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Comparative Evaluation of G.S.M Quality Services of Network Performance in the Nigerian Telecommunication Industry.

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Mughele, E.S. & Olatokun, W. PhD.

ABSTRACT
This study is aimed at presenting a report on the quality of services and the evaluation of GSM network performance for various locations. The indicator compares the network's capacity for calls established as against congested calls given the number of call attempts for six different locations. This is demonstrated in the ratio of the network capacity with respect to the number of call attempts, established, and congested across six distributed locations. The locations were randomly distributed; series of graphs and measurement were taken. A multi-variate analysis of variance (MANOVA), which led to the use of a non-parametric test, Kruskal-wallis H, for ranking the difference in median. The result provided comparism of the mean and the median for the optimal capacity of the attempted, established and congested calls for each location under study. This is to enable service provider determine facilities deployed to various locations, to achieve optimal performance and meet customer satisfaction.

Key words: Telecomunication, G.S.M, Teledensity, network capacity.

1. INTRODUCTION

Telecommunication infrastructure remains one of the major issues affecting technology deployment required for growth and development in Nigeria (Awe, 2007). When Nigeria gained her independence in 1960, there were only 18,724 functional telephone lines for an estimated population of 45 million, which was a "teledensity" ratio of 0.04 telephones per 100 people Mughele et al (2011). During the thirty-odd years of military rule, there was very little by way of investment in telecommunications, and other sectors did not fare any better. According to the International Telecommunication Union, by 1996 Nigeria's teledensity ratio was a mere 0.36 (Ajala 20050). It rose slightly to 0.4 by 1999; according to the Nigeria Communication Commission (NCC) (Ndukwe, 2008). Nigeria's teledensity is a far cry from the African average of 1.67. Even the NCC admits that Nigeria has had a very limited telephone network for many years, and the waiting list is estimated at over 10 million people, who have applied to the incumbent monopoly, NITEL (established in 1985) for services.

However, with the liberalization of the telecommunication industry in 2001, the story changed dramatically. The teledensity ratio had tripled within just one year of GSM operation. By May 2005 Nigeria, with an estimated population of 128,771,988, had more than 9 million GSM subscribers, making the country one of the fastest growing GSM markets in the world. At the moment, there are five GSM operators in Nigeria: MTN, GloMobile, MTEL, Airtel and Etisalat. MTN enjoys the greatest patronage, with over 4 million subscribers (Ajala 2005). It was predicted that between 2003 and 2006, Nigeria's GSM market would be Africa's fastest-growing mobile market, and this prediction had been fulfilled. The competition is getting fiercer by the day as operators have to compete desperately for the same potential subscribers.

Four years after the start of the GSM era in Nigeria, the focus is gradually shifting from providing coverage to providing quality service. Mughele et al (2011, observed that the euphoria of owning a phone set is gradually giving way to complaints of dropped calls and congestion. The operators are fast realizing that they are in a highly competitive environment where subscribers can make or break them. Dissatisfaction by subscribers give rise to a high rate of subscriber churn and low revenue for the operator. The performance of the network has a direct impact on the revenues. The NCC is putting pressure on the operators to step up the quality of services offered Nigerians and had even gone a step further to award contracts to private companies to conduct comparative analyses of the quality of service offered by each of the operators. The NCC is further threatening to sanction any operator that fails to pay attention to quality (Ndukwe, 2008).

2. RELATED LITERATURE

The GSM revolution in Nigeria started in August 2001 and brought a great change in the face of Information and Communication Technology (ICT) in the country. At the inception, the NCC licensed three major operators namely, ECONET (now Airtel), MTN, and MTEL. In year 2002 another company called GLOBACOM was licensed to provide GSM services making a total of four operators. Today MTEL is no longer in existence leaving the other three as the major operators in the country. These three major operators have been doing well relatively in the provision of voice and data communication in the country. It is therefore important for all the operators to ensure that the subscribers enjoy the best of services. One major issue is the complaints emanating from different locations of dropped calls and congestion of calls from customers. This complaint varies for the various locations at the same point in time. The challenge therefore, is that some location across the country experience high level of congestion while others are minimal based on the quality of service deployed for such locations.

2.1 Statistics and Traffic Measurement Subsystem
Base Switching Center (BSC) and Mobile Switching Center (MSC) levels to have both a local and global view of the network .Different events are counted and collected by a subsystem called the Statistics and Traffic measurement Subsystem (STS) (Adegoke and Opkeki 2010). In the BSC, these events can be handovers, call setups, dropped calls, allocation of different channels, etc. There are also a number of status counters, reporting the status of equipment within the network, such as the current number of occupied channels. By continuously supervising the results from STS, the operator can obtain a very good overview of the radio network performance, which can help detect problems early. The balance of the capacity of these interfacing devices and the demand from subscribers determine the condition of congestion (Mughele at el 2012).

The cost of building a base station and its maintenance is very high, so the operators have to buy the land, antennae, transmitters, generators and employ security personnel to prevent vandalisation, before a base station site can stand. In the course of time and as the number of subscribers had grown beyond the capacity of the present cell and there is need for cell expansion or division, the operators will only need to inform the organization that is providing them with the infrastructures for the need of expansion

3. RESEARCH DESIGN

3.1 Unstructured Interview
An unstructured interview was conducted at the MTN national networking headquarters. Information was obtained from the radio frequency analyzer manager and the network geographic manager. The data logging system was also observed. Data integrity is assured by using data obtained from MTN data logging system (Mughele et al 2012).

3.2 Sampling Techniques
The study adopted the existing strata, already in existence, the six geo-political zones in Nigeria. Six different locations were randomly selected as a representative of the entire Population. These locations are Lagos, Enugu, Port-Harcourt, Kano, Yola, and Abuja. A performance evaluation was conducted to compare and evaluate the quality of services deployed (Mughele et al 2011).

3.3 Research Hypothesis
H_0 There is no significant difference between Total Call attempts, Total call established and Total call congested on system capacity of the network based on location
H_1 There is a significant difference between Total Call attempts, Total call established and Total call congested on system capacity of the network based on location

4. DATA ANALYSIS
A multivariate analysis of variance (MANOVA) was conducted to compare the means for attempted calls, established and congested call for a period of 91 days, for the randomly selected location. Since the data did not meet all the normality conditions for (MANOVA), an equivalent non-parametric test was conducted.

Adopting Kruskal-Wallis H to compare the median of the various levels of calls for all six locations to determine the quality of service and performance of network capacity. This test was conducted using Statistical Package for the Social Sciences (SPSS).

4.1 Data Analysis and Interpretation
Assumptions

- One independent variable consists of **two or more categorical independent groups**.The independent variables are the locations Lagos, Yola, P.H., Abuja, Kano and Enugu, Represented as 1, 2, 3, 4, 5 and 6 respectively.
- Two or more dependent variables those are (**continuous**). The dependent variables are call attempted, call established and call congested.
- Multivariate Normality. The distribution is not normal. A Kruskal-Wallis**non-parametric** test will be most appropriate.

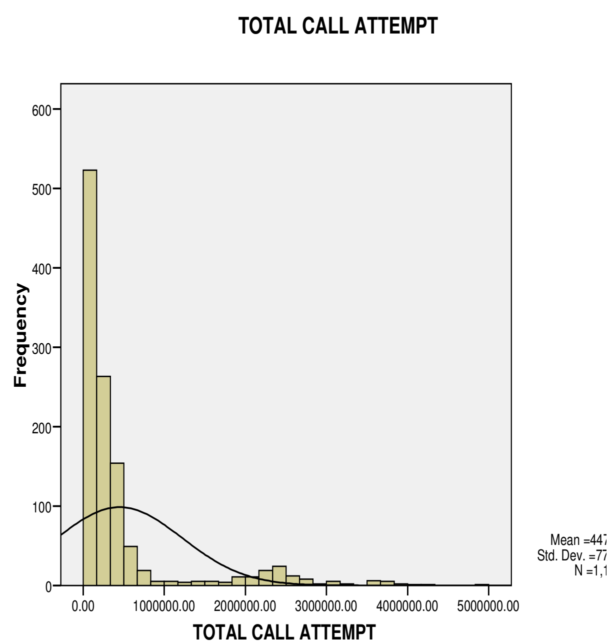

Fig.1. Graph Total calls Attempted for six locations - Total Call Attempt with distribution skewed to the left

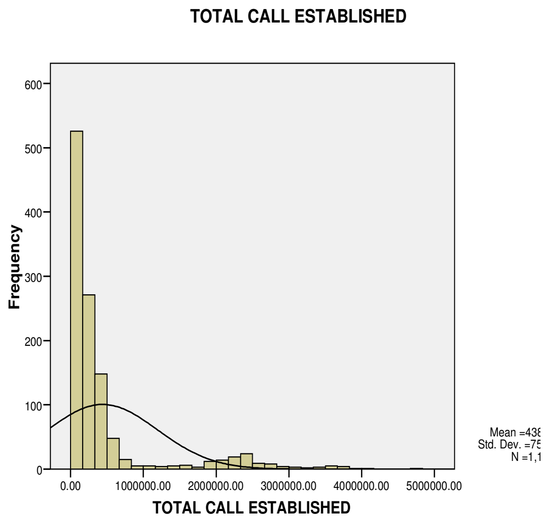

Fig. 2. Graph Total calls Established for six location Total Call established with distribution skewed to the left

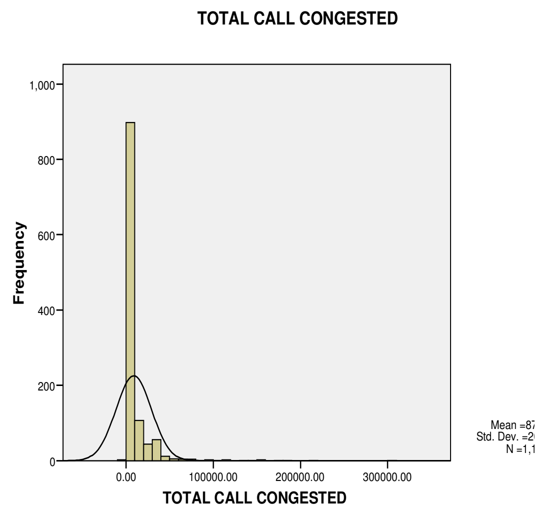

Fig. 3. Graph Total calls Congested for six location Total Call Congested with an approximately normal distribution

Table.1: Kruskal-Wallis Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
TOTAL CALL ATTEMPT	1146	447551.6414	773029.01683	.00	4964612.00
TOTAL CALL ESTABLISHED	1146	438764.9415	756443.39793	.00	4778622.00
TOTAL CALL CONGESTED	1146	8787.3874	20300.42356	-2.00	301888.00
LOCATION FROM WHERE DATA COLLECTED	1146	3.50	1.709	1	6

Table 2: Kruskal-Wallis Ranks

	LOCATION FROM WHERE DATA COLLECTED	N	Mean Rank
TOTAL CALL ATTEMPT	LAGOS	191	923.88
	YOLA	191	236.26
	PORT-HARCOURT	191	612.48
	ABUJA	191	655.99
	KANO	191	508.14
	ENUGU	191	504.25
	Total	1146	
TOTAL CALL ESTABLISHED	LAGOS	191	924.71
	YOLA	191	235.12
	PORT-HARCOURT	191	613.75
	ABUJA	191	659.70
	KANO	191	507.55
	ENUGU	191	500.18
	Total	1146	

	LOCATION FROM WHERE DATA COLLECTED	N	Mean Rank
TOTAL CALL CONGESTED	LAGOS	191	877.47
	YOLA	191	308.60
	PORT-HARCOURT	191	564.97
	ABUJA	191	462.76
	KANO	191	601.82
	ENUGU	191	625.38
	Total	1146	

Table 3: Kruskal-Wallis Test Statistics (a,b)

	Total Call Attempt	Total Call Established	Total Call Congested
Chi-Square	442.706	447.469	311.070
Df	5	5	5
Asymp. Sig.	.000	.000	.000

a Kruskal Wallis Test
b Grouping Variable:

5. LOCATION FROM WHERE DATA COLLECTED

The Ranks table show the mean rank of call attempts, call established and call congested for each location group. The Test Statistics table presents the Chi-square value (Kruskal-Wallis H), the degrees of freedom and the significance level.

Output of the Kruskal-Wallis
There was a **statistically significant difference** from the location from where data was collected.

CALL ATTEMPT
(H(5) = 442.706, **P** < 0.05) with a mean rank for LAGOS 923.88, ABUJA 655.99, PORT-HARCOURT 612.48,KANO 508.14, ENUGU 504.25 and YOLA 236.26.

CALL ESTABLISHED
(H(5) = 447.469, **P** < 0.05) with a mean rank for LAGOS 924.71, ABUJA 659.70, PORT-HARCOURT 613.75, KANO 507.55, ENUGU 500.18 and YOLA 235.12

CALL CONGESTED
(H(5) = 311.070, **P** < 0.05) with a mean rank for LAGOS 877.47, ENUGU 625.38, KANO 601.82, PORT-HARCOURT 564.97, ABUJA 462.76, YOLA 308.60

Therefore we accept the alternative hypothesis and reject the null hypothesis. This implies that there is a significant difference between Total Call attempts, Total call established and Total call congested on system capacity of the network based on location. This shows that the capacity of BTS, BSC, BSC and other telecommunication facilities deployed to each of the location by MTN service provider are not the same. It could be based on the number of calls emanating from such location. However, call congested showing disparity in the locations mean rank with equipment deployed.

With Lagos having the highest congestion, Yola has the least congestion and Enugu has the second highest congestion may be due to the business activities, even when the population is lower than Kano and Port-Harcourt.

The one-way MANOVA is used to determine whether there are any differences between independent groups on more than one continuous dependent variable. In this regard, it differs from a one-way ANOVA only in measuring more than one dependent variable at the same time, unlike the one-way ANOVA that only measures one dependent variable.

5.1 Assumptions

- One independent variable consists of **two or more categorical independent groups**.The independent variables are locations which are Lagos, Yola, P.H., Abuja, Kano and Enugu, Represented as 1, 2, 3, 4, 5 and 6 respectively
- Two or more dependent variables which, are (**continuous**). The dependent variables are call attempted, call established and call congested.
- Multivariate Normality. We assume normal
- Equality of variances between the independent groups (**homogeneity of variances**).Levene's **F** Statistic has a significance value of (p<0.05)=0.000 therefore, the assumption of homogeneity of variance is not met for TOTAL CALL ATTEMPT, TOTAL CALL ESTABLISHED and TOTAL CALL CONGESTED. This would mean that we do not have similar variances.

Table 4 : Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
TOTAL CALL ATTEMPT	370.933	5	1140	.000
TOTAL CALL ESTABLISHED	382.401	5	1140	.000
TOTAL CALL CONGESTED	78.801	5	1140	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a Design: Intercept+LOCATION

Table 5 : Tests of Between-Subjects Effects

Source	Dependent Variable	Df	F	Sig.	Partial Eta Squared
LOCATION	TOTAL CALL ATTEMPT	5	299.732	.000	.568
	TOTAL CALL ESTABLISHED	5	304.373	.000	.572
	TOTAL CALL CONGESTED	5	92.151	.000	.288

a Computed using alpha = .05
b R Squared = .568 (Adjusted R Squared = .566)
c R Squared = .572 (Adjusted R Squared = .570)
d R Squared = .288 (Adjusted R Squared = .285)

There was a statistically significant effect on TOTAL CALL ATTEMPT (**F** (5, 1140) = 299.732; **P** < .05), TOTAL CALL ESTABLISHED (**F** (5, 1140) = 304.373; **P** < .05) and TOTAL CALL CONGESTED (**F** (5, 1140) = 92.151; **P** < .05). As such, we accept the alternative hypothesis at **P** < .05. Implying that there is a significant effect due attempted, established and congested calls for each of the locations.

Table 6: Multiple Comparisons

Tukey HSD

Dependent Variable	(I) LOCATION FROM WHERE DATA COLLECTED	(J) LOCATION FROM WHERE DATA COLLECTED	Mean Difference (I-J)	Sig.
TOTAL CALL ATTEMPT	LAGOS	YOLA	1713824.2408(*)	.000
		PORT-HARCOURT	1455582.8796(*)	.000
		ABUJA	1441245.5393(*)	.000
		KANO	1561147.4921(*)	.000
		ENUGU	1549116.1885(*)	.000
	YOLA	LAGOS	-1713824.2408(*)	.000
		PORT-HARCOURT	-258241.3613(*)	.000
		ABUJA	-272578.7016(*)	.000
		KANO	-152676.7487(*)	.040
		ENUGU	-164708.0524(*)	.020
	PORT-HARCOURT	LAGOS	-1455582.8796(*)	.000
		YOLA	258241.3613(*)	.000
		ABUJA	-14337.3403	1.000
		KANO	105564.6126	.328
		ENUGU	93533.3089	.469
	ABUJA	LAGOS	-1441245.5393(*)	.000
		YOLA	272578.7016(*)	.000

Dependent Variable	(I) LOCATION FROM WHERE DATA COLLECTED	(J) LOCATION FROM WHERE DATA COLLECTED	Mean Difference (I-J)	Sig.
		PORT-HARCOURT	14337.3403	1.000
		KANO	119901.9529	.194
		ENUGU	107870.6492	.304
	KANO	LAGOS	-1561147.4921(*)	.000
		YOLA	152676.7487(*)	.040
		PORT-HARCOURT	-105564.6126	.328
		ABUJA	-119901.9529	.194
		ENUGU	-12031.3037	1.000
	ENUGU	LAGOS	-1549116.1885(*)	.000
		YOLA	164708.0524(*)	.020
		PORT-HARCOURT	-93533.3089	.469
		ABUJA	-107870.6492	.304
		KANO	12031.3037	1.000
TOTAL CALL ESTABLISHED	LAGOS	YOLA	1681931.6178(*)	.000
		PORT-HARCOURT	1427703.0366(*)	.000
		ABUJA	1410534.5759(*)	.000
		KANO	1533588.0366(*)	.000
		ENUGU	1524504.4764(*)	.000
	YOLA	LAGOS	-1681931.6178(*)	.000
		PORT-HARCOURT	-254228.5812(*)	.000
		ABUJA	-271397.0419(*)	.000
		KANO	-148343.5812(*)	.041
		ENUGU	-157427.1414(*)	.024
	PORT-HARCOURT	LAGOS	-1427703.0366(*)	.000
		YOLA	254228.5812(*)	.000
		ABUJA	-17168.4607	.999
		KANO	105885.0000	.295
		ENUGU	96801.4398	.398
	ABUJA	LAGOS	-1410534.5759(*)	.000
		YOLA	271397.0419(*)	.000
		PORT-HARCOURT	17168.4607	.999
		KANO	123053.4607	.149
		ENUGU	113969.9005	.218
	KANO	LAGOS	-1533588.0366(*)	.000
		YOLA	148343.5812(*)	.041
		PORT-HARCOURT	-105885.0000	.295
		ABUJA	-123053.4607	.149
		ENUGU	-9083.5602	1.000
	ENUGU	LAGOS	-1524504.4764(*)	.000
		YOLA	157427.1414(*)	.024
		PORT-HARCOURT	-96801.4398	.398
		ABUJA	-113969.9005	.218
		KANO	9083.5602	1.000
TOTAL CALL CONGESTED	LAGOS	YOLA	31892.6230(*)	.000
		PORT-HARCOURT	27875.7173(*)	.000
		ABUJA	30710.9634(*)	.000
		KANO	27559.4555(*)	.000

Dependent Variable	(I) LOCATION FROM WHERE DATA COLLECTED	(J) LOCATION FROM WHERE DATA COLLECTED	Mean Difference (I-J)	Sig.
	YOLA	ENUGU	24611.7120(*)	.000
		LAGOS	-31892.6230(*)	.000
		PORT-HARCOURT	-4016.9058	.200
		ABUJA	-1181.6597	.985
		KANO	-4333.1675	.135
	PORT-HARCOURT	ENUGU	-7280.9110(*)	.001
		LAGOS	-27875.7173(*)	.000
		YOLA	4016.9058	.200
		ABUJA	2835.2461	.590
		KANO	-316.2618	1.000
	ABUJA	ENUGU	-3264.0052	.429
		LAGOS	-30710.9634(*)	.000
		YOLA	1181.6597	.985
		PORT-HARCOURT	-2835.2461	.590
		KANO	-3151.5079	.470
	KANO	ENUGU	-6099.2513(*)	.007
		LAGOS	-27559.4555(*)	.000
		YOLA	4333.1675	.135
		PORT-HARCOURT	316.2618	1.000
		ABUJA	3151.5079	.470
	ENUGU	ENUGU	-2947.7435	.547
		LAGOS	-24611.7120(*)	.000
		YOLA	7280.9110(*)	.001
		PORT-HARCOURT	3264.0052	.429
		ABUJA	6099.2513(*)	.007
		KANO	2947.7435	.547

Based on observed means.
** The mean difference is significant at the .05 level.*

The multiple Comparisons table above shows that for TOTAL CALL ATTEMPT were statistically significantly different for all cases but not between PORT-HARCOURT and ABUJA (P = 1.000), PORT-HARCOURT and KANO (P = .328), PORT-HARCOURT and ENUGU (P = .469),

ABUJA and KANO (P = .194), ABUJA and ENUGU (P = .304) and KANO and ENUGU (P = 1.000).

The multiple Comparisons table above shows that for TOTAL CALL ESTABLISHED were statistically significantly different for all cases but not between PORT-HARCOURT and ABUJA (P = .999), PORT-HARCOURT and KANO (P = .295), PORT-HARCOURT and ENUGU (P = .389), ABUJA and KANO (P = .149), ABUJA and ENUGU (P = .218) and KANO and ENUGU (P = 1.000).

The multiple Comparisons table above shows that for TOTAL CALL CONGESTED were statistically significantly different for all cases but not between YOLA and PORT-HARCOURT (P = .200), YOLA and ABUJA (P = .985), YOLA and KANO (P = .135), PORT-HARCOURT and ABUJA (P = .590), PORT-HARCOURT and KANO (P = 1.000), PORT-HARCOURT and ENUGU (P = .429), ABUJA and KANO (P = .470) and KANO and ENUGU (P = .547).

These differences can be easily visualised by the plots generated by this procedure, as shown below:

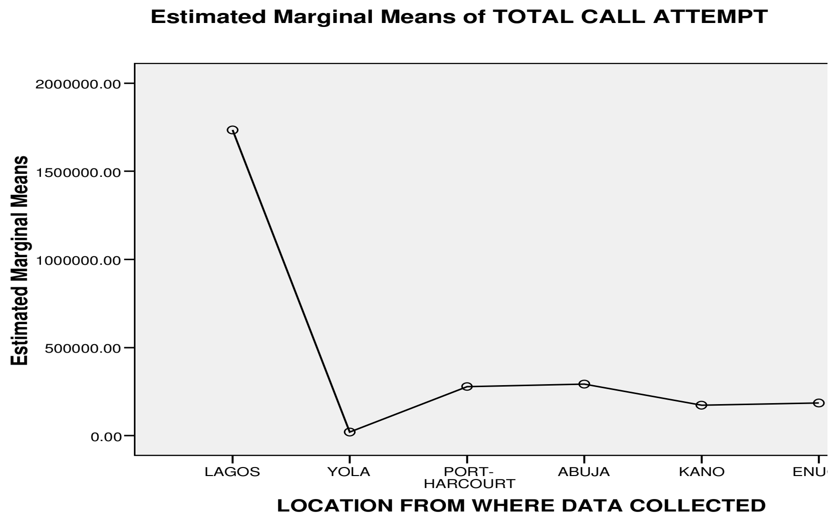

Fig 4

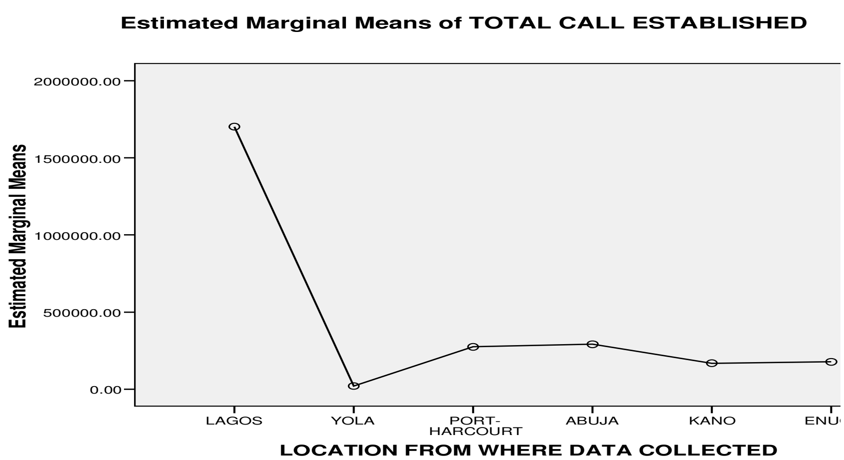

Fig. 5

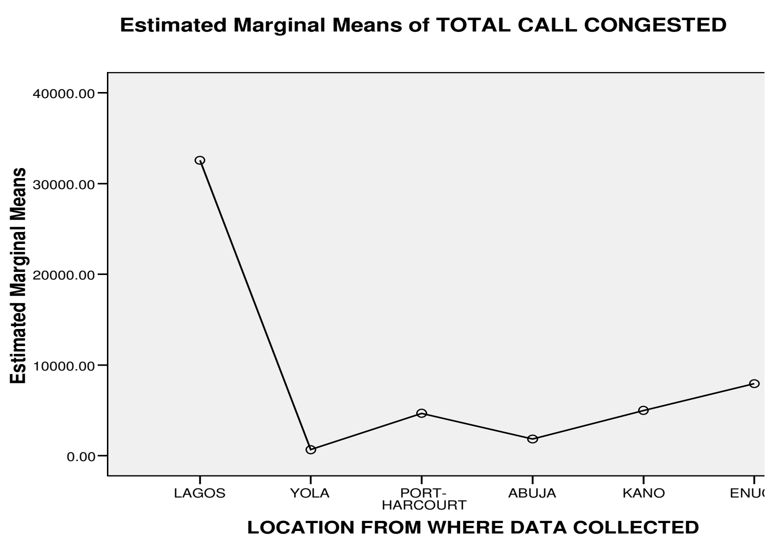

Table 7

Table 7: TOTAL CALL ATTEMPT
Tukey HSD

LOCATION FROM WHERE DATA COLLECTED	N	Subset		
	1	2	3	1
YOLA	191	20546.7906		
KANO	191		173223.5393	
ENUGU	191		185254.8429	
PORT-HARCOURT	191		278788.1518	
ABUJA	191		293125.4921	
LAGOS	191			1734371.0314
Sig.		1.000	.194	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares

The error term is Mean Square (Error) = 259306484233.093.

a Uses Harmonic Mean Sample Size = 191.000.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c Alpha = .05.

Table 8: TOTAL CALL ESTABLISHED
Tukey HSD

LOCATION FROM WHERE DATA COLLECTED	N	Subset		
	1	2	3	1
YOLA	191	19876.9476		
KANO	191		168220.5288	
ENUGU	191		177304.0890	
PORT-HARCOURT	191		274105.5288	
ABUJA	191		291273.9895	
LAGOS	191			1701808.5654
Sig.		1.000	.149	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares

The error term is Mean Square(Error) = 246134517783.009.

a Uses Harmonic Mean Sample Size = 191.000.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c Alpha = .05.

Table 9: TOTAL CALL CONGESTED

Tukey HSD

LOCATION FROM WHERE DATA COLLECTED	N	Subset		
	1	2	3	1
YOLA	191	669.8429		
ABUJA	191	1851.5026		
PORT-HARCOURT	191	4686.7487	4686.7487	
KANO	191	5003.0105	5003.0105	
ENUGU	191		7950.7539	
LAGOS	191			32562.4660
Sig.		.135	.429	1.000

Means for groups in homogeneous subsets are displayed.

Based on Type III Sum of Squares

The error term is Mean Square(Error) = 294775571.216.

a Uses Harmonic Mean Sample Size = 191.000.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c Alpha = .05.

6. CONCLUSION

Higher quality in a GSM service operation is achievable but only through fast and accurate network optimization. Using GIS in standard network monitoring tools are known to reduce the stress of the quality-monitoring engineer and increase productivity by more than 70%. The task of GSM network optimization is highly complex and specialized, but it is also a task with enormous potential rewards, as each incremental improvement in system performance can translate to huge cost savings and increased revenues for the operator. It was observed that these network operators need to improve the quality of service offered to their teeming customers. The study also shows that the congestion rate for Lagos is the highest followed by Enugu, and Yola had the least congestion experience. Redirection of call can be considered and proper study of the location conducted to determine deployment of network facilities in order to improve customer satisfaction.

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