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INVESTIGATING THE PERFORMANCE OF GSM NETWORK IN OGUN STATE, NIGERIA USING RELIABILITY INDICES

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ABSTRACT

The paper investigated the operational performance of some GSM networks in Ota, Ogun State, Nigeria. Various call data of some subscribers that placed call from one network to another were collated. The reliability of inter-network performance was calculated using the Indices of Reliability (IR). The results obtained were graphically analyzed using the Microsoft Excel software. The results showed that the subscriber that initiate call tagged as subscriber 'B' had a 40% successful connection performance from other network, while subscriber with network 'D'' had a 90% chance to receive call from any network. Further results showed that there is a 60% chance of connectivity between similar network for D-D^l, 20% for line A-A^l and E-E^l respectively. The weakest link in the network from the analysis was identified as line B-B^l with an average reliability value of 88% followed by C-C^l with reliability value of 94% which is lower than the reliability benchmark of a minimum of 99%.

1. INTRODUCTION

Before the advent of mobile technology, communication between at least two parties was a great challenge across the globe. However, from the inception of electronic mobile communication in Sub-Saharan Africa, interconnection between various networks have been a major challenge (Open signal, 2015). Efforts to bridge this gap and improve on the means of communication led to the advent of Private Telecommunication Operators PTOs, Mobile Network Operators MNOs, and Global System for Mobile Communication GSM technology in the twentieth century with the purpose of introducing digital communication in the system while replacing the analogue means. With the passage of time, the technology was enjoyed by a good number of Nigerians but the question is: How reliable was the technology when it was introduced? How reliable is the technology right now?

The strong competition among the Private Telephone Operators PTOs has led to various strategies by the concerned authorities to create and keep existing customers. Nigeria has maintained its lead as African's largest telecom market with active subscribers of 92,006,608 by the end of February, 2012. (NCC, 2012). Another survey conducted by open signal in 2015 revealed that 66% of Nigerians use phones with dual SIM card (Open signal, 2015), One of the major reasons why Nigerians patronize more than one network operator may not be unconnected with poor reliability emanating from the various MNOs. The probability that a system will continue to perform well at a giving time in a giving environmental condition is known as reliability (Airoboman *et al.*, 2016). Hence, there is need for the MNO's and PTO's to optimize their system with the overall aim of improving the reliability. In one way or the other, humans have lost their lives and loved ones, rare opportunities have been missed; lives have been put at risk and irrecoverable time lost due to the laxity portrayed by both the MNO's and PTOs in resolving their system reliability constraints.

The quality of services presently portrayed by the concerned authorities is poor. The aspects off this quality of service according to (Parusaraman *et al.*, 1985; Ndukwe, 2000; Zeithaml *et al*, 2008) are: availability, reliability, flexibility, assurance and simplicity. Although the scope of this research dwells more on service quality with respect to reliability. According to (Okamoto *et al.*, 2009; Shalangwa and Singh, 2011; Ferreira *et al.*, 2012; Idim and Anyasi, 2014) losses are encountered in the signal strength of GSM due to free space, refraction, activities of human etc and these may lead to poor performance of GSM signal especially in confined areas. Quality of Service (QoS) according to (Venetis. and Ghauri, 2004) has been considered as a major determinant in customer retention and loyalty. Service quality results in repeated sales and increased market share, which leads to customer loyalty (Buzzell and Gale, 1987). Providing a high service quality can lead an organization to charge premium price (Brown *et al.*, 1992). High service quality enhances customers' favorable behavioral intentions while simultaneously reduces their unfavorable intentions (Zeithaml *et al.*, 1996). The implication of the above discussion is that with high service quality, GSM customers are attracted, and when happy and satisfied, may have an increased propensity to stay longer with their GSM service provider. However, this quality has been found not to be the same in different locations across the country, this is a major drawback because all subscribers within a giving network pay the same amount of bill for voice calls or short message service (SMS) sent. It is therefore imperative that the authority in charge with the regulation screens such irregularities away from the system. This must be done because a research by (Odinma, 2011), revealed that in Nigeria users have no genuine choice with respect to which PTO's to patronize hence, the authority in charge needs to come to the rescue. On the other hand, it is also very important for the PTO's to be aware that customer loyalty is proportional to good service quality (Yoo and Park, 2007) and good service quality implies a no tolerance to downtime (Ikhine *et al*, 2017) this quality thereby differentiates one operator from the other (Adeleke and Suraju, 2012).

The major motivation of this work, therefore, is to discover the network operator that is most reliable with respect to the area where this study was conducted. This would in turn give a better idea of which service provider to rely on in case of an urgent situation.

2. MATERIALS AND METHODS

Four (4) dual SIM GSM phones and eight SIM cards (2 SIM cards each per network) of four different networks were used. Multiple calls were placed for 5 days a week (Morning 8:00am, Afternoon 12:00pm and Evening 5:00pm) for a period of five weeks and this was done within ota axis in Ogun State, Nigeria. The number of trials when placing a call from a-b was taken as three (3), and the reason for this was to reduce error in the results. Calls were placed from lines A-A^l, A-B^l, A-C^l, A-D^l, B-A^l, B-B^l etc. Where lines A, B, C, D, A$'$, B$'$, C'and D' are taken as: 0907*****30, 0906*****37, 0815*****51, 0909*****59 0706*****61, 0907*****32,

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0811*****71, and 0909*****58 respectively. The results obtained are shown in Tables 1-5, Tables 6-10 shows the calculated RI while the results summary is shown in Tables 11-12. The indices of reliability have been used to calculate how reliable are each of the network with respect to the geographical area where the data were collected from. Equations 1-5 were used in calculating the reliability of the various network.

$$MTBF = \sum_{i=1}^{n} PC_i \Big/ \sum_{i=1}^{n} UC_i \quad (1)$$

$$FR = \sum_{i=1}^{n} UC_i \Big/ \sum_{i=1}^{n} PC_i - DT \quad (2)$$

$$MTTF = \sum_{i=1}^{n} PC_i - DT \Big/ \sum_{i=1}^{n} UC_i \quad (3)$$

$$MTTR = \sum_{i=1}^{n} PC_i \Big/ \sum_{i=1}^{n} UC_i - \sum_{i=1}^{n} PC_i - DT \Big/ \sum_{i=1}^{n} UC_i \quad (4)$$

$$REL = \sum_{i=1}^{n} PC_i \Big/ \sum_{i=1}^{n} PC_i - \sum_{i=1}^{n} UC_i \quad (5)$$

PC = Placed Calls, DT = Downtime, CC = Connected Calls, UC = Unconnected Calls, RI = Reliability Indices, Rel = Reliability

3. RESULTS AND DISCUSSION

The only real alternative to QoS performance is to analyse the data collected and proffer a way forward. Table 1-5 show the results of PC within the investigation period of the research. The IR was calculated using equations 1-5 and the obtained results are shown in Table 6-10. Table 11-12 gives the summary of the results while the Excel software was used for graphical results interpretation.

Table 1: Results of PC in Week 1

Network	Placed calls	CC	UC
A-A’	108	106	2
A-B’	207	196	11
A-C’	252	243	9
A-D’	252	241	11
B-A’	225	214	11
B-B’	234	227	7
B-C’	252	240	12
B-D’	216	211	5
C-A’	252	245	7
C-B’	234	224	10
C-C’	216	208	8
C-D’	198	193	5
D-A’	252	242	10
D-B’	198	194	4
D-C’	198	192	6
D-D’	216	209	7

Table 2: Results of PC in Week 2

Network	Placed Calls	CC	UC
A-A'	84	80	4
A-B'	84	80	4
A-C'	249	229	20
A-D'	249	237	12
B-A'	84	80	4
B-B'	249	230	19
B-C'	249	233	16
B-D'	168	163	5
C-A'	249	230	19
C-B'	249	234	15
C-C'	168	159	9
C-D'	168	163	5
D-A'	249	234	15
D-B'	168	160	8
D-C'	168	159	9
D-D'	168	162	6

Table 3: Results of PC in Week 3

Network	Placed Calls	CC	UC
A-A'	336	320	16
A-B'	336	322	14
A-C'	336	316	20
A-D'	336	329	7
B-A'	336	321	15
B-B'	336	322	14
B-C'	336	319	17
B-D'	336	325	11
C-A'	336	321	15
C-B'	336	325	11
C-C'	336	315	21
C-D'	336	326	10
D-A'	336	324	12
D-B'	336	321	15
D-C'	336	316	20
D-D'	336	320	16

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Table 4: Results of PC in Week 4

Network	Placed Calls	CC	UC
A-A’	336	314	22
A-B’	336	303	33
A-C’	336	318	18
A-D’	336	329	7
B-A’	336	306	30
B-B’	336	314	22
B-C’	336	322	14
B-D’	336	322	14
C-A’	336	317	19
C-B’	336	318	18
C-C’	336	315	21
C-D’	336	319	17
D-A’	336	321	15
D-B’	336	311	25
D-C’	336	312	24
D-D’	336	323	13

Table 5: Results of PC in Week 5

Network	Placed Calls	CC	UC
A-A’	336	292	44
A-B’	336	274	62
A-C’	336	265	71
A-D’	336	299	37
B-A’	336	276	60
B-B’	336	270	66
B-C’	336	277	59
B-D’	336	301	35
C-A’	336	272	64
C-B’	336	282	54
C-C’	336	279	57
C-D’	336	299	37
D-A’	336	284	52
D-B’	336	284	52
D-C’	336	277	59
D-D’	336	294	42

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Table 6: RI of Week 1

Network	MTBF	FR	MTTF	MTTR	REL
A-A’	54	0.0189	53	1	0.9815
A-B’	18.82	0.0537	18.64	0.18	0.9469
A-C’	28	0.036	27.78	0.22	0.9643
A-D’	22.91	0.044	22.73	0.18	0.9563
B-A’	20.45	0.0493	20.27	0.18	0.9511
B-B’	33.43	0.0302	33.14	0.29	0.9701
B-C’	21	0.048	20.83	0.17	0.9524
B-D’	43.2	0.0234	42.8	0.4	0.9769
C-A’	36	0.028	35.71	0.29	0.9722
C-B’	23.4	0.0431	23.2	0.2	0.9573
C-C’	27	0.0374	26.75	0.25	0.963
C-D’	39.6	0.0255	39.2	0.4	0.9747
D-A’	25.2	0.04	25	0.2	0.9603
D-B’	49.5	0.0204	49	0.5	0.9798
D-C’	33	0.0306	32.67	0.33	0.9697
D-D’	30.86	0.0327	30.57	0.29	0.9676

Table 7: RI of Week 2

Network	MTBF	FR	MTTF	MTTR	REL
A-A’	21	0.0488	20.5	0.5	0.9524
A-B’	21	0.0488	20.5	0.5	0.9524
A-C’	12.45	0.081	12.35	0.1	0.9197
A-D’	20.75	0.0486	20.58	0.17	0.9518
B-A’	21	0.0488	20.5	0.5	0.9524
B-B’	13.11	0.0769	13	0.11	0.9237
B-C’	15.56	0.0648	15.44	0.13	0.9357
B-D’	33.6	0.0301	33.2	0.4	0.9702
C-A’	13.11	0.0769	13	0.11	0.9237
C-B’	16.6	0.0607	16.47	0.13	0.9398
C-C’	18.67	0.0542	18.44	0.22	0.9464
C-D’	33.6	0.0301	33.2	0.4	0.9702
D-A’	16.6	0.0607	16.47	0.13	0.9398
D-B’	21	0.0482	20.75	0.25	0.9524
D-C’	18.67	0.0542	18.44	0.22	0.9464
D-D’	28	0.0361	27.67	0.33	0.9643

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Table 8: RI of Week 3

Network	MTBF	FR	MTTF	MTTR	REL
A-A’	21	0.0479	20.88	0.13	0.9524
A-B’	24	0.0419	23.86	0.14	0.9583
A-C’	16.8	0.0599	16.7	0.1	0.9405
A-D’	48	0.021	47.71	0.29	0.9792
B-A’	22.4	0.0449	22.27	0.13	0.9554
B-B’	24	0.0419	23.86	0.14	0.9583
B-C’	19.76	0.0509	19.65	0.12	0.9494
B-D’	30.55	0.0329	30.36	0.18	0.9673
C-A’	22.4	0.0449	22.27	0.13	0.9554
C-B’	30.55	0.0329	30.36	0.18	0.9673
C-C’	16	0.0629	15.9	0.1	0.9375
C-D’	33.6	0.0299	33.4	0.2	0.9702
D-A’	28	0.0359	27.83	0.17	0.9643
D-B’	22.4	0.0449	22.27	0.13	0.9554
D-C’	16.8	0.0599	16.7	0.1	0.9405
D-D’	21	0.0479	20.88	0.13	0.9524

Table 9: RI of Week 4

Network	MTBF	FR	MTTF	MTTR	REL
A-A’	15.27	0.0659	15.18	0.09	0.9345
A-B’	10.18	0.0988	10.12	0.06	0.9018
A-C’	18.67	0.0539	18.56	0.11	0.9464
A-D’	48	0.021	47.71	0.29	0.9792
B-A’	11.2	0.0898	11.13	0.07	0.9107
B-B’	15.27	0.0659	15.18	0.09	0.9345
B-C’	24	0.0419	23.86	0.14	0.9583
B-D’	24	0.0419	23.86	0.14	0.9583
C-A’	17.68	0.0569	17.58	0.11	0.9435
C-B’	18.67	0.0539	18.56	0.11	0.9464
C-C’	16	0.0629	15.9	0.1	0.9375
C-D’	19.76	0.0509	19.65	0.12	0.9494
D-A’	22.4	0.0449	22.27	0.13	0.9554
D-B’	13.44	0.0749	13.36	0.08	0.9256
D-C’	14	0.0719	13.92	0.08	0.9286
D-D’	25.85	0.0389	25.69	0.15	0.9613

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Table 10: RI of Week 5

Network	MTBF	FR	MTTF	MTTR	REL
A-A’	7.64	0.1317	7.59	0.05	0.869
A-B’	5.42	0.1856	5.39	0.03	0.8155
A-C’	4.73	0.2126	4.7	0.03	0.7887
A-D’	9.08	0.1108	9.03	0.05	0.8899
B-A’	5.6	0.1796	5.57	0.03	0.8214
B-B’	5.09	0.1976	5.06	0.03	0.8036
B-C’	5.69	0.1766	5.66	0.03	0.8244
B-D’	9.6	0.1048	9.54	0.06	0.8958
C-A’	5.25	0.1916	5.22	0.03	0.8095
C-B’	6.22	0.1617	6.19	0.04	0.8393
C-C’	5.89	0.1707	5.86	0.04	0.8304
C-D’	9.08	0.1108	9.03	0.05	0.8899
D-A’	6.46	0.1557	6.42	0.04	0.8452
D-B’	6.46	0.1557	6.42	0.04	0.8452
D-C’	5.69	0.1766	5.66	0.03	0.8244
D-D’	8	0.1257	7.95	0.05	0.875

As seen from Table 11, it can be said that with a 90% chance, line D' is the most reliable when it comes to receiving calls from other network under the period of investigation. On the other hand, calls placed to line B'& C' shows a poor reliability. When considering the results in terms of percentages it could therefore be established from Table 11 that line B’&C’ has a 40% and 60% chance of not connecting to another network. It should be noted here that line D' proved to be more reliable by not appearing among the network with the least reliability in Table 11. Table 12 shows the reliability of calls established between mutual networks i.e line A-A', B-B', C-C' and D-D' the aim of doing this was to establish if there could be connectivity problem between the same network. The findings from the table, reveals that D-D' has the best connectivity i.e it could connect with its corresponding network 60% of the time while A-A' and B-B' has 20% chances each. Furthermore, it was also established that there is 50-50 chance of calls not connecting when dealing with B-B' while C-C' and A-A' has 33% and 17.3% chances respectively. It should also be noted that line D-D' did not fall into any of this category therefore it can be concluded that with respect to the analysis and obtained result line D-D' is the most reliable while B-B' possess the least reliability value.

Table 11: Reliability summary of PC of different MNO’s

Period	Most Reliable	Reliability	Least reliable	Reliability
Week1	A-A’	0.9815	A-B’	0.9469
Week2	B-D’	0.9702	A-C’	0.9197
	C-D’	0.9702		
Week 3	A-D’	0.9792	C-C’	0.9375
Week 4	A-D’	0.9792	A-B’	0.9018
Week 5	B-D’	0.8958	A-C’	0.7887

Table 12: Reliability summary of PC of mutual MNO's

	Most Reliable	Reliability	Least reliable	Reliability
Week1	A-A'	0.9815	C-C'	0.9469
Week2	D-D'	0.9643	B-B'	0.9197
Week3	B-B'	0.9583	C-C'	0.9375
Week 4	D-D'	0.9613	A-A'	0.9345
Week 5	D-D'	0.875	B-B'	0.9345
			B-B'	0.7887

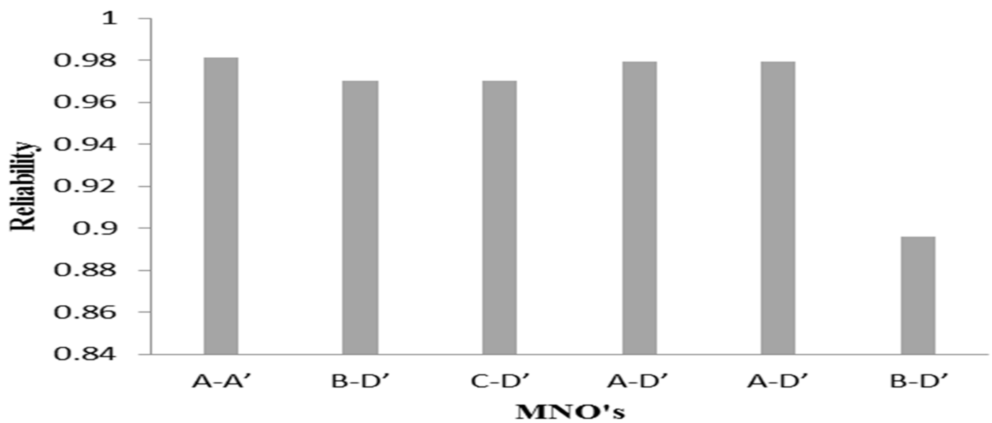

Figure 1: Most reliable network with respect to another network

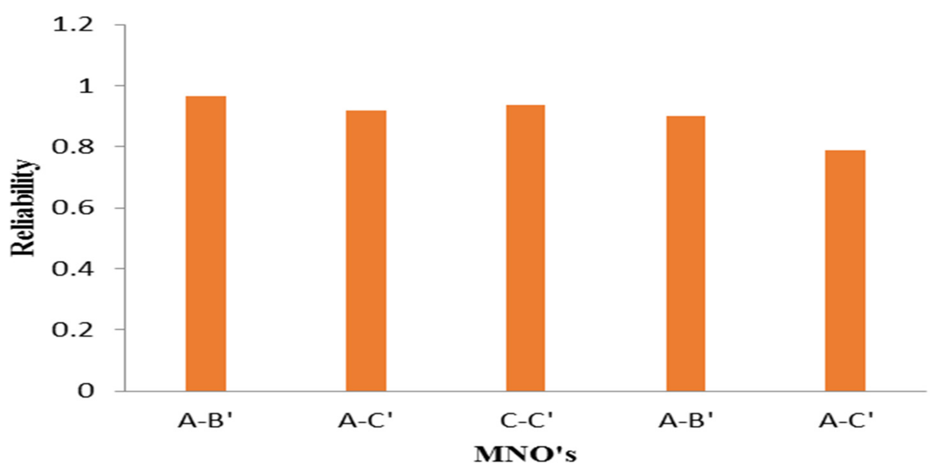

Figure 2: Least reliable network with respect to another network

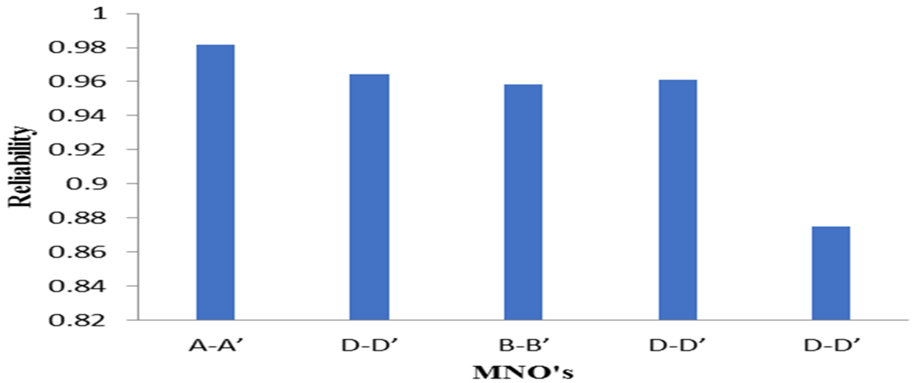

Figure 3: Most reliable network with respect to mutual network

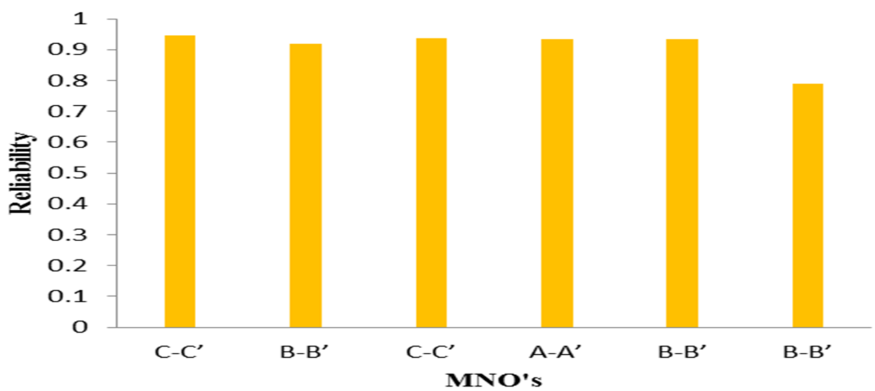

Figure 4: Least reliable network with respect to mutual network

4. CONCLUSION

This paper has investigated the network performance of the various MNO's using the IR and the results have been discussed. However, it should be noted that although a network may be more reliable than the other but none of the MNO's under review could produce reliability value that is within accepted standard of 0.99 (Airoboman *et al*, 2017). It is therefore recommended that more work need to be done with respect to improving the infrastructure by introducing a more recent maintenance technique as stated in Airoboman *et al*. (2017), using a very good energy mix to provide power supply to their base stations as well as providing adequate security for their system in order to guide against vandals.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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