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Modeling and Characterization of Next Generation Network in a Developing Economy: From Data Collection to Estimation of Traffic Parameters

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ABSTRACT: *The accurate estimation of the traffic parameters, especially traffic intensity that the network must support is a key criterion in the development of an effective Next Generation Network (NGN) model. In this paper, starting from data collection involving users of telecommunication services in Benue State, Nigeria, the call rate, data transaction rate, call holding times/data transaction time and traffic intensity have been estimated at the 23 local government headquarters of the State. The existing network in Benue State is GSM based and the services provided are Voice, SMS and Internet. A marketing research was first conducted to determine the level of services usage by the amount of money spent by the high, middle and low income earners. Then using the prevailing tariff rates, the amount of data transferred in bits for the three classes of services were determined. The traffic model used is based on a probabilistic model of events initiated by calls and transactions of NGN services. The model is used to estimate the symmetrical and asymmetrical traffic intensities separately at each of the 23 headquarters representing the network nodes. Generally, the results of the study show that a developing country is characterized by a prevalence of voice and SMS services, and limited Internet services; large number of low income earners; and low rates of call/data transactions and traffic intensities. The study demonstrates a method to estimate traffic parameters at different network nodes starting from subscriber field studies. The use of the method will facilitate the preparation of both business and technical plans for effective and efficient planning and dimensioning of NGN networks in a developing economy.*

Keywords - *Developing Economy, Gini Coefficients, Next Generation Network, Probabilistic Model, Symmetrical and Asymmetrical Traffic Intensity*

I. INTRODUCTION

The aim of telecom operators (fixed and mobile) around the world is to migrate their networks to NGN in order to benefit from the NGN features as well as to avoid the drawbacks coming from their legacy networks, beside the financial factors such as reducing the capital expenditure (CAPEX) and the operation expenditure (OPEX) [1], [2], [3], [4]. The reduction of CAPEX and OPEX together with the guarantee for delivery of high quality of services can be achieved by careful data collection and estimation of traffic parameters [3], [5], [6]. Network dimensioning entails the estimation of the needed resources and requirements such as traffic intensity, bandwidth, number of links, number of interfaces (E1s), e.t.c., which help to determine the needed quantities of equipment for the network [3], [5]. Especially, the accurate estimation of the traffic intensity that the network must support is quintessential for efficient network modeling and dimensioning [7], [8].

Under the cap-and-replace scenario, for the migration of PSTN to NGN, when NGN equipment coexists with PSTN equipment, traffic measurements are usually made of the existing network and the values obtained may be used for dimensioning purposes. This cannot be the case in a replace-and-grow scenario which characterizes the design of the NGN architecture of a typical developing economy, whereby the existing PSTN is completely dispensed with [9]. Ostensibly, this situation requires the application of traffic modeling methods for which there are no historical data. Some of the commonly employed techniques for forecasting of telecommunications services for which there are no historical data are market research, expert opinion and sectorial econometrics [8], [10]. One traffic modeling methodology that incorporates the above-mentioned techniques is the probabilistic model of events initiated by calls of NGN services [11].

In this paper, starting from data collection involving users of telecommunication services in Benue State, Nigeria, the rate of calls and data transactions, call holding times, and traffic intensities have been estimated at the 23 local government headquarters of the State. A marketing research was first conducted to determine the level of services usage by amount of money spent by the high, middle and low income earners. Then using the prevailing tariff rates, the amount of data transferred in bits for the different services were determined.

In the classic work of A. Krendzel et al [11], symmetrical and asymmetrical subsets of services could be decomposed into as much as three classes each, including voice, data, video and multimedia services. However, the existing network in Benue State is GSM based and the NGN services provided are mainly voice, and data services comprised mainly of text messages and internet browsing. Hence the Benue State NGN is modeled with voice based services (belonging to symmetrical subset) and designated as class 1, and SMS and Internet services (belonging to asymmetrical subset) and designated as class 1 and class 2 respectively. Then, using the procedures of the probabilistic model, the symmetrical and asymmetrical traffic intensities are estimated separately at each of the 23 headquarters representing the network nodes. The values of the traffic intensities are significant for the capacity planning and dimensioning of NGN network in a developing economy.

The rest of the paper is organized as follows: Section 2 describes the decomposition of NGN services. This is followed by a discussion in section 3 about the distribution of NGN users. Section 4 is about the estimation of the rate of calls and data transactions. In section 5, the procedure for the estimation of the traffic intensity is outlined; while section 6 presents data collection and analysis. Lastly, in section 7, is the conclusion.

II. DECOMPOSITION OF NGN SERVICES

The probabilistic model enables estimating the main parameters for symmetrical and asymmetrical traffic separately depending on the NGN services generating the traffic. In this case, NGN services are decomposed into some classes, and the potential users distributed into some subgroups.

Firstly, a set of NGN services is divided into two subsets with each of the subset divided into different classes in accordance with features of the generated traffic intensity. The subsets and classes of services are as follows.

2.1 First Subset

These are services concerning the real-time establishment of connectivity between endpoints. These are characterized by the transfer of the symmetrical traffic and the strict control of Quality of Service (QoS). This subset is made up of the following classes of services [11]:

2.1.1 Traditional Telephony

On the provision of such services, network equipment should support the transfer of the bidirectional flow with the rate of 64 kbit/s.

2.1.2 Video Telephony

On the provision of video telephony, it is necessary to support the transfer of bidirectional E1 flow from network equipment with a throughput of 2048kbit/s.

2.1.3 Other Services

These are other services that require support of the transfer of some bidirectional E1 flows from network equipment.

2.2 Second Subset

These are services that generate the asymmetrical traffic. This subset is made up of the following classes of services:

2.2.1 E-mails, Web-pages, etc

These are services that deal with the transfer of a small amount of information about 1 kbit/transaction on average.

2.2.2 Texts, Small Amount of Audio and Visual Information

This class is characterized by the transfer of information of about 100 kbits per transaction on average.

2.3 Multimedia Services

These are services that deal with the transfer of information of about 10 Mbit/transaction on average.

In the classic work of A. Krendzel et al [11], symmetrical and asymmetrical subsets could be decomposed into as much as three classes each, including video and multimedia services. However, in the Benue State situation, the NGN services used as shown by the marketing research are voice calls, SMS and Internet. Hence the voice based services will be designated as class 1 belonging to the symmetrical subset, SMS services as class 1 belonging to the asymmetrical subset and Internet as class 2 also belonging to the asymmetrical subset.

III. DISTRIBUTION OF NGN USERS

The demand for NGN services depends on both the solvency of users and tariffs on the services. Since it is supposed that the tariffs on the aforementioned different classes of services will be unequal, then a non-uniformity of distribution of services between users will exist for each class. In order to take into account this fact when estimating parameters of data traffic, it is worthwhile to distribute all NGN users into some subgroups in accordance with their demand for NGN services from the different classes. Parameters of the non-uniformity of the distribution of NGN services for each class may be considered as the input data. Usually the non-uniform distribution of incomes between inhabitants is characterized by the Gini coefficients in statistics [11]. Values of the Gini coefficients may be defined on a basis of statistical information regarding the demand for NGN services [11].

Given the values of Gini coefficients, users may be distributed in accordance with their demand for NGN services [11]. In this case, the users are distributed into three subgroups and considering that only two classes of services are used and designated as class 1 and class 2 as stated earlier, the procedures are as follows:

Let the income group, F_i(i=1, 2, 3) produce the highest say A% of demand for NGN services from the second class of services. The relative number of users, say in the high income group, is determined as follows:

$$F_3 = (A\%)^{\left(\frac{\alpha_2}{\alpha_2 - 1}\right)} \quad (1)$$

Where $\alpha_i (i = 1, 2, 3)$are parameters of Pareto distribution derived from the Gini coefficients.

Then let users of a second subgroup create the highest B% and the above-considered subgroup (i.e. the high income group) create C% of demand for NGN services from the first class. Then the users from these two subgroups will create (B+C)% of demand for NGN services from the first class. Then the relative number of users in the second subgroup is determined as:

$$F_2 = [(C + B)\%]^{\left(\frac{\alpha_1}{\alpha_1 - 1}\right)} - F_3 \quad (2)$$

Finally, the relative number of users in the remaining subgroup may be found as:

$$F_1 = 1 - F_2 - F_3 \quad (3)$$

In Benue State, majority of the local areas use only one class of services for each of the symmetrical and asymmetrical subsets so the application of the above procedure in such cases involve only one class separately.

IV. ESTIMATION OF THE RATE OF CALLS AND DATA TRANSACTIONS

The decomposition of NGN services and the distribution of NGN users give the possibility to form the probabilistic model of the initiation of the calls and data transactions based on the intersection of events from two statistically independent exhaustive groups.

Let the events included in the first group be denoted by $i = 1, 2, 3$; they correspond with demand for services from the first, second, and third classes respectively. And the events included in the second group are denoted $j = 1, 2, 3$; they correspond with demands initiated by users from the low income, middle income and high income subgroups respectively. Since these groups of events are independent, the probability of an intersection of the events is equal to the product of probabilities of each of the events [11].

The procedure for the calculation of the specific rate of calls and data transactions (λ_{ij}) per user between nodes of an NGN network subsystem in busy hour for the nine ($i, j = 1, 2, 3$) intersections of events from the two above-mentioned groups of events is outlined by the following equations [11]. It is based on the solution of three systems of equations that are formed for each of the classes of NGN services.

The solution will yield the values for λ_{ij} when i =1, and $j = 1, 2, 3$ as follows:

$$\lambda_{12} = \frac{\lambda_{11} Q_{12} F_1}{Q_{11} F_2}$$
$$\lambda_{13} = \frac{\lambda_{11} Q_{13} F_1}{Q_{11} F_3} \qquad (4)$$

Where $Q_{ij}(i, j = 1, 2, 3)$ represents the share of calls and transactions in busy hour, relating to users of low income, middle income and high income subgroups respectively when services from first and second classes respectively are initiated; where the value, λ_{11} is included in the input data.

It can be readily seen that (4) apply ideally to our case study, since i =1 in majority of the local government areas, and the different income groups are also three.

In order to find the family of solutions when $i = 2$, 3 and $j = 1, 2, 3$, the input data defined in (5) is used.

$$\gamma_i,\ i = 1, 2, 3,\ \gamma_1 + \gamma_2 + \gamma_3 = 1, \qquad (5)$$

where γ_i is the distribution of total amount of transaction in busy hour amongst the different classes i.

The solutions are given as follows:

$$\lambda_{ij} = \frac{\gamma_i \sum_j \lambda_{1j} F_j}{\gamma_1 F_j};\quad i = 2, 3;\ j = 1, 2, 3 \qquad (6)$$

It is also easy to apply (6) to suit our case study by simply setting $i = 2$; $j = 1, 2, 3$ since, in this case, there are only up to two classes of services.

V. ESTIMATION OF THE TRAFFIC INTENSITY

In order to calculate the traffic intensity in Erlangs generated on network nodes in Benue State, it is necessary to determine the average call holding time and the average transaction time T_i (i =1, 2) corresponding to procedures of NGN services supported by the above-mentioned classes of symmetrical and asymmetrical services. This is also an application of the probabilistic model in line with our case study.

For the symmetrical subset of services, that is, voice calls, characterized by strict control of Quality of Service (QoS), the values of T_i (i =1, 2) are assigned on the basis of statistical information.

The traffic intensity per user generated by calls of NGN services belonging to the ith class if they are initiated by users from the jth subgroup is obtained as follows [11]:

$$A_{ij} = \frac{\lambda_{ij} T_i}{3600} \qquad i = 1;\ j = 1, 2, 3 \qquad (7)$$

Therefore, the traffic intensity, from all the users may be determined as:

$$A_i = \frac{T_i \sum_j F_j \lambda_{ij}}{3600};\quad i = 1;\ j = 1, 2, 3 \qquad (8)$$

Therefore, the total traffic intensity created by NGN services on channels with the throughput c_i, from the first subset may be found as:

$$A_s = \frac{\sum c_i A_i}{c_2} \qquad i = 1 \qquad (9)$$

The average transaction time corresponding to procedures of NGN services from the asymmetrical subset is:

$$T_i = \frac{w_i}{c_i},\ \text{sec/trans} \qquad i = 1, 2 \qquad (10)$$

Where w_i is the average amount information transferred during a transaction to be assigned on the basis of statistical data.

The value of c_2 in (9) is chosen as 2048 kbits/s for the basic channel, E1, with regard to the level of demand for NGN services. The values of $c_i(i = 1, 2)$ are chosen as c_1= 64 kbits/s for voice calls and text messages (SMS), and c_2 = 2048 kbits/s for Internet.

The traffic intensity generated per user by NGN services belonging to the ith class, if they are initiated by users from the jth subgroup is obtained as follows:

$$A_{ij} = \frac{\lambda_{ij} T_i}{3600} \qquad i = 1, 2; \quad j = 1, 2, 3 \qquad (11)$$

The traffic intensity created by transactions from the asymmetrical subset of NGN services that are initiated by all users may be found as:

$$A_i = \frac{T_i \sum_j F_j \lambda_{ij}}{3600}; \quad i = 1, 2; \quad j = 1, 2, 3 \qquad (12)$$

Therefore, the expression for the estimation of the total traffic intensity created by NGN services from the second subset (the asymmetrical load) on channels with the throughput c_i, is:

$$A_a = \frac{\sum c_i A_i}{2048} \qquad i = 1, 2 \qquad (13)$$

Finally, the total traffic intensity generated by NGN services on some E1 channels is:

$$A_T = A_s + A_a \qquad (14)$$

VI. DATA COLLECTION AND ANALYSIS

The data collection methodology was a marketing research carried out in the 23 local government headquarters of Benue State, conducted with oral interviews and filling of questionnaires. The result of the survey gave the distribution of the demand for NGN services into symmetrical (voice) and asymmetrical (SMS and Internet) services, and users into high, medium and low income groups. A total number of one hundred inhabitants were involved in each local government area. The results are shown in Table 1 and graphically in Fig. 1. The results show the preponderance of voice and SMS services in the State. It can be seen that 100 % of the inhabitants use Voice and SMS services in the 23 and 6 local government areas respectively. The Internet services are used in only 5 local government areas each having less than 100 % of users as depicted in Table 1 and Fig. 1. Also notice that the low income users are more in number followed by the middle income users for all the three classes of services, except Internet which has the highest number of users in the middle income group. This shows that the high income group has the least number of users of NGN services in Benue State.

For the purpose of this analysis, voice based services will be designated as class 1 belonging to the symmetrical subset, SMS services as class 1 belonging to the asymmetrical subset and Internet services as class 2 also belonging to the asymmetrical subset.

Table 2 shows the distribution of demand for NGN services by total amount of data in megabits transferred in busy hour for each class of services. The calculation of the values was based on the cost of 1 kilobit of data at the rate of 5 Kobo (approximately 0.05 Cents) charged by GSM operators in Benue State. The demand trend is shown graphically in Fig. 2. It is clear that the demand for voice services is somewhat the highest throughout the State with Internet services having the highest demand in Makurdi, the State capital, followed by the main cities of Otukpo, Gboko, Oju and Katsina-Ala. The SMS services generally have the least demand.

Table I: Distribution of Demand for Each Class of NGN Services by Number of Inhabitants into High, Medium and Low Income Groups

S/N	*LOCAL GOVERNMENT*	*SYMMETRICAL SERVICES: VOICE*	*ASYMMETRICAL SERVICES: SMS*	*ASYMMETRICAL SERVICES: INTERNET*

	HEADQUARTERS	High Income Group %	Middle Income Group %	Low Income Group %	Total %	High Income Group %	Middle Income Group %	Low Income Group %	Total %	High Income Group %	Middle Income Group %	Low Income Group %	Total %
1	Igumale	11	41	48	100	11	38	30	79	0	0	0	0
2	Obagaji	9	36	55	100	9	36	45	90	0	0	0	0
3	Ugbokpo	8	34	58	100	8	34	44	86	0	0	0	0
4	Buruku	8	38	54	100	8	37	44	89	0	0	0	0
5	Gboko	20	37	43	100	20	37	38	95	20	31	26	77
6	Gbajimba	8	30	62	100	8	30	45	83	0	0	0	0
7	Aliade	12	37	51	100	12	37	39	88	0	0	0	0
8	Naka	9	29	62	100	9	29	47	85	0	0	0	0
9	Katsina-Ala	14	38	48	100	14	38	48	100	13	37	18	68
10	Tse-Agberagba	10	33	57	100	10	33	57	100	0	0	0	0
11	Adikpo	12	33	55	100	12	33	55	100	0	0	0	0
12	Ugba	11	40	49	100	11	40	31	82	0	0	0	0
13	Makurdi	26	38	36	100	26	38	36	100	26	37	29	92
14	Obarike-Ito	10	34	56	100	10	34	45	89	0	0	0	0
15	Otukpa	13	30	57	100	13	30	38	81	0	0	0	0
16	Idekpa	10	35	55	100	10	34	41	85	0	0	0	0
17	Oju	13	40	47	100	13	40	38	91	13	33	16	62
18	Okpoga	12	33	55	100	12	29	33	74	0	0	0	0
19	Otukpo	19	41	40	100	19	41	40	100	17	39	19	75
20	Wannune	9	28	63	100	9	28	56	93	0	0	0	0
21	Sankera	10	30	60	100	10	30	38	78	0	0	0	0
22	Lessel	8	25	67	100	8	24	48	80	0	0	0	0
23	Vandeikya	14	35	51	100	14	35	51	100	0	0	0	0
	Mean	**12**	**35**	**53**	**100**	**12**	**34**	**43**	**89**	**18**	**35**	**22**	**75**

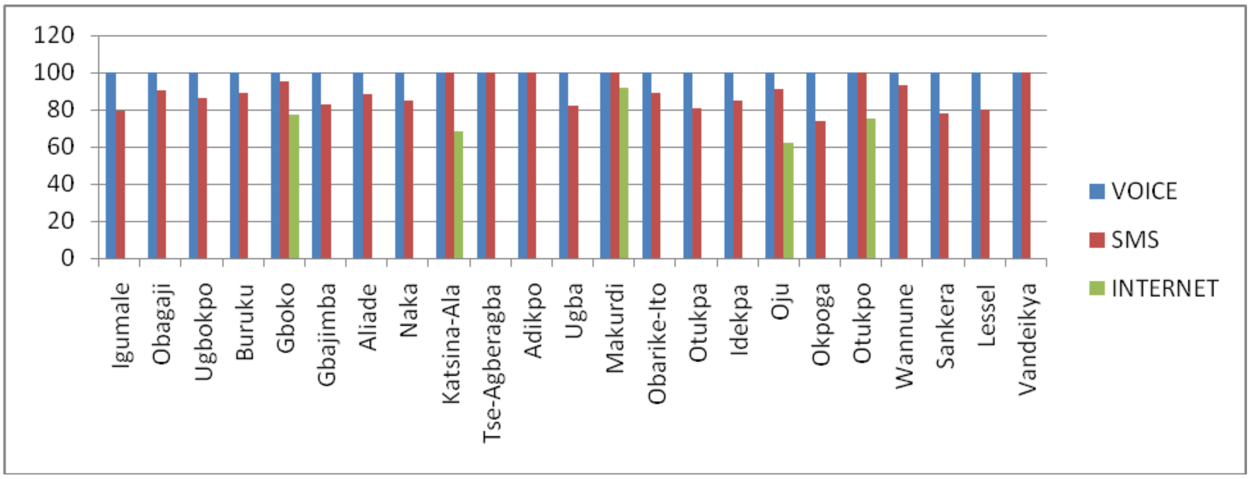

Figure 1: distribution of demand for each class of NGN services by the total number of inhabitants in the high, medium and low income groups

Table II: Distribution of Demand for Each Class of NGN Services by Total Amount of Data Transferred in Busy by the High, Medium and Low Income Groups

S/N	*LOCAL GOVERNMEN*	*VOICE Megabits*	*SMS Megabits*	*INTERNET Megabits*

	T HEADQUARTERS	High Income Group	Middle Income Group	Low Income Group	Total	High Income Group	Middle Income Group	Low Income Group	Total	High Income Group	Middle Income Group	Low Income Group	Total
1	Igumale	132	160	71	363	6.4	22.32	11.40	40	0	0	0	0
2	Obagaji	160	199	73	432	14	34.40	22.40	70	0	0	0	0
3	Ugbokpo	150	219	88	457	13	21.60	26.80	61	0	0	0	0
4	Buruku	94	153	82	329	6.4	23.20	26.52	56	0	0	0	0
5	Gboko	392	334	127	853	39	45.80	38.00	123	388	264	93	745
6	Gbajimba	150	216	84	450	10	28.00	22.76	61	0	0	0	0
7	Aliade	208	241	81	530	18	33.60	26.40	78	0	0	0	0
8	Naka	180	170	83	433	6.6	31.00	27.28	65	0	0	0	0
9	Katsina-Ala	248	222	102	572	23	45.60	41.80	110	102	327	52	482
10	Tse-Agberagba	110	157	69	336	11	14.40	10.40	36	0	0	0	0
11	Adikpo	99	133	64	296	7.0	16.04	24.32	48	0	0	0	0
12	Ugba	240	317	80	637	22	45.20	19.20	86	0	0	0	0
13	Makurdi	330	296	91	717	50	43.38	55.16	148	718	619	290	1626
14	Obarike-Ito	190	219	79	488	16	31.40	27.00	74	0	0	0	0
15	Otukpa	260	204	78	542	24	33.20	22.00	79	0	0	0	0
16	Idekpa	136	151	62	349	4.4	18.00	15.80	38	0	0	0	0
17	Oju	226	355	104	685	18	54.40	37.20	109	164	280	77	521
18	Okpoga	174	149	78	401	6.4	14.00	6.52	27	0	0	0	0
19	Otukpo	356	334	133	823	34	65.80	59.80	160	282	435	103	820
20	Wannune	92	159	70	321	6.4	17.20	22.04	46	0	0	0	0
21	Sankera	200	186	83	469	20	26.00	22.40	69	0	0	0	0
22	Lessel	123	104	91	318	5.2	16.00	27.00	48	0	0	0	0
23	Vandeikya	92	155	58	305	14	29.20	23.16	66	0	0	0	0
	Mean	**189**	**210**	**84**	**483**	**16**	**31**	**27**	**74**	**331**	**385**	**123**	**839**

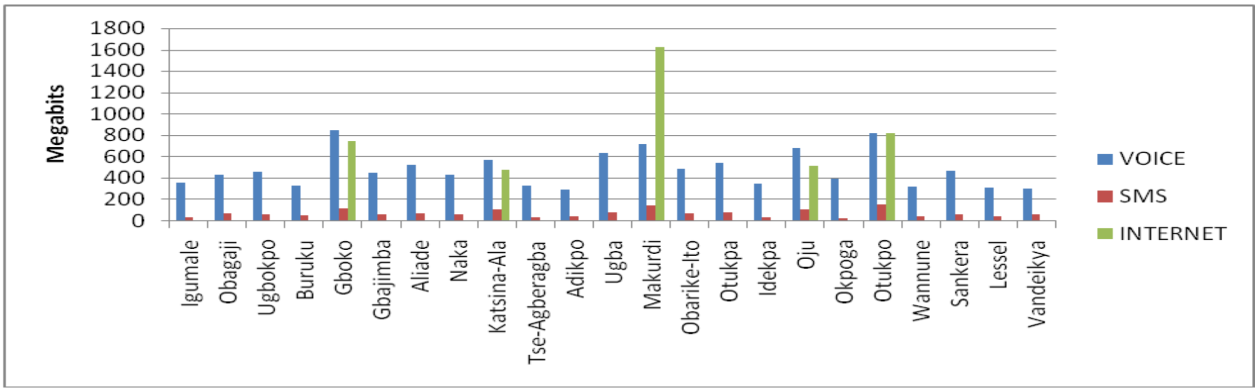

Figure 2: total amount of data transferred in busy hour for each class of services

Other important data collected were call number, number of text messages, call holding time and number of Internet transactions.

Using the initial data shown in Table 2, other model input parameters were calculated using (1), (2), (3) and (5). They include the following.

i. Criteria for decomposition of services (γ_1, γ_2);
ii. Relative number of users in the High, Middle and Low Income subgroups F_3, F_2, and F_1 respectively.
iii. Share of calls and transactions in busy hour, Q_{11}, Q_{12}, Q_{13}; and Q_{21}, Q_{22}, Q_{23} relating to users of low income, middle income and high income subgroups respectively when services from first and second classes respectively are initiated.

Given these input parameters, the main traffic parameters, that is, rate of voice calls and rate of data transactions, call holding time and data transaction time, and traffic intensity were estimated using (4) to (14) and the results are as shown in Tables 3, 4 and 5 respectively. Also, the results are shown graphically in Figs. 3, 4 and 5 respectively.

Table III: Rate of Calls and Data Transactions in Busy Hour per User

S/N	*LOCAL GOVERNMENT HEADQUARTERS*	*VOICE*				*SMS*				*INTERNET*			
		HIGH INCOME λ_{13}	*MIDDLE INCOME* λ_{12}	*LOW INCOME* λ_{11}	*TOTAL*	*HIGH INCOME* λ_{13}	*MIDDLE INCOME* λ_{12}	*LOW INCOME* λ_{11}	*TOTAL*	*HIGH INCOME* λ_{23}	*MIDDLE INCOME* λ_{22}	*LOW INCOME* λ_{21}	*TOTAL*
1	Igumale	2.32	5.10	4.5	11.9	3.93	9.66	5.0	18.6	0	0	0	0
2	Obagaji	1.80	5.05	4.3	11.2	5.18	10.3	6.2	21.7	0	0	0	0
3	Ugbokpo	1.95	5.36	4.5	11.8	4.43	4.99	7.6	17.0	0	0	0	0
4	Buruku	2.50	5.55	4.9	13	3.30	3.95	8.0	15.3	0	0	0	0
5	Gboko	7.67	5.62	7.2	20.5	12.9	14.5	12.5	39.9	72	96.2	77	245
6	Gbajimba	1.92	4.29	4.4	10.6	4.97	11.7	6.3	22.3	0	0	0	0
7	Aliade	2.08	6.06	4.8	12.9	7.54	12.4	8.5	28.4	0	0	0	0
8	Naka	2.58	2.72	4.3	9.60	5.98	15.8	7.3	29.1	0	0	0	0
9	Katsina-Ala	4.02	4.64	5.6	14.3	6.98	8.76	11.0	26.7	28	55.6	26	110
10	Tse-Agberagba	1.69	4.27	4.4	10.4	2.45	5.49	2.0	9.94	0	0	0	0
11	Adikpo	2.25	3.43	4.6	10.3	2.53	3.00	6.0	11.5	0	0	0	0
12	Ugba	2.09	6.06	4.4	12.6	8.37	14.2	7.7	30.3	0	0	0	0
13	Makurdi	6.30	4.30	6.0	16.6	36.3	42.2	20.0	98.6	370	486	270	1126
14	Obarike-Ito	1.84	3.61	4.6	10.1	6.46	10.9	7.5	24.9	0	0	0	0
15	Otukpa	3.33	2.69	4.3	10.3	7.96	10.2	7.2	25.3	0	0	0	0
16	Idekpa	1.66	3.72	4.4	9.78	4.01	10.3	5.0	19.3	0	0	0	0
17	Oju	2.77	7.29	5.6	15.7	7.61	20.9	12.0	40.5	69	116	29	213
18	Okpoga	2.84	2.56	4.6	10.0	1.92	3.64	6.0	11.6	0	0	0	0
19	Otukpo	4.74	4.55	6.7	16	23.8	26	19.0	68.7	112	171	72	355
20	Wannune	1.81	3.88	4.6	10.3	2.15	2.56	5.0	9.71	0	0	0	0
21	Sankera	2.63	2.69	4.2	9.52	6.94	8.53	7.4	22.9	0	0	0	0
22	Lessel	1.31	3.06	4.7	9.07	2.68	3.00	7.0	12.7	0	0	0	0
23	Vandeikya	2.17	4.05	4.7	10.9	5.01	8.91	6.0	19.9	0	0	0	0
	Mean	**2.8**	**4.4**	**4.9**	**12.1**	**7.5**	**11.4**	**8.3**	**27.2**	**130**	**924**	**185**	**410**

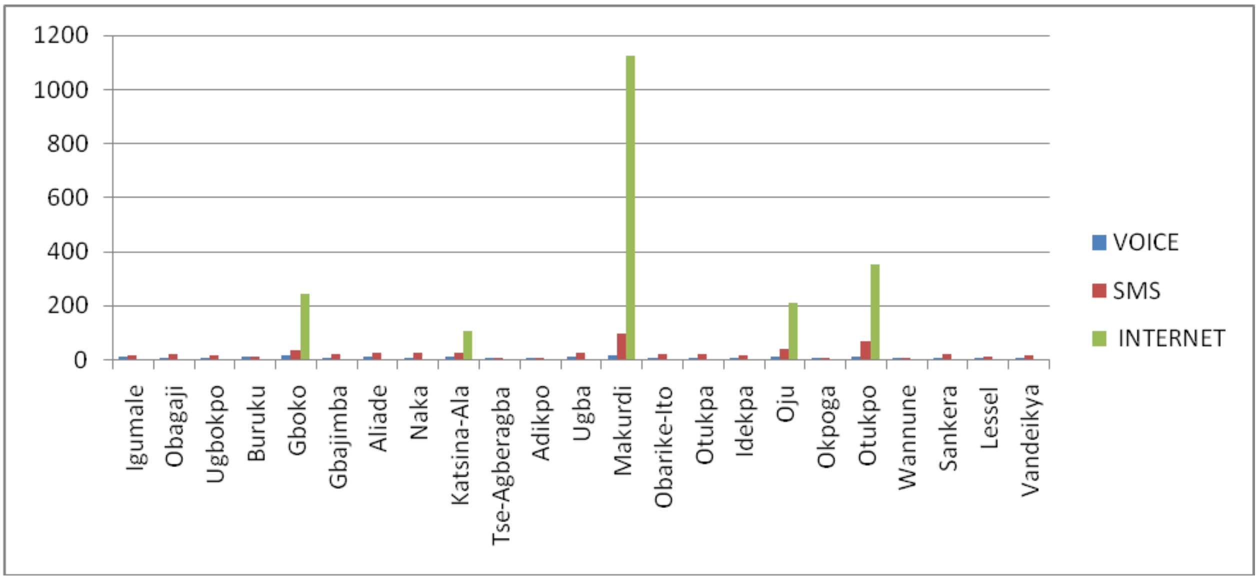

Figure 3: rate of calls and data transactions in busy hour per user

Table IV: Average Call Holding Time and Data Transaction Time per User

S/N	*LOCAL GOVERNMENT HEADQUARTERS*	*VOICE*	*SMS*	*INTERNET*
		Average Call Holding Time, T_1 Secs	*Average Transaction Time, T_1 Secs*	*Average Transaction Time, T_2 Secs*
1	Igumale	135	1.25	0
2	Obagaji	168	1.25	0
3	Ugbokpo	174	1.25	0
4	Buruku	113	1.25	0
5	Gboko	192	1.25	6
6	Gbajimba	168	1.25	0
7	Aliade	174	1.25	0
8	Naka	174	1.25	0
9	Katsina-Ala	153	1.25	4
10	Tse-Agberagba	109	1.25	0
11	Adikpo	115	1.25	0
12	Ugba	186	1.25	0
13	Makurdi	194	1.25	10
14	Obarike-Ito	174	1.25	0
15	Otukpa	174	1.25	0
16	Idekpa	121	1.25	0
17	Oju	192	1.25	5
18	Okpoga	146	1.25	0
19	Otukpo	205	1.25	6
20	Wannune	103	1.25	0
21	Sankera	180	1.25	0
22	Lessel	79	1.25	0
23	Vandeikya	107	1.25	0
	Mean	**154**	**1.25**	**6.2**

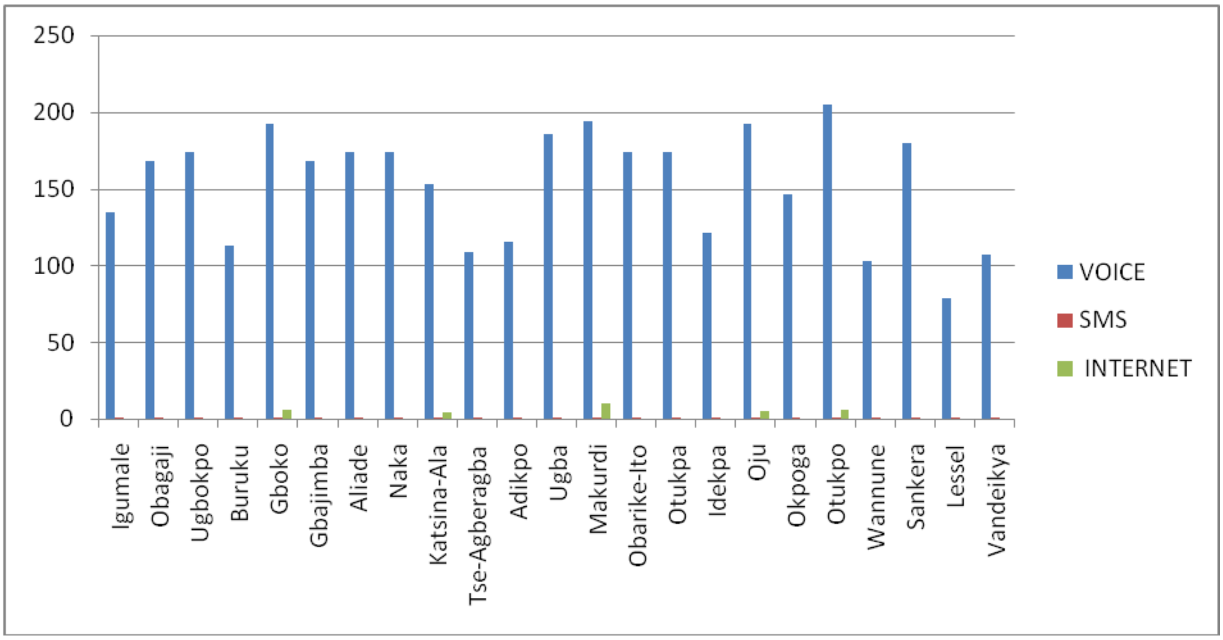

Figure 4: average call holding time and data transaction time per user

Table V: Traffic Intensity per User at the Network Nodes

S/N	LOCAL GOVERNMENT HEADQUARTERS	SYMMETRICAL SERVICES	ASYMMETRICAL SERVICES			TOTAL TRAFFIC INTENSITY PER USER
		VOICE Erlangs A_s	SMS Erlangs	INTERNET Erlangs	TOTAL Erlangs A_a	$A_T = (A_s + A_a)$ ERLANGS
1	Igumale	0.0044	0.000069	0	0.000069	0.0045
2	Obagaji	0.0050	0.000080	0	0.000080	0.0051
3	Ugbokpo	0.0057	0.000062	0	0.000062	0.0058
4	Buruku	0.0056	0.000056	0	0.000056	0.0057
5	Gboko	0.011	0.0046	0.14	0.14	0.15
6	Gbajimba	0.0050	0.000081	0	0.000081	0.0051
7	Aliade	0.0059	0.00010	0	0.00010	0.0060
8	Naka	0.0046	0.00010	0	0.00010	0.0047
9	Katsina-Ala	0.0062	0.0031	0.043	0.043	0.049
10	Tse-Agberagba	0.0031	0.000038	0	0.000038	0.0031
11	Adikpo	0.0034	0.000044	0	0.000044	0.0034
12	Ugba	0.0061	0.00011	0	0.00011	0.0062
13	Makurdi	0.0088	0.011	1.030	1.030	1.040
14	Obarike-Ito	0.0046	0.00009	0	0.00009	0.0047
15	Otukpa	0.0049	0.000092	0	0.000092	0.0050
16	Idekpa	0.0031	0.000069	0	0.000069	0.0032
17	Oju	0.0083	0.0049	0.095	0.095	0.10
18	Okpoga	0.0041	0.000041	0	0.000041	0.0041
19	Otukpo	0.0090	0.0080	0.20	0.20	0.21
20	Wannune	0.0030	0.000035	0	0.000035	0.0030
21	Sankera	0.0047	0.000083	0	0.000083	0.0048
22	Lessel	0.0021	0.000047	0	0.000047	0.0022
23	Vandeikya	0.0033	0.000073	0	0.000073	0.0034
	Mean	**0.005**	**0.001**	**0.07**	**0.07**	**0.07**

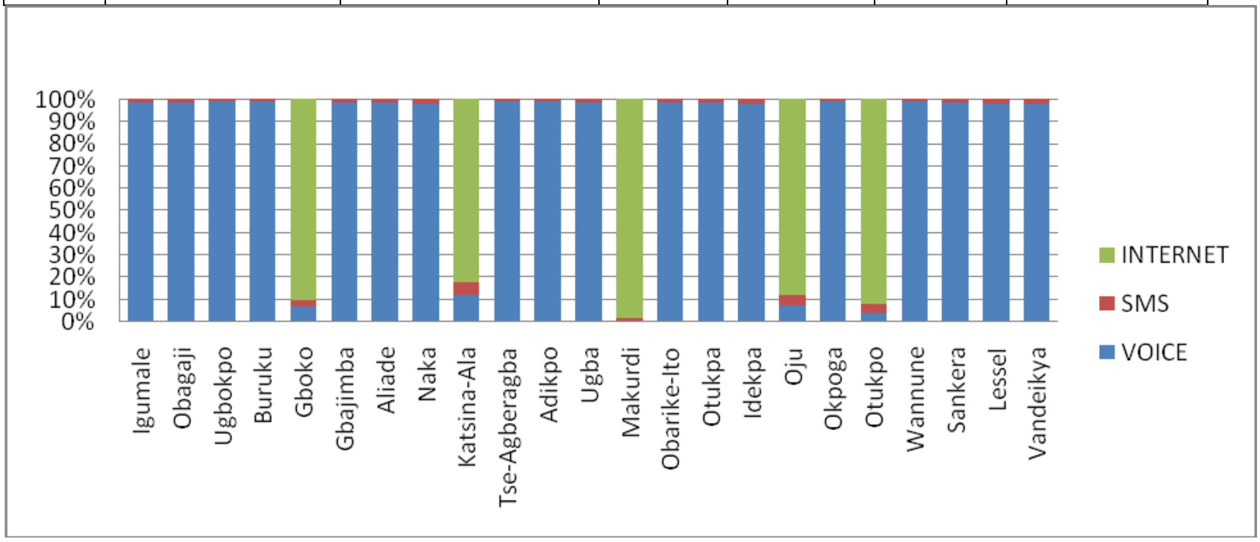

Figure 5: traffic intensity per user at the network nodes

Fig. 5 shows that the symmetrical voice services and asymmetrical SMS services constitute the predominance of NGN traffic in Benue State occurring at all the 23 network nodes; the asymmetrical Internet traffic occurs at only 5 network nodes. Notice the huge dominance of voice traffic (with a contribution of more than 95%) over SMS traffic in all the 18 towns covered by only these two services. Also notice that Internet traffic similarly dominates the voice and SMS services in the 5 areas covered by all the three classes of services.

Generally speaking, the average values of traffic intensity per user in Erlangs are 0.005 for voice services; 0.001 for SMS; and 0.07 for Internet. This typifies the traffic pattern for a developing economy since the existing telecommunications infrastructure are still largely legacy and not encouraging for widespread Internet services. Also the low solvency of majority of the users owing to the fledgling economy is a major factor for the generally low values of rate of calls/data transactions, and traffic intensities. Thus, it is instructive to dimension the NGN taking this traffic pattern into consideration. Fig. 5 succinctly illustrates this traffic pattern.

VII. CONCLUSION

In this paper, the probabilistic traffic model has been used for the estimation of traffic parameters for an NGN in a developing society. Such model input parameters as Gini coefficients defining the non-uniformity of demand for NGN services; relative number of subscribers in the low, medium and high income subgroups; the distribution of the total amount of calls and transactions in busy hour for each class of service; the distribution of the total amount of data transferred; and the share of calls and transactions in busy hour relating to users of each of the sub-groups were obtained either directly or derived from statistical data obtained from a marketing research conducted on the 23 local government headquarters of Benue State. The research primarily sourced information on the level of usage of various NGN services by the high, middle, and low income groups in the State. This consequently showed the main services used in the State as voice calls, text messages and Internet. Then using the prevailing tariff at the rate 5 Kobo (approximately 0.05 Cents) per 1 kilobit, the amount of data transferred, in bits, was estimated for each class of service and used to derive the various model input parameters. Then, using the procedures of the probabilistic model, the symmetrical and asymmetrical traffic intensities were estimated separately at each of the 23 headquarters representing the various network nodes of the NGN. Other key traffic parameters that were got from this method include rate of voice calls and rate of data transactions, call holding time and data transaction time. For instance, the average values of traffic intensity per user in Erlangs are 0.005 for voice services; 0.001 for SMS; and 0.07 for Internet.

Generally, the results of the study show that a developing country is characterized by a prevalence of voice and SMS services and limited Internet services; high number of low income earners; and low rates of call/data transactions, and traffic intensities.

This study demonstrates a method to estimate traffic parameters at different network nodes starting from subscriber field studies. The use of the method will facilitate the preparation of both business and technical plans for effective and efficient planning and dimensioning of NGN networks in a developing economy.

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