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Analysis of Global System for Mobile Communication (GSM) Network in Port Harcourt under Different Loading Conditions Using Erlang - B Techniques.

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ABSTRACT: *This work was carried out to analyze Global System for Mobile Communications (GSM) Network in Port Harcourt under different loading conditions using Erlang-B Technique. The GSM network, since its introduction, has been embraced by many people throughout the world [1]. This is attributable to the edge it has over the first generation (1G) . As should be expected, this rapid rise in the number of subscribers has resulted or created some issues to the network providers [2]. Network providers therefore work round the clock to ensure that their customers are given the best in terms of quality of service (QoS). This work found out that for good performance of GSM network, voice channels must always be greater than the traffic load the system experiences. The work also bared that as the value of traffic load rises while the number of voice channels remains constant, more calls are blocked. The analysis further bared that voice channels are under-utilized if traffic loads are too small compared to the installed voice channels in a base station. The result obtained shows the six (6) BTS according to their performance, BTS 5 (62.5% accepted, 37.5% rejected and 0% under-utilized blocking probability), BTS 4 (62.5% accepted, 12.5% rejected and 25% under-utilized blocking probability), BTS 6 (50% accepted, 0% rejected and 50% under-utilized blocking probability), BTS 3 (37.5% accepted, 37.5% rejected and 25% under-utilized blocking probability), BTS 2 (37.5% accepted, 50% rejected and 12.5% under-utilized blocking probability) and BTS 1 (37.5% accepted, 62.5% rejected and 0% under-utilized blocking probability).*

KEYWORDS: *Analysis; Erlang B; GSM; Network; Traffic Load.*

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I. INTRODUCTION

The GSM network is a of (2G) network, that's, of a second generation, which is a digital system [3]. Before it was introduced the first generation (1G) network, purely analog, was in use. As GSM service came up, number of subscribers grew rapidly-such that in a few years it has more subscribers than the first generation system [4]. this expansion of Global System for Mobile Communications (GSM) network has its own effects on the network providers and the subscribers. The providers of GSM network work round the clock to provide services for the ever growing subscribers while maintaining high quality of service (QoS). [5] noted that GSM subscribers complain of their failure to get GSM services when they needed the services. Common complains have been “Network busy”, “Error in Connection” etc. Analyzing the effects of the growing traffic load on the system will help the operators of GSM network to improvetheir service delivery**.**

Global System for Mobile Communication Network Operates with 900MHZ, 1800MHZ, 1900MHZ and 2100MHZ frequencies. Since GSM uses full duplex in its operation, two frequencies are used: one frequency form mobile station to base station, called uplink frequency, and another frequency from base station to mobile station, called downlink frequency, [5] as shown in figure 1.

Figure 1: Direction of uplink and downlink Frequency

Application of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) to the GSM network is one advantage of the digital system. The bandwidth of 25MHZ is divided into 125 different frequencies called carrier frequencies, each 200KHZ apart when frequency division multiple access is applied to it. Each of the carrier frequencies is subjected further to Time Division Multiple Access. That is, each carrier frequency is divided into eight timeslots, as shown in figure 2. One timeslot is assigned to a subscriber.

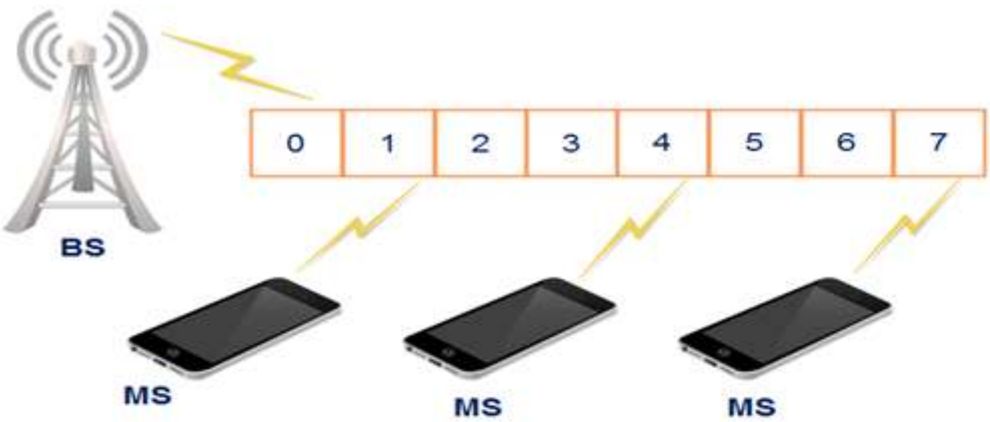

Figure 2: Division of a Carrier into Timeslots

II. LITERATURE REVIEW

In [6] performance analysis of Global System for Mobile (GSM) Communications Network in Kano State was carried out, which showed that the four major network providers in Nigeria failed to realize the minimum target by the Nigeria Communications Commission (NCC) for HOSR, CSSR, etc. As considered in [7], GSM network performance analysis is very important as it helps in determining if GSM subscribers really get satisfied for using the network. The issue of signal problems mentioned in [7] as found in the network considered appears to be a major problem in other cities, especially in developing countries like Nigeria. To actually improve service delivery, much work has to be done by the network providers to analyze their performance and determine where specifically improvement is needed. Use of Drive Test has been done in cellular networks like CDMA, LTE, GSM UMTS etc for the purpose of analysis and optimization of the quality of service (QOS) of the network providers [8]. It is therefore not surprising that experts are giving much attention to the issue of GSM network planning, network evaluation, and network optimization [9]. All of this is geared toward making sure that users of GSM network obtain maximum satisfaction, and for the network providers to spend less but gain much from their service delivery. [10] used the data obtained from the operating center of the network to evaluate mobile networks. Though the work only considered vasofone network, it compared its result with the samples of measurement taken to a certain KPI in Kaduna and Abuja base station controller. The work in [11] looked at analysis of signal strength of GSM mobile networks. Drive tests were used to take data. It was during a program that usually takes place in Ogun State once a year that the drive test was conducted. It was estimated that out of 250,000 individuals that would be present, 100,000 would use their handsets. To ensure that the network resources were fully loaded, the drive test was taken during their break time when many would be using their phones.

III. LOADING GSM NETWORK

In GSM, the number of calls that come in at a given time is called arrival rate (Ar). Similarly, the average calls the system is able to service at a given time is called service rate (Sr).

Determination of Traffic Load

$\text{Traffic Load } (A_t) = \frac{A_r}{S_r}$ (1)

$\text{Traffic Load } (A_t) = \frac{N_c D}{3600}$ (2)

Where

A_r is the arrival rate,

S_r is the service rate

N_c is the number of callers during the busy hour

D is the call duration.

Determination of Service rate

Equating (1) and (2)

$\frac{A_r}{S_r} = \frac{N_c D}{3600}$ (3)

Arrival rate, (A_r) is the same as the number of callers during the busy hour,(N_c). From (3) service rate is

$\text{Service Rate } (S_r) = 3600/D$ (4)

Where

D is Average call duration

Usual value for D is 60s. [3]

Determination of blocking probability

The blocking probability is calculated using Erlang B formula [6].

$b = \frac{a^n}{n!} / \sum_{i=0}^{n} \frac{a^i}{i!}$ (5)

where

a is the traffic load in erl.

n is the vice channel.

Loading the system with different subscribers [30,60, 90, 120,150,180,210 and 240] respectively one at a time. The traffic load is calculated as follows:

Loading with 30 subscribers

Arrival rate (A_r)= 30

$$Service\ Rate\ (S_r) = \frac{3600}{60} = 60\ s$$

$$Traffic\ Load\ (A_t) = \frac{30}{60} = 0.5 erl$$

Loading with 60 subscribers

Arrival rate (A_r)= 60

$$Service\ Rate\ (S_r) = \frac{3600}{60} = 60\ s$$

$$Traffic\ Load\ (A_t) = \frac{60}{60} = 1.0 erl$$

Loading with 90 subscribers

Arrival rate (A_r)= 90

$$Service\ Rate\ (S_r) = \frac{3600}{60} = 60\ s$$

$$Traffic\ Load\ (A_t) = \frac{90}{60} = 1.5 erl$$

Loading with 120 subscribers

Arrival rate (A_r)= 120

$$Service\ Rate\ (S_r) = \frac{3600}{60} = 60\ s$$

$$Traffic\ Load\ (A_t) = \frac{120}{60} = 2.0\ erl$$

Loading with 150 subscribers
Arrival rate (A_r)= 150

$$Service\ Rate\ (S_r) = \frac{3600}{60} = 60\ s$$
$$Traffic\ Load\ (A_t) = \frac{150}{60} = 2.5\ erl$$

Loading with 180 subscribers
Arrival rate $(\mathrm{A_r})$= 180

$$\mathrm{Service\ Rate\ (S_r)} = \frac{3600}{60} = 60\ \mathrm{s}$$
$$\mathrm{Traffic\ Load\ (A_t)} = \frac{180}{60} = 3.0\ \mathrm{erl}$$

Loading with 210 subscribers
Arrival rate $(\mathrm{A_r})$= 210

$$\mathrm{Service\ Rate\ (S_r)} = \frac{3600}{60} = 60\ \mathrm{s}$$
$$\mathrm{Traffic\ Load\ (A_t)} = \frac{210}{60} = 3.5\ \mathrm{erl}$$

Loading with 240 subscribers
Arrival rate $(\mathrm{A_r})$= 240

$$\mathrm{Service\ Rate\ (S_r)} = \frac{3600}{60} = 60\ \mathrm{s}$$
$$\mathrm{Traffic\ Load\ (A_t)} = \frac{240}{60} = 4.0\ \mathrm{erl}$$

Using the value of the traffic loads [0.5 erl,1.0 erl,1.5 erl, 2.0 erl, 2.5 erl ,3.0 erl, 3.5 erl and 4.0 erl] obtained above, the blocking probability(b)is calculated for each of the voice channels [5, 6, 7, 8, 9 and 10], respectively using (5).

For a traffic load (a) = 0.5erl and Voice channels n=5

$$\mathrm{b} = \frac{0.5^5}{5!} \Big/ \sum_{i=0}^{5} \frac{0.5^5}{5!}$$
$$\mathrm{b} = 1.58\mathrm{x}10^{-4}$$

For a traffic load (a) = 0.5erl and Voice channels n=6

$$\mathrm{b} = \frac{0.5^6}{6!} \Big/ \sum_{i=0}^{6} \frac{0.5^6}{6!}$$
$$\mathrm{b} = 1.32\mathrm{x}10^{-5}$$

For a traffic load (a) = 0.5erl and Voice channels n=7

$$\mathrm{b} = \frac{0.5^7}{7!} \Big/ \sum_{i=0}^{7} \frac{0.5^7}{7!}$$
$$\mathrm{b} = 9.40\mathrm{x}10^{-7}$$

For a traffic load (a) = 0.5erl and Voice channels n=8

$$\mathrm{b} = \frac{0.5^8}{8!} \Big/ \sum_{i=0}^{8} \frac{0.5^8}{8!}$$
$$\mathrm{b} = 5.88\mathrm{x}10^{-8}$$

For a traffic load (a) = 0.5erl and Voice channels n=9

$$\mathrm{b} = \frac{0.5^9}{9!} \Big/ \sum_{i=0}^{9} \frac{0.5^9}{9!}$$

$$b = 3.26x10^{-9}$$

For a traffic load (a) = 0.5erl and Voice channels n=10

$$b = \frac{0.5^{10}}{10!} / \sum_{i=0}^{10} \frac{0.5^{10}}{10!}$$

$$b = 1.63x10^{-10}$$

Similar calculation was performed for traffic loads [1.0 erl,1.5 erl,2.0 erl,2.5 erl,3.0 erl,3.5 erl and 4.0 erl] respectively for each voice channels [5, 6, 7, 8, 9 and 10]. As shown in Table 1.

IV. RESULTS AND DISCUSSION

Table 1: shows the blocking probability at different voice channels. The statutory limit for blocking probability provided by Nigerian communications commission (NCC) is less than or equal to 0.02[14]. Therefore, blocking probability that falls within this range is accepted. However, blocking probability that falls above the statutory limit is rejected. A cursory look at table 1, shows that the accepted blocking probability according to NCC regulation are those indicated by green colour and rejected blocking probability are those indicated by red colour. However, the blue colour indicates blocking probability that are too small which implies that the voice channels are under-utilized and will lead to loss of revenue to the operators and the country.

Table 2: shows the blocking probability at different traffic loads. According to NCC regulation, the blocking probability in green colour are accepted and the blocking probability in red are rejected. However, the blocking probability indicated by blue colour occured when the traffic load is 2.0 erl and voice channel is 10. The implication is that for a traffic load of 2.0 erl, allotting 10 channels for voice calls to it is too much and will lead to loss of revenue to the operator and to the country.

Figure 3: shows the graph of blocking probability against traffic load. A quick look at the graph in figure 3 shows that for traffic loads up to 4.0erl, only blocking probability for 9 and 10 voice channels did not violate the NCC statutory limit. However, blocking probability for 5, 6, 7 and 8 voice channels violated the statutory limit. This implies that a lot of congestion occurred in the system.

Figure 4 shows graph of blocking probability against voice channels. The graph indicates that the blocking probability reduces as the voice channels are increased in any BTS.

Figure 5 shows the performance of the six (6) base transceiver station (BTS). A quick look at figure 5 shows the BTS in the order of their performance. BTS 5 (62.5% accepted, 37.5% rejected and 0% under-utilized blocking probability), BTS 4 (62.5% accepted, 12.5% rejected and 25% under-utilized blocking probability), BTS 6 (50% accepted, 0% rejected and 50% under-utilized blocking probability), BTS 3 (37.5% accepted, 37.5% rejected and 25% under-utilized blocking probability), BTS 2 (37.5% accepted, 50% rejected and 12.5% under-utilized blocking probability) and BTS 1 (37.5% accepted, 62.5% rejected and 0% under-utilized blocking probability).

Table1: **Blocking Probability (b) at Different Voice Channels (n)**

Traffic load a (erl)	Blocking Probability (b)					
	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10
0.5	1.58E-4	1.32E-5	9.40E-7	5.88E-8	3.26E-9	1.63E-10
1.0	3.07E-3	5.11E-4	7.30E-5	9.12E-6	1.01E-6	1.01E-7
1.5	1.42E-2	3.53E-3	7.57E-4	1.42E-4	2.36E-5	3.55E-6
2.0	3.67E-2	1.21E-2	3.44E-3	8.59E-4	1.91E-4	3.82E-5
2.5	6.97E-2	2.82E-2	9.98E-3	3.11E-3	8.63E-4	2.16E-4
3.0	1.10E-1	5.22E-2	2.19E-2	8.13E-3	2.70E-3	8.10E-4
3.5	1.54E-1	8.25E-2	3.96E-2	1.70E-2	6.58E-3	2.30E-3
4.0	1.99E-1	1.17E-1	6.27E-2	3.04E-2	1.38E-2	5.31E-3

Table2: Blocking Probability (b) at Different Traffic Load

Voice Channels (n)	Blocking Probability (b)		
	a=2.0(erl)	a=2.5(erl)	a=3.0(erl)
5	3.67E-2	6.97E-2	1.10E-1
6	1.21E-2	2.82E-2	5.22E-2
7	3.44E-3	9.98E-3	2.19E-2
8	8.59E-4	3.11E-3	8.13E-3
9	1.91E-4	8.63E-3	2.70E-3
10	3.82E-5	2.16E-4	8.10E-4

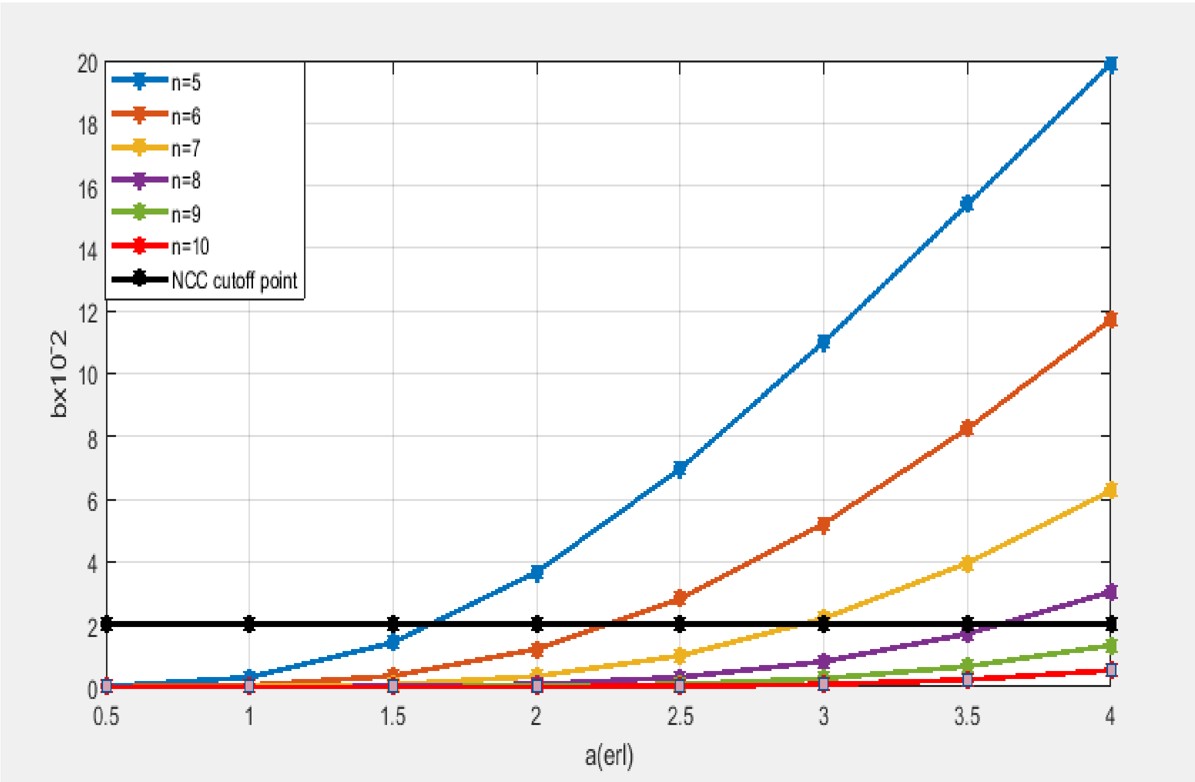

Figure 3: Graph of Blocking Probability against Traffic Loads.

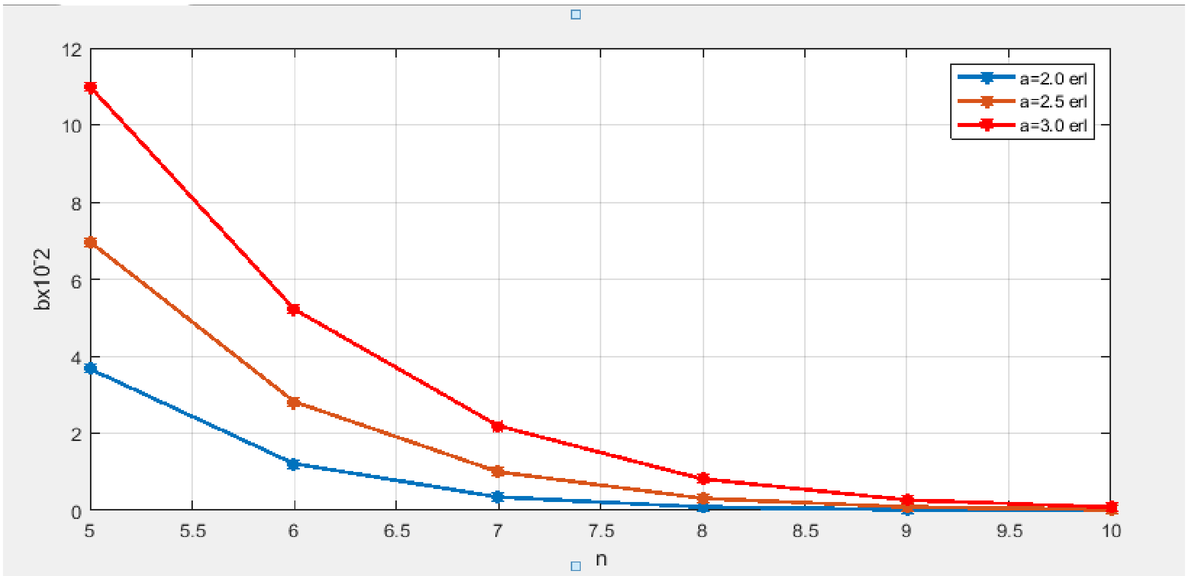

Figure 4: Graph of Blocking Probability against Voice Channels

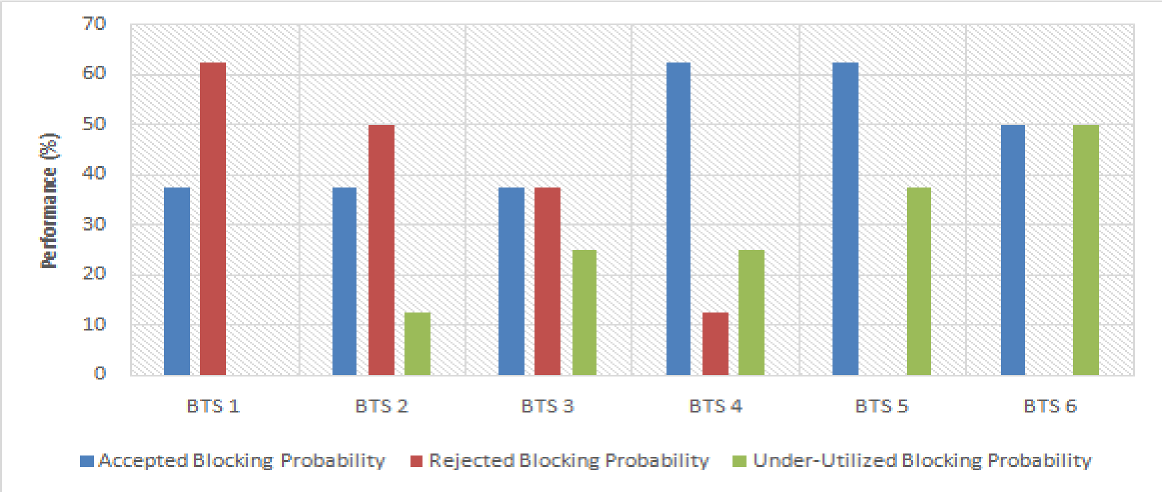

Figure 5: Graph of Base Transceiver Station Performance

V. CONCLUSION

The purpose of any analysis of GSM network is to ascertain how the network performs with a view to having the network improved to meet the yeanings of the ever growing network subscribers. The analysis carried out in this work shows that Global System for Mobile Communications Network (GSM) will perform well if the system is not allowed to be overloaded. The loading used in the work for a network that has 5, 6, 7, 8, 9, and 10 voice channels showed over-utilization and under-utilization of the channels. The work will really be of great help to network providers who strive hard to satisfy their customers.

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