

Empirical Determination of the Effect of Call Traffic Periods on GSM Network Signal Receptions

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Abstract

Apart from environmental issues, one of the factors that seriously affect received radio signal level in a cell site is call traffic. From the reviewed literatures, it was stated that when there is high call rate the received power in a GSM network coverage area tends to go down due to power demand on the transmitter and that phenomenon tends to further lower the quality of service of GSM networks. To investigate that, several measurements of received signal strength were conducted at a particular localized point (06.385005N, 007.400830E) in the MTN network base station located along Uzo Saba Road, Umuewashi, Nsude in Udi Local Government Area of Enugu state, Nigeria, at periods of low call traffic, light call traffic and heavy call traffic. Analysis of the data collected shows that as call traffic increases fluctuations of the received signal level increases also. The result is that quality of service of such network will greatly be impaired during heavy call periods.

Keywords: Call traffic, Base station, Received Signal Strength, Traffic Capacity, Network Coverage Area.

1.0 Introduction

Telecommunication industry is witnessing an unprecedented transformation due to new technologies that are emerging almost every day. And the need for individuals, Governments, cooperate organizations and others to communicate among themselves and make use of the numerous services made available by these technologies has placed enormous pressure on communication equipments for expansions to enable them accommodate the increasing demands. These will naturally in turn increase call traffic. At certain times in the day this call traffic is low but at other times (called busy hours) when the need to communicate is very high, call traffic is heavy [1][2]. During heavy traffic periods received signal are likely to keep on fluctuating and these fluctuations may manifest itself in call service interruptions, dropped calls, blocked calls, inability to initiate calls etc, which seriously degrades the Network quality of service. Since received signal in a GSM network coverage area is directly related to call traffic [3]. Therefore the pattern of relationship between call traffic and received

signal in GSM network was investigated in this paper.

2.0 Literature Review

2.1 Call traffic

Call traffic can be defined as the number of calls (ongoing calls and call attempts) on a telecommunication network during a given period of time. Calls here refer to both voice and data [2].

Mobile radio networks are operated with finite, limited resources (the spectrum of frequencies available). These resources have to be used effectively to ensure that all users receive good service, that is, the quality of service has to be consistently maintained. The need to carefully use the limited spectrum brought about the development of cells in mobile networks, enables frequency re-use by successive clusters of cells [4]. Systems that efficiently use the available spectrum have been developed e.g. the GSM system. [5] defined spectral efficiency as the traffic capacity unit divided by the product of bandwidth and surface area element, and is dependent on the number of radio channels per

cell and the cluster size (number of cells in a group of cells) given as:

$$\text{efficiency} = \frac{N_c}{Bw \cdot A_c} \quad (1)$$

where N_c is the number of channels per cell, Bw is the system bandwidth, and A_c is Area of cell. The wider the cell coverage area the probability that more subscribers are likely to place demands on the Network.

2.2 Traffic capacity versus coverage

Mobile systems use one or more of three different techniques of access (Time division multiple access (TDMA), Frequency division multiple access (FDMA), Code division multiple access (CDMA) [6]. Let a case of Code Division Multiple Access be considered for the relationship between traffic capacity and coverage (area covered by cells). CDMA cellular systems can allow an increase in traffic capacity at the expense of the quality of service. That is to say that as the traffic capacity increases Network quality of service decreases [7]. In TDMA/FDMA cellular radio systems, allocate channels to customers. In FCA the number of channels in the cell remains constant irrespective of the number of customers in that cell. This results in traffic congestion, lost calls and received signal fluctuations increase when traffic gets heavier [8].

A better way of channel allocation in cellular systems is Dynamic Channel Allocation (DCA) which is supported by the GSM, and other systems. DCA is a better way not only for handling busy cell traffic but also in efficiently utilizing the cellular radio resources. DCA allows the number of channels in a cell to vary with the traffic load, hence increasing channel capacity with little costs. Since a cell is allocated a group of frequency carriers (e.g. f_1 - f_7) for each user, this range of frequencies form the bandwidth (Bw) of that cell. If the cell covers an area A_c , and each user has bandwidth BW then the number of channels C_n [5] will be

$$C_n = Bw/B \quad (2)$$

The density of channels C_d will be

$$C_d = \frac{Bw}{A_c B} \quad (3)$$

This formula shows that as the coverage area A_c is increased, the channel density C_d decreases. And if traffic demand in such Network increases, quality of service will further decrease because received signal fluctuations will increase.

2.3 Base station

In mobile systems, base station provides the connection between mobile nodes and the wider telecommunication network. Mobile system base stations are the nodes of mobile networks. Every base station provides a closely defined area – the radio cell – with reception. It represents the main contributor to the energy consumption of a mobile cellular network [4].

The total power output of a typical mobile base station depends on the type of antenna, the number of analog and digital channels that operate at a given time and at their maximum strength, and the antenna gain which gives the signals direction and strength. The power output of a GSM Base Station is measured in watts, and is about 1,000 times less than that produced by a television transmitter. Maximum power radiated from the antenna at the top of the mast is in the region of Kilowatts [4]. However, the situation is more complicated when there are multiple antennas at the same site. It is even more complicated when base stations are located at the same site as television or radio transmitters.

A GSM base station does not always transmit at maximum power because of the TDMA techniques adopted by the GSM. The power transmitted by a GSM base station is largely variable. Hence, the commonly used worst-case assessment approach overestimates exposure in actual conditions and overlooks the relation between the power transmitted by the base station and the traffic the base station is connected to.

On the other hand, according to Royal Society of Canada, 1999, factors that influence the received signal by a node at any point in the GSM network coverage area includes:

- The power output, frequency and type of transmitter;
- The distance of the receiving node from the transmitter;
- The location of the receiving node with respect to the transmitted beam;
- The type of antenna and the direction of the transmitted beam;
- The presence of other structures near the receiving node that may shield or reflect the RF signals towards it;
- The traffic load at any point in time the network is carrying

The areas covered by base stations are not all the same size. The coverage of a radio cell in the GSM system can vary, from a few hundred meters in city centres to several kilometers in the countryside. Radio cells for the new mobile communications standard UMTS often cover considerably smaller distances as UMTS uses far lower transmission power. It is also the case that, when transmission and reception conditions are favorable, the power output of mobile phones and base stations reduces even further [10].

3.0 Methodology

Since this work is an empirical study, several field measurements of received signal strength at a particular localized point and at four different call periods for several days for five months, were carried out and data obtained plotted using MATLAB plots and then analyzed.

3.1 Measurement Environment

For the convenience of the researchers, considering the number of field measurements required for investigations of this nature, a location along Uzo Saba Road, Umuewashi, Nsude, in Udi Local Government Area of Enugu state, Nigeria (Lat. 06.385005N, Long. 007.400830E on satellite map) was chosen for all the measurements conducted. See Fig.1. The GSM Network of study is MTN, Nigeria. The average received signal strength at that location of -85dBm was confirmed after taking the average of 30 measurements at that point with

Mongoose signal field strength meter [4]. And the location is surrounded by a farm land with patches of trees here and there. For the purpose of this work, that location will be known as point X.



Fig.1: Satellite view of the study field

As already explained, call traffic is stated as one of the factors that contribute to the received signal variations in a GSM network coverage area. Therefore signal behaviors at different call traffic volumes are the major focus of this work. To carry out this investigation, several field measurements of received signal strength at point X in MTN network coverage Area, was carried out at different call observation periods classified as low call traffic, light call traffic and heavy call traffic periods. Most Telecommunication network operators take as low call traffic period, the calls made between 05.30hrs and 06.30hrs, light call traffic period between 11.00hrs and 12.00hrs and heavy call traffic between 09.00hrs to 10.00hrs and 19.00hrs to 21.00hrs of the day [10]. These periods constituted the call observation periods for this work.

Field measurements were taken only at those periods on ten different days each in the months of December 2010, March 2011, June 2011, July 2011 and September 2011 covering five months. On each measurement day, signal strength measurements were taken during the observation periods of low call traffic (05.30hrs – 06.30hrs), light call traffic (11.00hrs – 12.00hrs) and heavy

call traffic (09.00hrs – 10.00hrs) and (19.00hrs – 20.00hrs). Recording charts was prepared for recording the signal changes observed within each minute for each 60minutes readings. A 60 minutes reading was taken as a cycle of measurements.

Average signal levels observed within each minute for every 60 minutes readings, average of the readings obtained for each observation periods for a month and rate of signal changes for each month were calculated and appropriately recorded. The recordings made were collated and plotted for analysis.

3.2 Measurement Tools

Mongoose signal field strength meter (MSFSM) because of its very handy size was used to carry out all the measurements in this investigation.

4.0 Data Presentation and Analysis

The aim of field measurements in this work was to empirically observe the pattern of impact of call traffic on received network signal level (for example whether an increase in call volume will either increase or decrease the level of signal received at a point in the network coverage area).

To conduct these experiments, for each of the observation periods, and standing at point X, the mongoose signal strength meter was tuned to receive signal from the network of study. With the recording chart and pen, the reading of signal

changes observed within 60 seconds for every minute was noted and for every cycle of measurements. Afterwards the average of the readings recorded within the 60 seconds was calculated and noted as the reading obtained for that minute and this process was repeated for 60 minutes for all the observation periods. Ten of such readings were made on ten different days for each observation call periods for the month. For example in the month of December 2010 readings were conducted on ten different days. For each of the measurement day, readings were conducted during each of the four observation periods. The average data obtained from the ten days measurements for each of the observation period is given in Table 1A as the readings obtained for December 2010 for each observation period, while Table 2A is the calculated rate of signal fluctuations for each observation period for December 2010 measurement month. This process was repeated for the other four months. Table 3 gives the calculated average of the five months measurements for each observation period as obtained in the Tables 1. In table 4 the average of each of the observation periods for the five months was put together in one table for plots and analysis. Table 5 is the summary of the average rate of signal changes for the five months experiments for each observation period (from Table 4)

Table1: Average of ten days measurements data for each observation period)

1A: December 2010 measured data									
Time (min)	Received signal in dBm				Time (min)	Received signal in dBm			
	0530 - 0600 hr	0800 - 0900 hr	1100 - 1200 hr	1900 - 2000 hr		0530 - 0600 hr	0800 - 0900 hr	1100 - 1200 hr	1900 - 2000 hr
1	-82	-102	-80	-101	31	-86	-101	-69	-100
2	-68	-101	-89	-101	32	-105	-90	-99	-102
3	-100	-100	-102	-100	33	-75	-89	-101	-103
4	-101	-99	-100	-102	34	-100	-102	-86	-89
5	-89	-90	-82	-101	35	-98	-101	-83	-103
6	-78	-101	-81	-99	36	-79	-78	-87	-80

7	-68	-106	-79	-90	37	-78	-84	-76	-78
8	-88	-79	-80	-104	38	-81	-83	-82	-77
9	-99	-88	-103	-98	39	-87	-69	-90	-106
10	-80	-100	-101	-96	40	-102	-104	-98	-107
11	-103	-102	-99	-87	41	-82	-103	-102	-108
12	-88	-103	-89	-108	42	-87	-76	-80	-86
13	-81	-75	-87	-104	43	-84	-68	-81	-102
14	-86	-99	-80	-103	44	-86	-110	-81	-81
15	-85	-102	-78	-100	45	-85	-87	-89	-73
16	-81	-105	-82	-99	46	-105	-78	-86	-107
17	-86	-92	-106	-110	47	-83	-103	-95	-106
18	-81	-86	-68	-80	48	-84	-86	-105	-82
19	-101	-80	-98	-78	49	-87	-103	-81	-105
20	-81	-102	-86	-103	50	-81	-99	-82	-104
21	-83	-104	-83	-102	51	-96	-95	-85	-89
22	-82	-101	-79	-100	52	-90	-89	-85	-85
23	-82	-81	-106	-99	53	-82	-86	-85	-88
24	-97	-106	-88	-98	54	-89	-110	-84	-104
25	-83	-89	-82	-103	55	-81	-100	-97	-102
26	-82	-96	-81	-89	56	-82	-89	-93	-86
27	-104	-98	-85	-90	57	-100	-102	-106	-85
28	-85	-103	-103	-109	58	-102	-83	-92	-108
29	-89	-81	-87	-100	59	-86	-102	-73	-85
30	-95	-102	-80	-89	60	-89	-86	-95	-110

Table 1B: Average rate of signal fluctuations for December 2010 measurements (from Table 1A)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 -0630hr	-101 or less	11	no network reception
	-100 to -91	10	weak network reception
	-90 to -81	30	moderate network reception
	-80 or above	09	good network reception
0800 -0900hr	-101 or less	25	no network reception
	-100 to -91	10	weak network reception

	-90 to -81	17	moderate network reception
	-80 or above	08	good network reception
1100-1200hr	-101 or less	10	no network reception
	-100 to -91	10	weak network reception
	-90 to -81	29	moderate network reception
	-80 or above	11	good network reception
1900-2000hr	-101 or less	28	no network reception
	-100 to -91	11	weak network reception
	-90 to -81	14	moderate network reception
	-80 or above	07	good network reception

Table 2A (March 2011 Measurement data)

Time (min)	Received signal in dBm				Time (min)	Received signal in dBm			
	0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr		0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr
1	-88	-104	-91	-103	31	-101	-103	-78	-97
2	-90	-78	-93	-102	32	-97	-103	-105	-97
3	-100	-100	-89	-102	33	-96	-102	-100	-102
4	-102	-98	-102	-90	34	-87	-105	-98	-102
5	-80	-90	-79	-87	35	-85	-98	-95	-90
6	-78	-99	-82	-98	36	-78	-97	-89	-86
7	-79	-101	-77	-105	37	-86	-89	-88	-82
8	-75	-102	-104	-97	38	-106	-108	-79	-78
9	-104	-90	-83	-96	39	-99	-106	-84	100
10	-98	-89	-85	-79	40	-84	-88	-104	-104
11	-97	-104	-69	-104	41	-85	-86	-88	-105
12	-90	-68	-101	-103	42	-87	-104	-77	-89
13	-88	-69	-98	-105	43	-82	-103	-98	-87
14	-102	-106	-90	-100	44	-102	-102	-88	-85
15	-89	-72	-89	-96	45	-99	-103	-87	-100
16	-88	-74	-70	-98	46	-99	-105	-79	-105
17	-88	-103	-100	-106	47	-87	-82	-107	-109
18	-89	-102	-97	-109	48	-85	-84	-88	-107
19	-98	-101	-90	-88	49	-82	-83	-79	-106

20	-99	-99	-102	-72	50	-105	-103	-97	-97
21	-105	-88	-101	-101	51	-85	-79	-99	-78
22	-80	-102	-90	-102	52	-84	-77	-80	-77
23	-78	-100	-89	-102	53	-84	-107	-86	-83
24	-85	-98	-82	-96	54	-80	-80	-74	-102
25	-86	-89	-79	-86	55	-83	-72	-86	-103
26	-88	-86	-80	-87	56	-85	-102	-101	-99
27	-99	-102	-82	-99	57	-102	-100	-103	-90
28	-80	-103	-106	-103	58	-89	-99	-100	-89
29	-87	-102	-89	-101	59	-87	-103	-99	-80
30	-100	-99	-87	-101	60	-78	-98	-74	-104

Table 2B: Average rate of signal changes for March 2011 Measurements (from Table 2A)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 - 0630hr	-101 or less	09	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	29	moderate network reception
	-80 or above	10	good network reception
0800 - 0900hr	-101 or less	27	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	12	moderate network reception
	-80 or above	09	good network reception
1100 - 1200hr	-101 or less	11	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	23	moderate network reception
	-80 or above	14	good network reception
1900 - 2000hr	-101 or less	26	no network reception
	-100 to -91	14	weak network reception
	-90 to -81	14	moderate network reception
	-80 or above	06	good network reception

Table 3A (June 2011 Measurement data)

Time in Min.	Received signal in dBm				Time in Min	Received signal in dBm			
	0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr		0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr
1	-82	-102	-89	-103	31	-78	-86	-79	-88
2	-84	-101	-68	-103	32	-103	-103	-98	-102
3	-86	-100	-104	-100	33	-103	-102	-97	-86
4	-100	-98	-99	-99	34	-100	-101	-102	-103
5	-98	-90	-100	-90	35	-97	-86	-101	-105
6	-78	-89	-80	-105	36	-89	-87	-89	-98
7	-102	-102	-103	-82	37	-92	-98	-87	-95
8	-91	-104	-73	-78	38	-89	-92	-98	-87
9	-80	-102	-98	-109	39	-83	-78	-99	-101
10	-90	-99	-86	-99	40	-78	-103	-104	-103
11	-101	-97	-105	-89	41	-99	-100	-89	-89
12	-104	-85	-99	-105	42	-96	-78	-80	-80
13	-106	-84	-90	-103	43	-87	-104	-86	-105
14	-82	-105	-88	-98	44	-88	-106	-108	-109
15	-79	-88	-79	-96	45	-83	-98	-100	-105
16	-89	-86	-72	-98	46	-102	-97	-98	-100
17	-100	-108	-103	-87	47	-103	-84	-103	-97
18	-99	-96	-102	-82	48	-82	-102	-76	-83
19	-105	-97	-87	-101	49	-85	-105	-86	-102
20	-98	-89	-80	-100	50	-89	-88	-88	-87
21	-82	-108	-82	-86	51	-87	-77	-89	-86
22	-83	-98	-85	-78	52	-79	-103	-90	-104
23	-104	-93	-103	-104	53	-96	-84	-102	-97
24	-85	-95	-80	-77	54	-90	-84	-101	-84
25	-88	-89	-85	-109	55	-89	-103	-88	-102
26	-90	-105	-86	-82	56	-85	-106	91	-81
27	-108	-103	-82	-88	57	-76	-108	-89	-86
28	-103	-105	-88	-103	58	-79	-71	-105	-102
29	-88	-79	-84	-102	59	-82	-82	-69	-101
30	-87	-80	-74	-101	60	-83	-103	-68	-102

Table 3B: Average rate of signal changes for June 2010 Measurements (from Table 3A)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 - 0630hr	-101 or less	12	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	28	moderate network reception
	-80 or above	08	good network reception
0800 - 0900hr	-101 or less	24	no network reception
	-100 to -91	14	weak network reception
	-90 to -81	16	moderate network reception
	-80 or above	06	good network reception
1100 - 1200hr	-101 or less	14	no network reception
	-100 to -91	10	weak network reception
	-90 to -81	23	moderate network reception
	-80 or above	13	good network reception
1900 - 2000hr	-101 or less	26	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	18	moderate network reception
	-80 or above	04	good network reception

Table 4A: (July 2011 Measurement data)

Time In min	Received signal in dBm				Time In min	Received signal in dBm			
	0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr		0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr
1	-78	-102	-78	-100	31	-85	-94	-104	-101
2	100	-99	-81	-98	32	-102	-95	-100	-102
3	-90	-102	-102	-103	33	-89	-88	-99	-105
4	-102	-102	-100	-104	34	-88	-101	-102	-100
5	-86	-102	-90	-105	35	-97	-104	-101	-99
6	-85	-101	-104	-96	36	-77	-89	-89	-74
7	-103	-98	-75	-90	37	-86	-75	-75	-106
8	-87	-90	-98	-89	38	-104	-96	-69	-87

9	-79	-73	-105	-100	39	-84	-103	-86	-86
10	-105	-103	-90	-106	40	-85	-86	-107	-103
11	-90	-78	-86	-94	41	-98	-80	-98	-102
12	-93	-105	-73	-79	42	-97	-105	-98	-101
13	-86	-98	-99	-103	43	-78	-100	-88	-96
14	-108	-83	-103	-95	44	-84	-85	-89	-86
15	-82	-76	-86	-78	45	-105	-79	-74	-105
16	-81	-105	-67	-102	46	-86	-106	-101	-105
17	-106	-102	-105	-85	47	-89	-101	-83	-86
18	-96	-96	-75	-86	48	-90	-98	-78	-93
19	-97	-89	-95	-105	49	-82	-94	-89	-104
20	-88	-74	-94	-83	50	-78	-88	-86	-101
21	-89	-99	-85	-99	51	-100	-87	-86	-96
22	-95	-107	-82	-77	52	-78	-106	-77	-105
23	-87	-83	-83	-103	53	-83	-94	-104	-109
24	-98	-77	-106	-88	54	-100	-89	-87	-105
25	-104	-104	-85	-78	55	-99	-108	-98	-79
26	-98	-78	-80	-107	56	-90	-96	-85	-105
27	-80	-103	-89	-84	57	-89	-78	-82	-105
28	-100	-102	-86	-82	58	-99	-109	-86	-89
29	-102	-103	-85	-104	59	-96	-80	-78	-101
30	-84	-103	-86	-102	60	-97	-104	-76	-102

Table 4B: Average rate of signal changes for July 2011 Measurements (from table 4A)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 - 0630hr	-101 or less	10	no network reception
	-100 to -91	17	weak network reception
	-90 to -81	26	moderate network reception
	-80 or above	07	good network reception
0800 - 0900hr	-101 or less	26	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	12	moderate network reception
	-80 or above	10	good network reception

1100 - 1200hr	-101 or less	12	no network reception
	-100 to -91	11	weak network reception
	-90 to -81	25	moderate network reception
	-80 or above	12	good network reception
1900 - 2000hr	-101 or less	29	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	13	moderate network reception
	-80 or above	06	good network reception

Table 5A (September 2011 Measurement data)

Time In min	Received signal in dBm				Time In min	Received signal in dBm			
	0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr		0530 - 0600hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr
1	-89	-101	-90	-99	31	-89	-101	-69	-105
2	-100	-102	-102	-103	32	-90	-102	-90	-102
3	-78	-101	-100	-109	33	-82	-101	-99	-104
4	-82	-100	-98	-102	34	-96	-100	-104	-106
5	-102	-101	-90	-98	35	-78	-101	-100	-97
6	-99	-102	-76	-100	36	-101	-102	-78	-99
7	-89	-102	-100	-104	37	-79	-102	-96	-100
8	-90	-99	-102	-90	38	-89	-99	-102	-104
9	-105	-99	-79	-88	39	-90	-99	-89	-78
10	-104	-98	-82	-99	40	-98	-98	-83	-106
11	-89	-104	-68	-104	41	-92	-104	-87	-102
12	-98	-89	-86	-99	42	-78	-89	-98	-83
13	-78	-78	-101	-76	43	-106	-78	-105	-108
14	-103	-105	-101	-79	44	-100	-105	-99	-85
15	-86	-77	-98	-101	45	-99	-77	-78	-88
16	-98	-79	-88	-102	46	-88	-79	-83	-106
17	-83	-106	-100	-87	47	-83	-106	-103	-96
18	-104	-98	-104	-90	48	-79	-98	-86	-98
19	-79	-85	-98	-98	49	-105	-85	-83	-104
20	-101	-96	-87	-100	50	-86	-96	-84	-104

21	-86	-103	-86	-108	51	-82	-103	-77	-78
22	-99	-96	-79	-82	52	-86	-96	-103	-76
23	-83	-97	-103	-85	53	-83	-97	-97	-107
24	-82	-103	-99	-69	54	-95	-103	-75	-101
25	-93	-90	-97	-102	55	-87	-90	-79	-75
26	-107	-88	-88	-82	56	-62	-88	-102	-90
27	-86	-79	-86	-85	57	-86	-79	-85	-106
28	-78	-104	-90	-84	58	-83	-104	-86	-89
29	-96	-102	-106	-105	59	-78	-102	-84	-105
30	-99	-104	-78	-71	60	-82	-104	-89	-102

Table 5B: Average rate of signal changes for September 2011 Measurements (from Table 5A)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 -0630hr	-101 or less	10	no network reception
	-100 to -91	13	weak network reception
	-90 to -81	11	moderate network reception
	-80 or above	26	good network reception
0800 -0900hr	-101 or less	25	no network reception
	-100 to -91	14	weak network reception
	-90 to -81	09	moderate network reception
	-80 or above	12	good network reception
1100 -1200hr	-101 or less	13	no network reception
	-100 to -91	14	weak network reception
	-90 to -81	10	moderate network reception
	-80 or above	23	good network reception
1900 -2000hr	-101 or less	26	no network reception
	-100 to -91	12	weak network reception
	-90 to -81	14	moderate network reception
	-80 or above	08	good network reception

Table 6: Average of the five Months Measurement for each observation period

Table 6A - Average of the 5 Months Measurements for low call period (0530hr – 0630hr)

Average of Received signal b/w 0530 – 0630 hrs							Average of Received signal b/w 0530 – 0630 hrs						
Time In Min	Received signal in dBm					Avg of 5 Month	Time In Min	Received signal in dBm					Avg of 5 Month
	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011			Dec. 2010	March 2011	June 2011	July 2011	Sept 2011	
1	-82	-88	-82	-78	-89	-84	31	-86	-101	-78	-78	-89	-86
2	-68	-90	-84	100	-100	-88	32	-105	-97	-103	-103	-90	-100
3	-100	-100	-86	-90	-78	-91	33	-75	-96	-103	-103	-82	-92
4	-101	-102	-100	-102	-82	-97	34	-100	-87	-100	-100	-96	-97
5	-89	-80	-98	-86	-102	-91	35	-98	-85	-97	-97	-78	-91
6	-78	-78	-78	-85	-99	-84	36	-79	-78	-89	-89	-101	-87
7	-68	-79	-102	-103	-89	-88	37	-78	-86	-92	-92	-79	-85
8	-88	-75	-91	-87	-90	-86	38	-81	-106	-89	-89	-89	-91
9	-99	-104	-80	-79	-105	-93	39	-87	-99	-83	-83	-90	-88
10	-80	-98	-90	-105	-104	-95	40	-102	-84	-78	-78	-98	-88
11	-103	-97	-101	-90	-89	-96	41	-82	-85	-99	-99	-92	-91
12	-88	-90	-104	-93	-98	-95	42	-87	-87	-96	-96	-78	-89
13	-81	-88	-106	-86	-78	-88	43	-84	-82	-87	-87	-106	-89
14	-86	-102	-82	-108	-103	-96	44	-86	-102	-88	-88	-100	-93
15	-85	-89	-79	-82	-86	-84	45	-85	-99	-83	-83	-99	-90
16	-81	-88	-89	-81	-98	-87	46	-105	-99	-102	-102	-88	-99
17	-86	-88	-100	-106	-83	-93	47	-83	-87	-103	-103	-83	-92
18	-81	-89	-99	-96	-104	-94	48	-84	-85	-82	-82	-79	-82
19	-101	-98	-105	-97	-79	-96	49	-87	-82	-85	-85	-105	-89
20	-81	-99	-98	-88	-101	-93	50	-81	-105	-89	-89	-86	-90
21	-83	-105	-82	-89	-86	-89	51	-96	-85	-87	-87	-82	-87
22	-82	-80	-83	-95	-99	-88	52	-90	-84	-79	-79	-86	-84
23	-82	-78	-104	-87	-83	-87	53	-82	-84	-96	-96	-83	-88
24	-97	-85	-85	-98	-82	-89	54	-89	-80	-90	-90	-95	-89
25	-83	-86	-88	-104	-93	-91	55	-81	-83	-89	-89	-87	-86
26	-82	-88	-90	-98	-107	-93	56	-82	-85	-85	-85	-62	-80
27	-104	-99	-108	-80	-86	-95	57	-100	-102	-76	-76	-86	-88
28	-85	-80	-103	-100	-78	-89	58	-102	-89	-79	-79	-83	-86
29	-89	-87	-88	-102	-96	-92	59	-86	-87	-82	-82	-78	-83
30	-95	-100	-87	-84	-99	-93	60	-89	-78	-83	-83	-82	-83

Table 6B - Average of the 5 Months Measurements for Heavy Call Period (0800hrs – 00900hrs)

Average of Received signal b/w 0800 – 0900 hrs							Average of Received signal b/w 0800 – 0900 hrs						
Time	Received signal in dBm					Avg of 5 Month	Time	Received signal in dBm					Avg of 5 Month
In Min	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011		In Min	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011	
1	-102	-104	-102	-102	-101	-102	31	-101	-103	-86	-94	-101	-97
2	-101	-78	-101	-99	-102	-96	32	-90	-103	-103	-95	-102	-99
3	-100	-100	-100	-102	-101	-101	33	-89	-102	-102	-88	-101	-96
4	-99	-98	-98	-102	-100	-99	34	-102	-105	-101	-101	-100	-102
5	-90	-90	-90	-102	-101	-95	35	-101	-98	-86	-104	-101	-98
6	-101	-99	-89	-101	-102	-98	36	-78	-97	-87	-89	-102	-91
7	-106	-101	-102	-98	-102	-102	37	-84	-89	-98	-75	-102	-90
8	-79	-102	-104	-90	-99	-95	38	-83	-108	-92	-96	-99	-96
9	-88	-90	-102	-73	-99	-90	39	-69	-106	-78	-103	-99	-91
10	-100	-89	-99	-103	-98	-98	40	-104	-88	-103	-86	-98	-96
11	-102	-104	-97	-78	-104	-97	41	-103	-86	-100	-80	-104	-95
12	-103	-68	-85	-105	-89	-90	42	-76	-104	-78	-105	-89	-90
13	-75	-69	-84	-98	-78	-81	43	-68	-103	-104	-100	-78	-91
14	-99	-106	-105	-83	-105	-100	44	-110	-102	-106	-85	-105	-102
15	-102	-72	-88	-76	-77	-83	45	-87	-103	-98	-79	-77	-89
16	-105	-74	-86	-105	-79	-90	46	-78	-105	-97	-106	-79	-93
17	-92	-103	-108	-102	-106	-102	47	-103	-82	-84	-101	-106	-95
18	-86	-102	-96	-96	-98	-96	48	-86	-84	-102	-98	-98	-94
19	-80	-101	-97	-89	-85	-90	49	-103	-83	-105	-94	-85	-94
20	-102	-99	-89	-74	-96	-92	50	-99	-103	-88	-88	-96	-95
21	-104	-88	-108	-99	-103	-100	51	-95	-79	-77	-87	-103	-88
22	-101	-102	-98	-107	-96	-101	52	-89	-77	-103	-106	-96	-94
23	-81	-100	-93	-83	-97	-91	53	-86	-107	-84	-94	-97	-94
24	-106	-98	-95	-77	-103	-96	54	-110	-80	-84	-89	-103	-93
25	-89	-89	-89	-104	-90	-92	55	-100	-72	-103	-108	-90	-95
26	-96	-86	-105	-78	-88	-91	56	-89	-102	-106	-96	-88	-96
27	-98	-102	-103	-103	-79	-97	57	-102	-100	-108	-78	-79	-93
28	-103	-103	-105	-102	-104	-103	58	-83	-99	-71	-109	-104	-93
29	-81	-102	-79	-103	-102	-93	59	-102	-103	-82	-80	-102	-94
30	-102	-99	-80	-103	-104	-98	60	-86	-98	-103	-104	-104	-99

Table 6C - Average of the 5 Months Measurements for Light Call Period (1100hrs – 1200hrs)

Average of Received signal from 1100 – 1200 hrs							Average of Received signal from 1100 – 1200 hrs						
Time In Min	Received signal in dBm					Avg of 5 Month	Time In Min	Received signal in dBm					Avg of 5 Month
	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011			Dec. 2010	March 2011	June 2011	July 2011	Sept 2011	
1	-80	-91	-89	-78	-90	-86	31	-69	-78	-78	-104	-105	-87
2	-89	-93	-68	-81	-102	-87	32	-99	-105	-81	-100	-102	-97
3	-102	-89	-104	-102	-100	-99	33	-101	-100	-102	-99	-104	-101
4	-100	-102	-99	-100	-98	-100	34	-86	-98	-100	-102	-106	-98
5	-82	-79	-100	-90	-90	-88	35	-83	-95	-90	-101	-97	-93
6	-81	-82	-80	-104	-76	-85	36	-87	-89	-104	-89	-99	-94
7	-79	-77	-103	-75	-100	-87	37	-76	-88	-75	-75	-100	-83
8	-80	-104	-73	-98	-102	-91	38	-82	-79	-98	-69	-104	-86
9	-103	-83	-98	-105	-79	-94	39	-90	-84	-105	-86	-78	-89
10	-101	-85	-86	-90	-82	-89	40	-98	-104	-90	-107	-106	-101
11	-99	-69	-105	-86	-68	-85	41	-102	-88	-86	-98	-102	-95
12	-89	-101	-99	-73	-86	-90	42	-80	-77	-73	-98	-83	-82
13	-87	-98	-90	-99	-101	-95	43	-81	-98	-99	-88	-108	-95
14	-80	-90	-88	-103	-101	-92	44	-81	-88	-103	-89	-85	-89
15	-78	-89	-79	-86	-98	-86	45	-89	-87	-86	-74	-88	-85
16	-82	-70	-72	-67	-88	-76	46	-86	-79	-67	-101	-106	-88
17	-106	-100	-103	-105	-100	-103	47	-95	-107	-105	-83	-96	-97
18	-68	-97	-102	-75	-104	-89	48	-105	-88	-75	-78	-98	-89
19	-98	-90	-87	-95	-98	-94	49	-81	-79	-95	-89	-104	-90
20	-86	-102	-80	-94	-87	-90	50	-82	-97	-94	-86	-104	-93
21	-83	-101	-82	-85	-86	-87	51	-85	-99	-85	-86	-78	-87
22	-79	-90	-85	-82	-79	-83	52	-85	-80	-82	-77	-76	-80
23	-106	-89	-103	-83	-103	-97	53	-85	-86	-83	-104	-107	-93
24	-88	-82	-80	-106	-99	-91	54	-84	-74	-106	-87	-101	-90
25	-82	-79	-85	-85	-97	-86	55	-97	-86	-85	-98	-75	-88
26	-81	-80	-86	-80	-88	-83	56	-93	-101	-80	-85	-90	-90
27	-85	-82	-82	-89	-86	-85	57	-106	-103	-89	-82	-106	-97
28	-103	-106	-88	-86	-90	-95	58	-92	-100	-86	-86	-89	-91

29	-87	-89	-84	-85	-106	-90	59	-73	-99	-85	-78	-105	-88
30	-80	-87	-74	-86	-78	-81	60	-95	-74	-86	-76	-102	-87

Table 6D - Average of the 5 Months Measurements for Heavy Call Period2 (1900hrs – 2000hrs)

Average of Received signal from 1900 – 2000 hrs							Average of Received signal from 1900 – 2000 hrs						
Time	Received signal in dBm					Avg of 5 Month	Time	Received signal in dBm					Avg of 5 Month
In Min	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011		In Min	Dec. 2010	March 2011	June 2011	July 2011	Sept 2011	
1	-101	-103	-103	-100	-99	-101	31	-100	-97	-88	-101	-105	-101
2	-101	-102	-103	-98	-103	-101	32	-102	-97	-102	-102	-102	-98
3	-100	-102	-100	-103	-109	-103	33	-103	-102	-86	-105	-104	-101
4	-102	-90	-99	-104	-102	-99	34	-89	-102	-103	-100	-106	-100
5	-101	-87	-90	-105	-98	-96	35	-103	-90	-105	-99	-97	-100
6	-99	-98	-105	-96	-100	-100	36	-80	-86	-98	-74	-99	-99
7	-90	-105	-82	-90	-104	-94	37	-78	-82	-95	-106	-100	-87
8	-104	-97	-78	-89	-90	-92	38	-77	-78	-87	-87	-104	-92
9	-98	-96	-109	-100	-88	-98	39	-106	100	-101	-86	-78	-87
10	-96	-79	-99	-106	-99	-96	40	-107	-104	-103	-103	-106	-94
11	-87	-104	-89	-94	-104	-96	41	-108	-105	-89	-102	-102	-105
12	-108	-103	-105	-79	-99	-99	42	-86	-89	-80	-101	-83	-101
13	-104	-105	-103	-103	-76	-98	43	-102	-87	-105	-96	-108	-88
14	-103	-100	-98	-95	-79	-95	44	-81	-85	-109	-86	-85	-100
15	-100	-96	-96	-78	-101	-94	45	-73	-100	-105	-105	-88	-89
16	-99	-98	-98	-102	-102	-100	46	-107	-105	-100	-105	-106	-94
17	-110	-106	-87	-85	-87	-95	47	-106	-109	-97	-86	-96	-105
18	-80	-109	-82	-86	-90	-89	48	-82	-107	-83	-93	-98	-99
19	-78	-88	-101	-105	-98	-94	49	-105	-106	-102	-104	-104	-93
20	-103	-72	-100	-83	-100	-92	50	-104	-97	-87	-101	-104	-104
21	-102	-101	-86	-99	-108	-99	51	-89	-78	-86	-96	-78	-99
22	-100	-102	-78	-77	-82	-88	52	-85	-77	-104	-105	-76	-85
23	-99	-102	-104	-103	-85	-99	53	-88	-83	-97	-109	-107	-89
24	-98	-96	-77	-88	-69	-86	54	-104	-102	-84	-105	-101	-97
25	-103	-86	-109	-78	-102	-96	55	-102	-103	-102	-79	-75	-99
26	-89	-87	-82	-107	-82	-89	56	-86	-99	-81	-105	-90	-92
27	-90	-99	-88	-84	-85	-89	57	-85	-90	-86	-105	-106	-92

28	-109	-103	-103	-82	-84	-96	58	-108	-89	-102	-89	-89	-94
29	-100	-101	-102	-104	-105	-102	59	-85	-80	-101	-101	-105	-95
30	-89	-101	-101	-102	-71	-93	60	-110	-104	-102	-102	-102	-94

Table 7: Summary of the average of the five Months Experiments for each observation period

Time In Min	Received signal average in dBm for				Time in min	Received signal average in dBm for			
	0530 - 0630hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr		0530 - 0630hr	0800 - 0900hr	1100 - 1200hr	1900 - 2000hr
1	-84	-102	-86	-101	31	-86	-97	-87	-101
2	-88	-96	-87	-101	32	-100	-99	-97	-98
3	-91	-101	-99	-103	33	-92	-96	-101	-101
4	-97	-99	-100	-99	34	-97	-102	-98	-100
5	-91	-95	-88	-96	35	-91	-98	-93	-100
6	-84	-98	-85	-100	36	-87	-91	-94	-99
7	-88	-102	-87	-94	37	-85	-90	-83	-87
8	-86	-95	-91	-92	38	-91	-96	-86	-92
9	-93	-90	-94	-98	39	-88	-91	-89	-87
10	-95	-98	-89	-96	40	-88	-96	-101	-94
11	-96	-97	-85	-96	41	-91	-95	-95	-105
12	-95	-90	-90	-99	42	-89	-90	-82	-101
13	-88	-81	-95	-98	43	-89	-91	-95	-88
14	-96	-100	-92	-95	44	-93	-102	-89	-100
15	-84	-83	-86	-94	45	-90	-89	-85	-89
16	-87	-90	-76	-100	46	-99	-93	-88	-94
17	-93	-102	-103	-95	47	-92	-95	-97	-105
18	-94	-96	-89	-89	48	-82	-94	-89	-99
19	-96	-90	-94	-94	49	-89	-94	-90	-93
20	-93	-92	-90	-92	50	-90	-95	-93	-104
21	-89	-100	-87	-99	51	-87	-88	-87	-99
22	-88	-101	-83	-88	52	-84	-94	-80	-85
23	-87	-91	-97	-99	53	-88	-94	-93	-89
24	-89	-96	-91	-86	54	-89	-93	-90	-97
25	-91	-92	-86	-96	55	-86	-95	-88	-99
26	-93	-91	-83	-89	56	-80	-96	-90	-92
27	-95	-97	-85	-89	57	-88	-93	-97	-92

28	-89	-103	-95	-96	58	-86	-93	-91	-94
29	-92	-93	-90	-102	59	-83	-94	-88	-95
30	-93	-98	-81	-93	60	-83	-99	-87	-94

Table5: Summary of the average rate of signal changes for the five Months Experiments for each observation period (from table 4)

Period	Received Power (dBm)	Rate of Received Signal changes within the range	Network indication associated with the received power level
0530 - 0630hr	-101 or less	0	no network reception
	-100 to -91	26	weak network reception
	-90 to -81	33	moderate network reception
	-80 or above	1	good network reception
0800 - 0900hr	-101 or less	8	no network reception
	-100 to -91	42	weak network reception
	-90 to -81	10	moderate network reception
	-80 or above	0	good network reception
1100 - 1200hr	-101 or less	3	no network reception
	-100 to -91	21	weak network reception
	-90 to -81	34	moderate network reception
	-80 or above	2	good network reception
1900 - 2000hr	-101 or less	10	no network reception
	-100 to -91 ;	39	weak network reception
	-90 to -81	11	moderate network reception
	-80 or above	0	good network reception

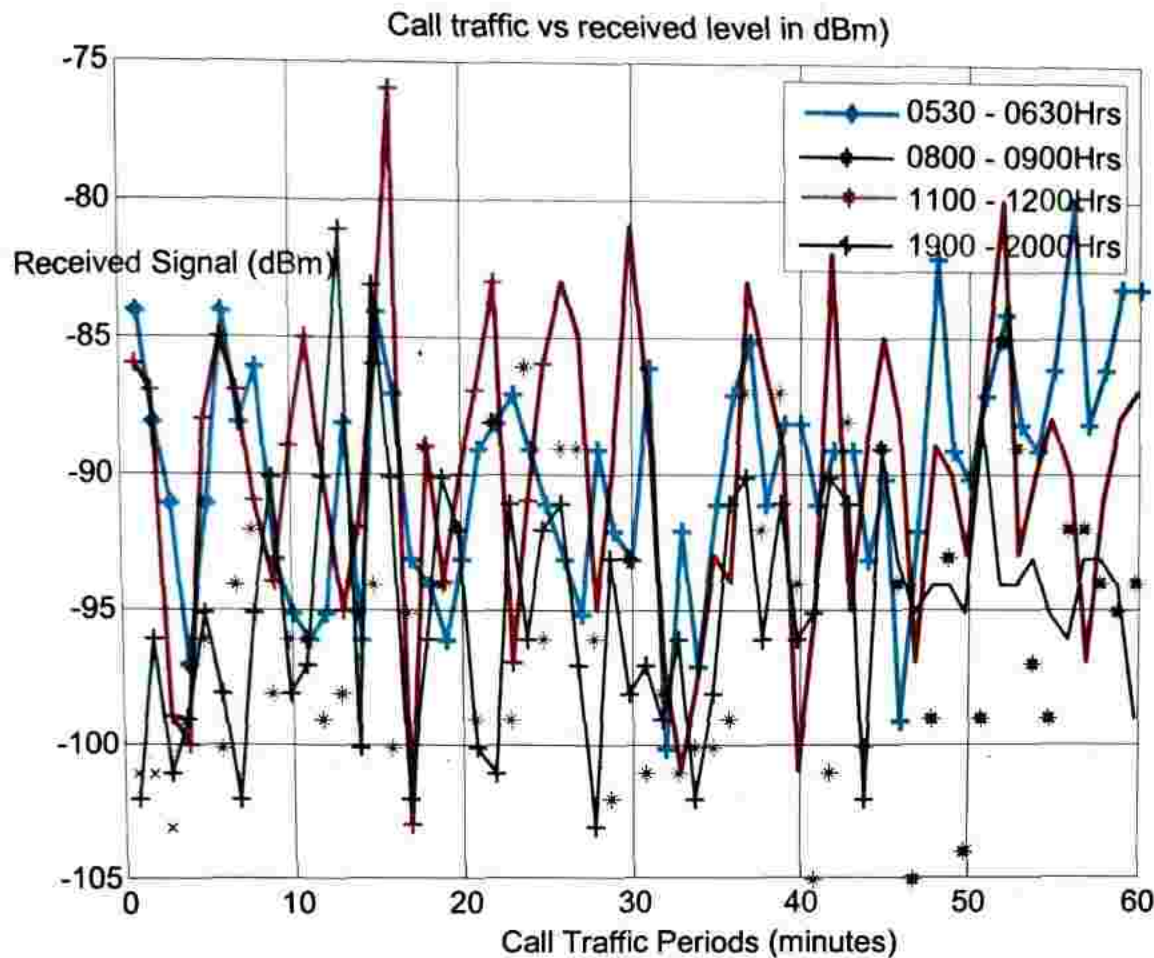


Fig.2: Signal Variations during different call periods in GSM Networks

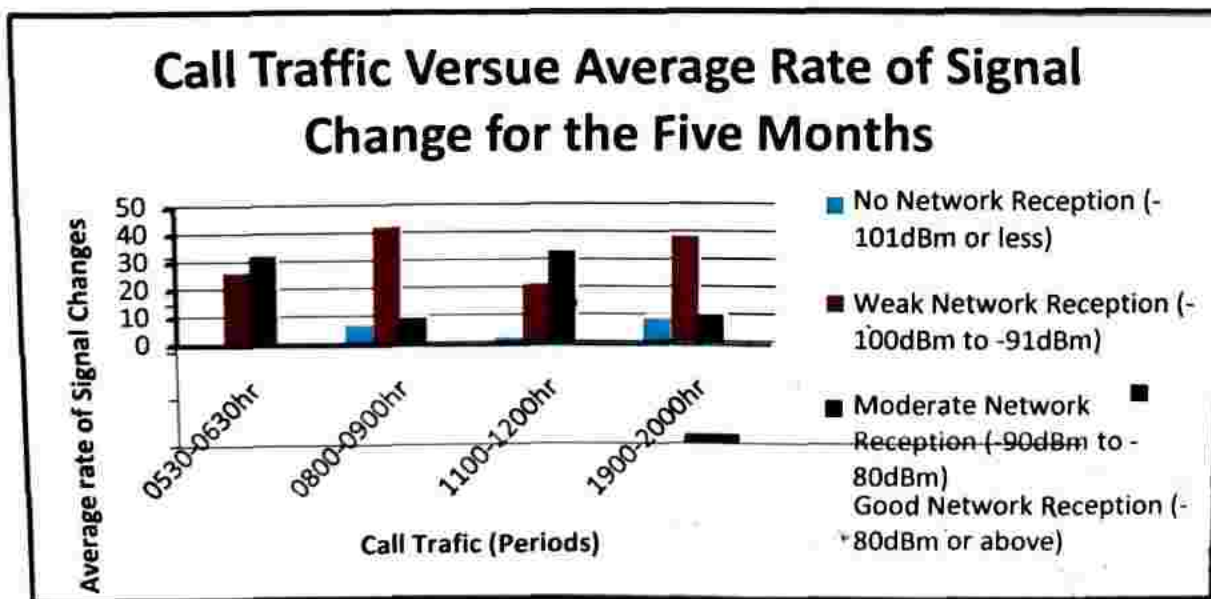


Figure 3: Average Rate of signal fluctuations for each observation periods

5.0 Analysis

From [10], when received signal level at any point in the network coverage area is -101dBm and less, the mobile receiver at such point will indicate 'no network reception' meaning that the node will not be able to either initiate or receive

communication. At -100 to -91dBm , the node will 'indicate weak signal reception', meaning that the probability of initiating, receiving or sustaining calls at that level is very small. At -90 to -81dBm , the node will 'indicate moderate network reception', meaning that the probability

of initiating and receiving calls at that level is high.

If the signal is at -80dBm and above, the node will 'indicate good network reception', meaning that the probability of initiating and receiving calls at that level is very high. If moderate network reception (-90dBm to -81dBm) is taken as the base line for good communication, it can be seen clearly from the field experiments shown in Fig.2 above that, at point X,

- (a) Only about 18% of network receptions crossed the base line during heavy call periods, while about 60% crossed the base line during light and low call periods.
- (b) Signal variations moves more toward its worst cases during the busy hours (0800hrs – 0900hrs and 1900 – 2000hrs) and less during the less busy periods (0530 – 0630hrs & 1100 – 1200hrs).

And from Fig.3, it also can be seen that the rate of signal variations are more frequent during heavy call periods and less during light and low call periods.

Therefore, the pattern of the effect of call traffic on GSM signal receptions is that the more the number of network users on the network the less received signal level at any point or location in that network coverage area.

6.0 Conclusion

Signal fluctuations observed in GSM networks during busy hours which this work has established, can be attributed to high power demand from the transmitter on account of more mobile stations being deployed to the network at such periods. Hence as volume of calls increases call interruptions, blocked calls, call drops etc are likely to increase also. There is therefore the need to increase transmitter power if a good network signal reception is to be maintained during heavy call periods in GSM networks.

This work will help network operators decide on the type of automatic power control to be deployed at the base transceivers to reduce received signal fluctuations especially during heavy call or high network demand periods .

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