

# INVESTIGATION ON ACCESSIBILITY INDEX AND QUALITY OF SERVICE OF GSM NETWORKS IN EKPOMA, NIGERIA

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**Abstract-** The paper investigates the accessibility index of cellular mobile networks at Ekpoma. The objective was to determine the performance and quality of service of GSM networks providers in Ekpoma, Nigeria. The assessment was based on the ability of a mobile network to setup and hold calls for a duration of 140 seconds. A total of 34,112 calls, made up of 8,528 intra-networks and 25,584 inter-networks, were initiated at 41 test points for a period of one year (May 2014 to April 2015). The test points selected spread across Ekpoma to account for all possible climatic conditions. The results showed that when network signals were available, steady and within the international acceptable standard of received signal strength level greater than  $-93\text{dBm}$ , all cellular mobile network operators at Ekpoma offered a good quality of service with an accessibility index greater than 81%. Conversely, the performance of all networks during periods of poor or fluctuating signals and both is unsatisfactory.

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**Keywords-** Accessibility Index; Global System For Mobile Communication (GSM); Network Operator, Subscribers, Test Points.

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## I. INTRODUCTION

The fundamental aim of the global system for mobile communication (GSM) network operator is to provide satisfactory service to its subscribers. The satisfaction can be achieved by subscribers if the services provided by the network operators are free from poor coverage, network congestion, drop call, crosstalk and unsuccessful establishment of intra and inter network calls. The ability of a mobile network to setup and hold quality calls is perhaps one of the major concerns to both consumers and the network operators [1,2]. A communication system is said to be a successful system when a call is established properly and effectively [3].

In telecommunications, the call setup success rate (CSSR) is the fraction of the attempt to make a call that result in a connection to the dialed number. Due to various reasons not all call attempts end in a connection to the dialed number. The fraction is usually measured as a percentage of all calls attempts made. Telecommunication network operators aim at increasing the call setup success rate as much as practical and affordable. In mobile networks this is achieved by improving radio coverage, expanding the capacity of the network and optimizing the performance of its elements, all of which may require considerable effort and significant investments on the part of the network operator [4].

Effective communication occurs when the received signal strength level at the mobile handset is greater than  $-93\text{dBm}$ , which is the internationally acceptable standard [1]. Service accessibility is the ability of a service to be obtained within specified tolerances and other given conditions, when requested by the user [5]. Accessibility assessment is one of the yardsticks to assess the quality of service provided by an operator [1,2,6]. It is therefore of significant interest to conduct

accessibility assessment of the mobile networks in Ekpoma, Nigeria with a view to assess their performance and the quality of service they provide.

Several factors can affect the quality of service of a mobile network [7]. It is necessary to look at quality of service mainly from the customer's point of view, that is, quality of service as judged by the user. There are standard metrics used by the telecommunication industry to rate the quality of service of a network [8]. One of such indices is audio quality. The audio quality considers monitoring a successful call for a period of time for the clarity of the communication channel. The paper investigates the accessibility index of cellular mobile networks at Ekpoma. And the performance and quality of cellular mobile service provided by various GSM networks vendors were assessed using observed data for a period of one year (May 2014 – April 2015).

## II. METHODOLOGY

### A. Site Meteorology

Ekpoma is located in the south-south geo-political zone of Nigeria. And Ekpoma town is the second most populated city in Edo state after Benin City, the state capital. It occupies a landmass of  $502\text{ km}^2$  and a population of 125,842 according to the 2006 census. The area investigated lies between latitude  $6^{\circ} 43'$  and  $6^{\circ} 45'$  North of the Equator, and longitude  $6^{\circ} 6'$  and  $6^{\circ} 8'$  East at an elevation of 333 meters above sea level. The location is made up of the following quarters (sites); Ujemen, Idumebo, Irukepken, Ihumudumu, Ukpenu, Ukhun, Ujeolen, Emaudo, Eguare, Emuhi, Uke, Illeh, Uhiele, Eghoro, Igor and Idoia [9]. These sites were considered in the investigation.

In order to evaluate the accessibility index and quality of services provided by the different network operators, eight Tecno y4 handsets equipped with SIM

(subscribers' identification modules) cards of the different network operators were used. The eight handsets were grouped in four pairs, with one handset being used as the source node and the other used as the destination node. The four pairs of handsets each represent the four different networks considered. At every test point, intra-network and inter-network calls assessment of the four mobile networks were carried out simultaneously to ensure equality of test condition. The quality of the calls was observed for a period of 140 seconds. Calls established between the source and destination nodes within the time frame of 140 seconds were recorded as successful calls while others, such as, calls not established by the network after a maximum number of three trials, call abandoned during the conversation phase and calls experiencing crosstalk during conversation were recorded as unsuccessful calls.

### B. Data and Method

The 41 test points considered were visited once a week during the period (May 2014 – April 2015) of the investigation. The test points are; (1) Iruokpen – Abia express junction, along Benin-Auchi road. (2) Iruokpen – Abia road, off Benin-Auchi road. (3) Iruokpen junction, along Benin-Auchi road. (4) Iruokpen road, by Iruokpen Post office. (5) Iruokpen – Sabo by-pass. (6) Iruokpen General Hospital. (7) Abia – Ujemen by-pass. (8) Supreme Hotel junction, by Ujemen Primary School. (9) Eghoro village, off Ujemen-Idumebo. (10) Oriafu junction, opposite PHCN office, Idumebo. (11) Ihumudumu community town hall, Iseleloa. (12) G-2 junction, Ihumudumu. (13) Judges quarter junction, Ihumudumu road. (14) Alli square round about. (15)

Ujeolen secondary school. (16) Ezekiel College of Theology, Ujeolen. (17) College of medicine, AAU (18) Uke primary school, Uke town. (19) 1-T4 junction by Benin-Auchi road. (20) AAU library, main campus. (21) Mariere hostel junction, main campus. (22) Faculty of Law, main campus. (23) Faculty of Engineering & Technology, main campus. (24) Ukpenu junction, along Benin-Auchi express road. (25) Borehole junction, along Benin-Auchi express road. (26) Opoji junction. (27) Akahia, Uhie. (28) Ukpoke, St. Paul's Anglican Church. (29) Idumegan, Ehanlen primary school. (30) Evbuakhuala village. (31) Illeh primary school by St. matthew's Anglican Church. (32) Evbuakhuala – Illeh road. (33) Ikeokogbe, by Assemblies of God church. (34) Ukhun road, by Supreme hotels junction. (35) Market square round about. (36) Mount Carmel School, Road 9. (37) Faculty of Agriculture, Emaudo Campus. (38) Emaudo secondary school. (39) Emuhi market square, Emuhi (40) Ukpenu – Emuhi road. (41). Ukpenu – Emuhi junction, by St. John's Anglican church, Ukpenu. The respective serial number of each test point was used to identify each test point The investigation on these networks was performed simultaneously at each test point, which provides equality of test condition [10,11].

### III. RESULTS AND DISCUSSION

The results of the intra-network and inter-network calls attempted during the period (May 2014 – April 2015) of the investigation are presented in Table I. The acronym NC represents number of calls initiated, SC represents successful calls, and USC is unsuccessful calls.

**TABLE I. ANALYSIS OF RESULT OF THE INTRA AND INTER NETWORK CALL ATTEMPTS FOR THE PERIOD (MAY 2014 – APRIL 2015)**

Test Point	Source Network	Destination Network															
		A				B				C				D			
		NC	SC	USC	%SC	NC	SC	USC	%SC	NC	SC	USC	%SC	NC	SC	USC	%SC
1	A	52	48	04	92	52	47	05	90	52	46	06	88	52	42	10	81
	B	52	46	06	88	52	50	02	96	52	44	08	85	52	43	09	83
	C	52	44	08	85	52	43	09	83	52	49	03	94	52	44	08	85
	D	52	44	08	85	52	40	12	77	52	46	06	88	52	49	03	94
2	A	52	50	02	96	52	49	03	94	52	50	02	96	52	49	03	94
	B	52	48	04	92	52	51	01	98	52	47	05	90	52	48	04	92
	C	52	48	04	92	52	48	04	92	52	50	02	96	52	49	03	94
	D	52	47	05	90	52	48	04	92	52	46	06	88	52	50	02	96
3	A	52	52	00	100	52	44	08	85	52	49	03	94	52	42	10	81
	B	52	44	08	85	52	50	02	96	52	47	05	90	52	43	09	83
	C	52	46	06	88	52	46	06	88	52	51	01	98	52	44	08	85
	D	52	44	08	85	52	43	09	83	52	44	08	85	52	49	03	94
4	A	52	50	02	96	52	46	06	88	52	42	10	81	52	46	06	88
	B	52	42	10	81	52	49	03	94	52	40	12	77	52	44	08	85
	C	52	40	12	77	52	38	14	73	52	46	06	88	52	40	12	77
	D	52	46	06	88	52	44	08	85	52	42	10	81	52	51	01	98
5	A	52	49	03	94	52	46	06	88	52	38	14	73	52	40	12	77
	B	52	48	04	92	52	52	00	100	52	40	12	77	52	46	06	88
	C	52	38	14	73	52	40	12	77	52	49	03	94	52	39	13	73
	D	52	46	06	88	52	44	08	85	52	38	14	73	52	49	03	94
6	A	52	46	06	88	52	41	11	79	52	40	12	77	52	41	11	79
	B	52	45	07	87	52	47	05	90	52	40	12	77	52	42	10	81
	C	52	46	06	88	52	43	09	83	52	50	02	98	52	44	08	85
	D	52	44	08	85	52	40	12	77	52	42	10	81	52	48	04	92

TABLE I. CONTINUATION

Test Point	Source Network	Destination Network															
		A				B				C				D			
		NC	SC	USC	%SC	NC	SC	USC	%SC	NC	SC	USC	%SC	NC	SC	USC	%SC
7	A	52	48	04	92	52	48	04	92	52	47	05	90	52	46	06	88
	B	52	47	05	90	52	48	04	92	52	44	08	85	52	45	07	87
	C	52	43	09	83	52	44	08	85	52	43	09	83	52	44	08	85
	D	52	48	04	92	52	46	06	88	52	46	06	88	52	50	02	96
8	A	52	49	03	94	52	47	05	90	52	44	08	85	52	47	05	90
	B	52	48	04	92	52	51	01	98	52	46	06	88	52	46	06	88
	C	52	44	08	85	52	44	08	85	52	47	05	90	52	44	08	85
	D	52	48	04	92	52	46	06	88	52	44	08	85	52	50	02	96
9	A	52	52	00	100	52	47	05	90	52	46	06	88	52	46	06	88
	B	52	50	02	96	52	52	00	100	52	46	06	88	52	48	04	92
	C	52	49	03	94	52	48	04	92	52	51	01	98	52	48	04	92
	D	52	48	04	92	52	47	05	90	52	47	05	90	52	50	02	96
10	A	52	49	03	94	52	47	05	90	52	45	07	87	52	41	11	79
	B	52	47	05	90	52	50	02	96	52	44	08	85	52	44	08	85
	C	52	41	11	79	52	49	03	94	52	48	04	92	52	40	12	77
	D	52	40	12	77	52	38	14	73	52	40	12	77	52	48	04	92
11	A	52	46	06	88	52	43	09	83	52	42	10	81	52	40	12	77
	B	52	48	04	92	52	49	03	94	52	47	05	90	52	46	06	88
	C	52	44	08	85	52	45	07	87	52	45	07	87	52	46	06	88
	D	52	44	08	85	52	46	06	88	52	44	08	85	52	49	03	94
12	A	52	50	02	96	52	50	02	96	52	47	05	90	52	48	04	92
	B	52	49	03	94	52	48	04	92	52	47	05	90	52	48	04	92
	C	52	48	04	92	52	48	04	92	52	48	06	88	52	46	06	88
	D	52	48	04	92	52	48	04	92	52	48	04	92	52	50	02	96
13	A	52	49	03	94	52	48	04	92	52	48	04	92	52	47	05	90
	B	52	48	04	92	52	50	02	96	52	47	05	90	52	46	06	88
	C	52	47	05	90	52	48	04	92	52	50	02	96	52	46	06	88
	D	52	49	03	94	52	47	05	90	52	47	05	90	52	51	01	98
14	A	52	49	03	94	52	47	05	90	52	45	07	87	52	43	09	83
	B	52	46	06	88	52	50	02	96	52	46	06	88	52	44	08	85
	C	52	44	08	85	52	42	10	81	52	48	04	92	52	40	12	77
	D	52	46	06	88	52	44	08	85	52	46	06	88	52	49	03	94
15	A	52	46	06	88	52	45	07	87	52	42	10	81	52	45	07	87
	B	52	45	07	87	52	49	03	94	52	45	07	87	52	47	05	90
	C	52	42	10	81	52	43	09	83	52	48	04	92	52	44	08	85
	D	52	45	07	87	52	46	06	88	52	46	06	88	52	51	01	98
16	A	52	49	03	94	52	47	05	90	52	44	08	85	52	46	06	88
	B	52	46	06	88	52	50	02	96	52	44	08	85	52	48	04	92
	C	52	44	08	85	52	43	09	83	52	48	04	92	52	40	12	77
	D	52	46	06	88	52	45	07	87	52	46	06	88	52	49	03	94
17	A	52	40	12	77	52	47	05	90	52	48	04	92	52	48	04	92
	B	52	48	04	92	52	51	01	98	52	47	05	90	52	47	05	90
	C	52	48	04	92	52	48	04	92	52	50	02	96	52	47	05	90
	D	52	49	03	94	52	47	05	90	52	47	05	90	52	50	02	96
18	A	52	48	04	92	52	41	11	79	52	40	12	77	52	38	14	73
	B	52	48	04	92	52	50	02	96	52	44	08	85	52	46	06	88
	C	52	40	12	77	52	44	08	85	52	48	04	92	52	40	12	77
	D	52	39	13	75	52	42	10	81	52	39	13	75	52	49	03	94
19	A	52	49	03	94	52	43	09	83	52	42	10	81	52	43	09	83
	B	52	47	05	90	52	50	02	96	52	42	10	81	52	45	07	87
	C	52	44	08	85	52	40	12	77	52	49	03	94	52	41	11	79
	D	52	42	10	81	52	41	11	79	52	40	12	77	52	48	04	92
20	A	52	47	05	90	52	44	08	85	52	41	11	79	52	42	10	81
	B	52	46	06	88	52	50	02	96	52	44	08	85	52	45	07	87
	C	52	41	11	79	52	44	08	85	52	48	04	92	52	41	11	79
	D	52	40	12	77	52	45	07	87	52	40	12	77	52	48	04	92
21	A	52	48	04	92	52	43	09	83	52	42	10	81	52	38	14	73
	B	52	46	06	88	52	49	03	94	52	45	07	87	52	44	08	85
	C	52	46	06	88	52	46	06	88	52	49	03	94	52	44	08	85
	D	52	44	08	85	52	42	10	81	52	40	12	77	52	47	05	90
22	A	52	50	02	96	52	48	04	92	52	42	10	81	52	46	06	88
	B	52	48	04	92	52	49	03	94	52	43	09	83	52	46	06	88
	C	52	44	08	85	52	43	09	83	52	48	04	92	52	42	10	81
	D	52	46	06	88	52	47	05	90	52	42	10	81	52	50	02	96
23	A	52	50	02	96	52	46	06	88	52	42	10	81	52	43	09	83
	B	52	48	04	92	52	51	01	98	52	42	10	81	52	45	07	87
	C	52	44	08	85	52	44	08	85	52	48	04	92	52	40	12	77
	D	52	42	10	81	52	44	08	85	52	40	12	77	52	48	04	92

TABLE I. CONTINUATION

Test Point	Source Network	Destination Network															
		A				B				C				D			
		NC	SC	USC	% SC	NC	SC	USC	% SC	NC	SC	USC	% SC	NC	SC	USC	% SC
24	A	52	49	03	94	52	46	06	88	52	45	07	87	52	46	06	88
	B	52	46	06	88	52	50	02	96	52	44	08	85	52	47	05	90
	C	52	44	08	85	52	44	08	85	52	49	03	94	52	41	11	79
	D	52	46	06	88	52	46	06	88	52	42	10	81	52	50	02	96
25	A	52	50	02	96	52	48	04	92	52	48	04	92	52	48	04	92
	B	52	48	04	92	52	50	02	96	52	47	05	90	52	47	05	90
	C	52	46	06	88	52	47	05	90	52	51	01	98	52	46	06	88
	D	52	47	05	90	52	46	06	88	52	48	04	92	52	50	02	96
26	A	52	51	01	98	52	47	05	90	52	47	05	90	52	46	06	88
	B	52	46	06	88	52	50	02	96	52	47	05	90	52	48	04	92
	C	52	46	06	88	52	48	04	92	52	50	02	96	52	46	06	88
	D	52	47	05	90	52	46	06	88	52	48	04	92	52	51	01	98
27	A	52	49	03	94	52	44	08	85	52	46	06	88	52	46	06	88
	B	52	44	08	85	52	48	04	92	52	42	10	81	52	42	10	81
	C	52	46	06	88	52	43	09	83	52	50	02	96	52	46	06	88
	D	52	46	06	88	52	42	10	81	52	46	06	88	52	50	02	96
28	A	52	44	08	85	52	38	14	73	52	39	13	75	52	40	12	77
	B	52	38	14	73	52	45	07	87	52	40	12	77	52	42	10	81
	C	52	40	12	77	52	39	13	75	52	46	06	88	52	38	14	73
	D	52	38	14	73	52	40	12	77	52	41	11	79	52	44	08	85
29	A	52	50	02	96	52	46	06	88	52	42	10	81	52	45	07	87
	B	52	47	05	90	52	50	02	96	52	42	10	81	52	45	07	87
	C	52	44	08	85	52	43	09	83	52	48	04	92	52	41	11	79
	D	52	42	10	81	52	41	11	79	52	39	13	75	52	48	04	82
30	A	52	49	03	94	52	46	06	88	52	43	09	83	52	45	07	87
	B	52	48	04	92	52	50	02	96	52	43	09	83	52	42	10	81
	C	52	42	10	81	52	43	09	83	52	48	04	92	52	39	13	75
	D	52	42	10	81	52	45	07	87	52	40	12	77	52	48	04	92
31	A	52	48	04	92	52	46	06	88	52	43	09	83	52	41	11	79
	B	52	46	06	88	52	50	02	96	52	42	10	81	52	44	08	85
	C	52	40	12	77	52	45	07	87	52	49	03	94	52	40	12	77
	D	52	41	11	79	52	40	12	77	52	38	14	73	52	48	04	92
32	A	52	47	05	90	52	37	15	71	52	39	13	75	52	40	12	77
	B	52	41	11	79	52	48	04	92	52	42	10	81	52	42	10	81
	C	52	42	10	81	52	38	14	73	52	47	05	90	52	38	14	73
	D	52	38	14	73	52	39	13	75	52	40	12	77	52	48	04	92
33	A	52	50	02	96	52	46	06	88	52	46	06	88	52	46	06	88
	B	52	46	06	88	52	49	03	94	52	47	05	90	52	47	05	90
	C	52	45	07	87	52	45	07	87	52	49	03	94	52	45	07	87
	D	52	45	07	87	52	43	09	83	52	45	07	87	52	50	02	96
34	A	52	47	05	90	52	42	10	81	52	38	14	73	52	39	13	75
	B	52	43	09	83	52	50	02	96	52	43	09	83	52	43	09	83
	C	52	40	12	77	52	46	06	88	52	49	03	94	52	43	09	83
	D	52	45	07	87	52	46	06	88	52	40	12	77	52	48	04	92
35	A	52	46	06	88	52	43	09	83	52	43	09	83	52	40	12	77
	B	52	44	08	85	52	50	02	96	52	46	06	88	52	42	10	81
	C	52	39	13	75	52	41	11	79	52	48	04	92	52	40	12	77
	D	52	42	10	81	52	44	08	85	52	45	07	87	52	48	04	92
36	A	52	49	03	94	52	43	09	83	52	40	12	77	52	44	08	85
	B	52	46	06	88	52	50	02	96	52	46	06	88	52	46	06	88
	C	52	41	11	79	52	43	09	83	52	47	05	90	52	42	10	81
	D	52	42	10	81	52	45	07	87	52	45	07	87	52	50	02	96
37	A	52	47	05	90	52	43	09	83	52	40	12	77	52	41	11	79
	B	52	45	07	87	52	50	02	96	52	43	09	83	52	45	07	87
	C	52	42	10	81	52	44	08	85	52	47	05	90	52	42	10	81
	D	52	45	07	87	52	45	07	87	52	44	08	85	52	48	04	92
38	A	52	49	03	94	52	46	06	88	52	43	09	83	52	45	07	87
	B	52	46	06	88	52	49	03	94	52	46	06	88	52	46	06	88
	C	52	46	06	88	52	42	10	81	52	50	02	96	52	44	08	85
	D	52	44	08	85	52	40	12	77	52	43	09	83	52	49	03	94
39	A	52	46	06	88	52	39	13	75	52	40	12	77	52	41	11	79
	B	52	41	11	79	52	47	05	90	52	39	13	75	52	41	11	79
	C	52	39	13	75	52	42	10	81	52	46	06	88	52	38	14	73
	D	52	40	12	77	52	44	08	85	52	42	10	81	52	47	05	90
40	A	52	50	02	96	52	46	06	88	52	42	10	81	52	45	07	87
	B	52	46	06	88	52	49	03	94	52	42	10	81	52	45	07	87
	C	52	40	12	77	52	41	11	79	52	47	05	90	52	40	12	77
	D	52	44	08	85	52	45	07	87	52	40	12	77	52	49	03	94
41	A	52	50	02	96	52	45	07	87	52	45	07	87	52	44	08	85
	B	52	46	06	88	52	49	03	94	52	45	07	87	52	46	06	88
	C	52	46	06	88	52	46	06	88	52	49	03	94	52	46	06	88
	D	52	48	04	92	52	44	08	85	52	46	06	88	52	50	02	96

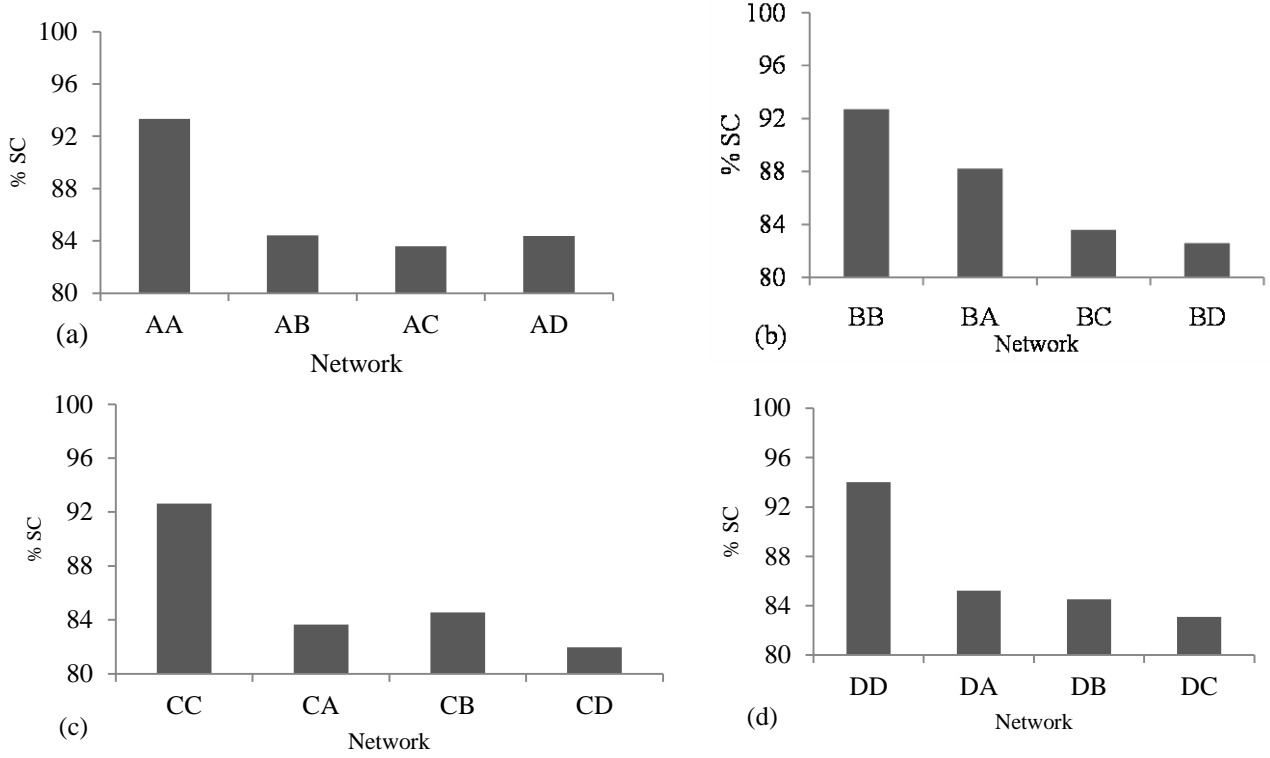


Fig. 1. Percentages of successful calls by (a) Network A, (b) Network B, (c) Network C and (d) Network D

The analysis for various networks is given as follows:

#### A. Intra-network calls

Given that the percentage of successful intra network calls by Network A is  $\%SC_{AA}$ , then the average accessibility percents for the intra-network calls is determined by the equation:

$$\overline{\%SC_{AA}} = \left( \sum_{n=1}^{N_{tp}} \%SC_{AA_n} \right) / N_{tp}, \quad (1)$$

where  $N_{tp}$  is the number of test points.

#### B. Inter-network calls

Given that the percentages of successful inter network calls from Network A to B, A to C and A to D is  $\%SC_{AB}$ ,  $\%SC_{AC}$  and  $\%SC_{AD}$  respectively, then the average accessibility percents are determine by the following equations:

$$\overline{\%SC_{AB}} = \left( \sum_{n=1}^{N_{tp}} \%SC_{AB_n} \right) / N_{tp}, \quad (2)$$

$$\overline{\%SC_{AC}} = \left( \sum_{n=1}^{N_{tp}} \%SC_{AC_n} \right) / N_{tp}, \quad (3)$$

$$\overline{\%SC_{AD}} = \left( \sum_{n=1}^{N_{tp}} \%SC_{AD_n} \right) / N_{tp}. \quad (4)$$

The results of the above analysis are given in Fig. 1. The Accessibility index assessment shows that all the

network operators in Ekpoma, Nigeria, offered a good level of accessibility for intra-network and inter-network during the period of the investigation. Nevertheless, the intra-connectivity was better than the inter-connectivity in all the networks at Ekpoma, during the period of investigation. The percentages of the successful intra-network calls for Network A, B, C and D (i.e., Net A, Net B, Net C and Net D) are 93.34%, 92.71%, 92.63% and 94.02% respectively. The percentages of the successful inter-network calls from Network A to B (AB), A to C (AC), A to D (AD); Network B to A (BA), B to C (BC), B to D (BD); Network C to A (CA), C to B (CB), C to D (CD); and Network D to A (DA), D to B (DB), D to C (DC) are 84.41%, 83.59% and 84.37%; 88.22%, 82.59% and 86.59%; 83.66%, 84.56% and 81.98%; and 85.22%, 84.51% and 83.10% respectively for the period of the investigation.

#### IV. CONCLUSION

The quality of service and accessibility assessment reveal that all the network operators in Ekpoma (Nigeria), offered a good quality of service and a good accessibility when the signals of the networks were available, steady and greater than  $-93\text{dBm}$ . However, unsuccessful establishment of intra and inter network calls, drop calls and crosstalk were observed when the signals were poor or fluctuating. In order for network operators to provide satisfactory service to its subscribers in Ekpoma, Nigeria, they should ensure 100% coverage with good and steady network signals in the town. When the required conditions are met by the network operators, there will be an excellent quality of service and excellent network connectivity

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