-up with one
139 or two attempts. Whereas on the Airtel network, it is obvious that for every 100
140 calls attempted, 44 of them were successful with the first or second dials while 52%
141 of those successful calls only occurred with three or more numbers of attempts on
142 the same Airtel network. In addition, the study shows that accessibility to both
143 Globacom and Etisalat networks can be accomplished with fewer numbers of
144 attempts. Consequently, this great degree of attempts before a call can be
145 established or set-up is an indication of greater degree of congestion on all the
146 GSM networks considered in the selected cities.

147 *Service Retainability*

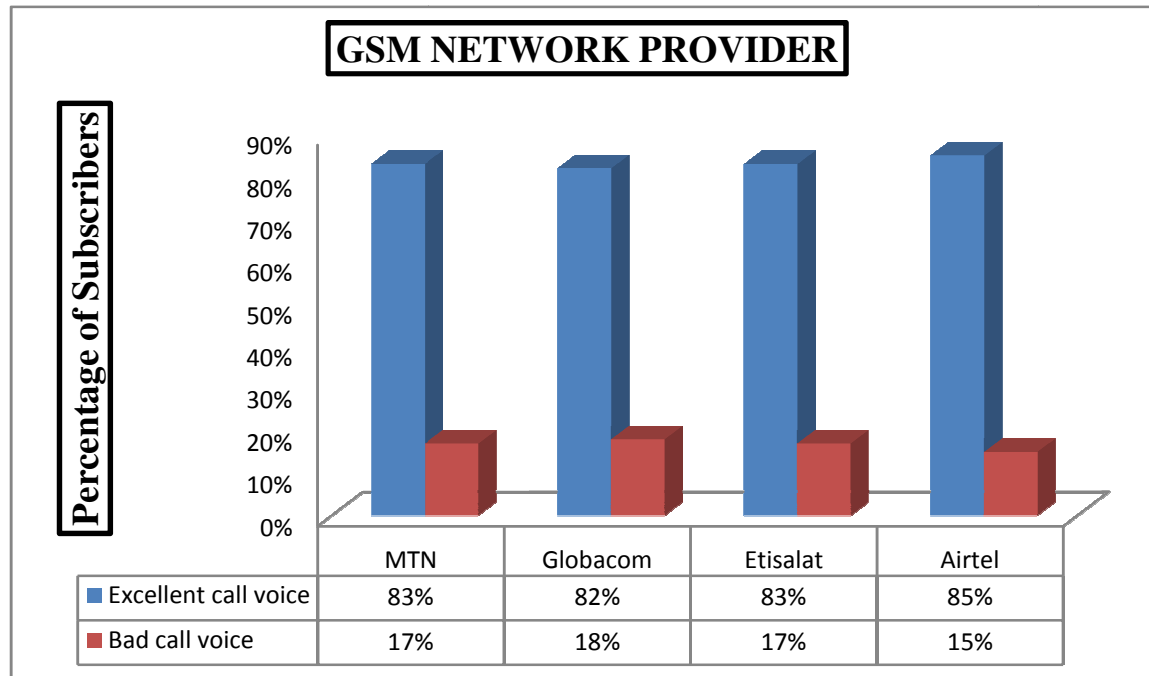
148 As the name implies service retainability reveals the extents to which a subscriber
149 remains on a network when the call has been launched or set-up. It is an evaluation
150 of possibility that an already launched call will not cut off while communication is
151 ongoing. Mainly, the Key performance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

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

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

172 *Connection (Call Voice) Quality*

173 The service integrity that is termed as connection quality is another assessment
174 parameters that is normally used in measuring the performance of the network that
175 is being subjected to constantly changes in response to increasing coverage and
176 capacity. This has to do with having a good or better service experience while
177 using the network. On a GSM network, voice quality or call voice quality is an
178 indicator of end-to-end speech communication or linking quality. According to
179 Kuboyeet *al.*, 2009, connection quality was computed using the mean opinion
180 scores (MOS) which estimate the overall acceptability of quality of call voice
181 communication base on rating. For this research work, GSM network users were
182 asked to specify if they normally hear other party perceptibly during conversion on
183 their GSM networks. The response gathered on this is depicted that over 80% of all
184 the subscribers in each of the network respond that the voice quality on all the
185 GSM networks was excellent while less than 20% respond the voice quality on all
186 the GSM bad.



187

188 *Figure 1: Audio Quality of the GSM Network Providers*

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

| | 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 |

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

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

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

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

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

219 **Conclusion**

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

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

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

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

240 **Recommendation**

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

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

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