Effects of Upsurge of Human Traffic on the Quality of Service of GSM Network in Eagle Square Abuja, Nigeria.

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ABSTRACT: Due to the rapid increase in the number of mobile subscribers in Abuja, Nigeria the optimization and performance evaluation of GSM network quality is therefore a key parameter in the race for subscribers and this can only be achieved where the network is sufficiently optimized to meet the grade of services expected from its subscribers/customers. This research is aimed at finding the panacea to the effects and defects of GSM network especially during Human upsurge so as to improve and ensure better quality of service for the generality of the subscribers.

Keywords: BTS, GSM Network, KPI, NCC, QoS, Subscribers, Upsurge Human Traffic

1. INTRODUCTION

It was a sigh of relief for Nigerians when the Global System for Mobile Communication (GSM) license was auctioned by the Nigeria Communications Commission (NCC) in February 2001, having been denied access to efficient and quality telecommunication services for quite a long time. However, the euphoria of the GSM launch in the country and subsequent commencement of services was soon to give way to a litany of complaints by subscribers to the various GSM networks. Poor quality of service became common place and a national issue, which had to be brought before the country`s House of Representatives in July 18, 2007 and the NCC, [1]. To find a lasting solution to the problem, the federal government through the regulating body for telecommunication services in Nigeria, the NCC, issued a benchmark on the key performance indicators (KPIs) for ascertaining quality of service of all the GSM networks in the country.

The network having been launched for over ten year now, have witnessed a little improvement in terms of better coverage and availability but the quality of service generally is still very far from being satisfactory, especially during major events when there is an upsurge of people for its attendance [29].

GSM network performance and QoS evaluation are most important steps for the mobile operator as the revenue and customer satisfaction is directly related to network quality and performance [15].

Network quality is therefore a key parameter in the race for subscribers and this can only be achieved where the network is sufficiently optimized to meet the grade of services expected from its customers. [25], suggested that GSM is not yet optimized and this is a motivation to trigger new research topics in optimization and performance evaluation due to the rapidly increased number of mobile subscribers.

The ultimate purpose of the research is to establish a baseline that correlates network quality and performance within an area with the upsurge of people during major events and characterize such areas where improvement can be achieved in terms of upgrading/optimizing the network elements preparatory to such events taking place. In addition to finding bottlenecks militating against optimal network performance, this work aims to identify the cause or the limiting factor impeding good quality of service and hence, select a management action to remove the problems and safeguard quality of service degradations [29].

2. REVIEW OF PREVIOUS WORKS.

Network Performance Management and Optimization is necessary to access network performance and maintain quality of Service (QoS) standards. It identifies inconsistencies or limitations in current overall network design and helps to improve processes. Thus, resulting in optimized networks and improved quality of service due to this fact there has been

much research concerning the quality of service (QoS) of Global System of Mobile Communication (GSM).

An appraisal of the performance of GSM operators using Nigeria as a case study and examined the problems facing the industry [1]. Having evaluated the parameters that attributed to poor quality of service by operators, they came up with methods that are suggested towards improving network performance. The methods suggested did not take into consideration the nature of user demands and capacity of channels. They only focused on improving the performance of the network elements.

Network performance evaluation and quality of service (QoS) improvement of mobile cellular systems in Nigeria using an ICH as a case study [28]. In this work the important Key Performance Indicators (KPIs) for QoS evaluation which are used in evaluating the Mobile networks was also identified. The result of their study show that the QoS of mobile system in the country is not 100% reliable and still needs to be improved upon.

In [11], the customer's complaint method was used to investigate performance evaluation on QoS of GSM networks in Nigeria. They employed four assessment parameters; network accessibility, service retainability, connection quality and network coverage for their investigation and concluded that the QoS and overall performance of the GSM operations in Nigeria is poor, unreliable and unsatisfactory. The building of more base stations to increase network coverage and ease congestion was recommended to the service providers, for an improved QoS and overall performance of their networks.

However [4], showed that an existing network can be optimized using different methodologies and time parameter tuning to offer remarkable QoS to the end users. They recommended that all mobile operators must ensure a better QoS up to a certain threshold and baselines in order to satisfy official regulatory bodies by ensuring robust and continuous optimization of their networks. Live network statistical model was employed to arrive at their conclusions and recommendations.

In Radio Access Network Quality Improvement Techniques [18] used drive test statistics to estimate the coverage and receive qualities of two GSM operators towards an improved network.

The NCC, as reported in the Guardian Newspaper of March 22, 2005 also used the drive test method in its report on Network Quality of Service and performance of the GSM networks in Nigeria.

In [6], the railway environment was used in investigating GPRS KPI measurement techniques through manual and automated field concepts. The railway environment presents a unique challenge for cellular radio coverage because of its difficult terrain by the fact that the train and mobile stations (MSs) may travel at very high speeds. They concluded that GPRS throughput performance decreases with increased mobility of the mobile station and recommended that the removal of mobility effect from trial measurements on railways would improve their comparability to stationary measurements, which are typically used for establishing KPI levels.

A knowledge based model can also be used to analyze the performance of a GSM network. In [20], data records from an operational GSM network was used to analyze network performance by employing a subsystem hierarchy for their data analysis. Four main components of user perceived quality were adopted for their investigation. These are cause–effect chains for blocking of services, call set up failures, call dropping and hand over failures. They concluded that knowledge of the cause effect chains generating the subscriber perceived quality problems can be used to enhance current radio resource usage in an operating network.

The last but not the least commonly used method to evaluate network performance is by the network data itself. The

network service providers install on their networks a Network Management System (NMS) with an online database that is responsible for the collection of everything that happens on its network, in a raw data form. In order to measure network performance and offer good quality of service for customer satisfaction and retention, this data is analysed and evaluated to spots events, trends, problems areas and key performance indicators. The availability of a detailed report on these trends and data aggregation allows for a faster and more accurate analysis and resolutions of customer complaints towards an efficient network with good QoS [26].

By the very nature that these reports show problem areas of the network in raw data form, it is seriously guarded by the network service providers. This has been the problem that previous researchers face in the adoption of network statistics method for performance analysis and evaluations. This underscores why research in the area (network statistics method), though most reliable compared to others, has not been very robust relative to the other two, earlier mentioned. I was able to obtain a solution that provides full visibility of the network data of an operational GSM network by which this research was undertaken. It is one of the best performance monitoring and evaluation techniques or methodology.

3. CELLULAR NETWORK PERFORMANCE

The operation of a cellular network can be interpreted to consist of a sequence of events. From network operations point of view, certain events are closely associated with bad performance, lack of resources or failures. The entire network event such as call drops, call initiation, traffic channel assignment, traffic channel release, traffic channel demand and many more are reported to the Base Station Controller (BSC) by the Base Transceiver Station (BTS). Therefore, different counters are being triggered against different events. An event either increases or decreases a specific counter value. The counters are computed by the BSC over a measurement period (typically one hour) and stored in the Network Management System. But this data is in the raw form and doesn't depict any meaningful information until it is interpreted using some formulation in the form of KPIs. Hence evaluation criteria use counters and KPIs to depict network QoS as a whole. These KPIs when taken together, forms the overall QoS report for the entire network in terms of service accessibility, retainability and connection quality as reported by [23].

4. SERVICE ACCESSIBILITY

This is the ease with which the service is obtained within a specified threshold and derivable when requested by the user. For instance, a short message service, SMS, sent by subscriber "A" to subscriber "B" switched ON and within the service area is set at five seconds by the regulatory authority, NCC (2009). If the message is not delivered after five seconds as bench marked by the regulator, the service is hence, inaccessible. The target for SMS success rate as set by the NCC is 100%. Accessibility is therefore the number of successful calls set up per the total number of calls access to the network.

The most common KPIs connected to accessibility are as listed below:

4.1. Paging success rate

The paging success rate measures the percentage of paging attempts that have been answered, either as a result of the first or the second repeated page.

$$\textbf{PSR} = \frac{\text{Time of Paging Responses}}{\text{Time of Paging}}$$

Possible reasons for poor Paging Performance could be traceable to:

- Paging congestion in MSC
- Paging congestion in BSC
- Paging congestion in Base Transceiver Station (BTS)
- Poor paging strategy
- Poor parameter setting
- Poor coverage
- High interference

The Nigerian Communications Commission, NCC, set this KPI at 95% of attempts for the busy hour.

4.2. SDCCH Access Success Rate.

SDCCH access success rate is a percentage of all SDCCH accesses received in the BSC.

Possible reasons for poor SDCCH Access Performance could be:

- Too High Timing Advance (MHT)
- Access Burst from another Co-channel, Co-BSIC Cell
- Congestion
- False Accesses due to High Noise Floor
- Unknown Access Cause Code

The busy hour SDCCH congestion as set by the NCC to be measured both at the BSC and cell level is 2%.

4.3. SDCCH Drop Rate

The SDCCH DROP RATE statistics compares the total number of RF losses (while using an SDCCH), as a percentage of the total number of call attempts for SDCCH channels. This statistics is intended to give an indication of how good the cell/system is at preserving calls.

$$\textbf{SDCCH Drop Rate} = \frac{\text{SDCCH Drops}}{\text{SDCCH Seizures}}$$

Possible reasons for SDCCH RF Loss include:

- Low Signal Strength on Down or Uplink
- Poor Quality on Down or Uplink
- Too High Timing Advance
- Congestion on TCH

The set target for this KPI is below 1.2%.

4. 4. Call Setup Success Rate (CSSR)

The QoS of a network can also be ascertained by the user experience in establishing a call. It can be very frustrating for the subscriber to a network that after repeated dialing, especially in an emergent situation, he cannot get his call through to the call party. The Call Setup Success Rate gives the fraction of attempts to establish a call which results in a successful connection to the dialed number. It is the ease by which a call is connected after a dial and measures successful TCH assignments over the total number of TCH assignment attempts. This KPI can be calculated using the following expression:

CSSR = (1 - *SDCCH Congestion Rate*)* *TCH Assignment Success Rate*

The following are some of the reasons which accounts for a low call setup success rate in a cell;

- Radio interface congestion.
- Effects of Interference and fading.
- Poor coverage.
- Faulty hardware units.
- Increase in radio traffic in inbound network.
- Limitations in access network transmission path.

Low CSSR can be improved by taking the following corrective actions:

- Upgrade and enhancement of radio resources.
- Expansion of the transport media to accommodate hardware upgrades such as addition of more TRXs to the congested cell.
- Reduction of mean time to repair (MTTR) where faults occur, to ensure resource availability.

The target for this KPI as set by the NCC is 98%.

4.5. Call Setup TCH Congestion Rate

The Call Setup TCH Congestion Rate statistics provides the percentage of attempts to allocate a TCH call setup that were blocked in a cell.

$$\textbf{Call Setup TCH Congestion Rate} = \frac{\textit{No of TCH Blocks (Excluding HO)}}{\textit{No of TCH Attempts}}$$

Possible reasons for call setup block include:

- Increasing Traffic Demand
- Bad Dimensioning
- HW Fault & Installation Fault
- High Antenna Position
- High Mean Holding Time (MHT)
- Low Handover Activity
- Congestion in Surrounding Cells

The set target for this KPI by NCC is below 2%.

5. SERVICE RETAINABILITY

Service retainability refers to the ability of the provided service, once it has been obtained, to continue unhindered for the requested duration. It is a measure of the probability that a call, once it has been connected, will not be disengaged or terminated until there is a sign off by the parties involved.

Retainability can thus be given as:

$$\textbf{Retainability} = \frac{\text{Total Calls Completed}}{\text{Total Successful Calls setup}}$$

The KPIs connected to service retainability are listed below.

5.1. Call Drop Rate

This KPI gives the rate of calls not completed successfully. This is expressed as:

$$\textbf{CDR} = \frac{\text{Number of TCH Drops after assignment}}{\text{Total Number of TCH assignment}}$$

Possible reasons for TCH Drop Call Rate are:

- Low Signal Strength on Down or Uplink
- Lack of Best Server
- Congestion in neighboring cells
- Battery Flaw
- Poor Quality on Down or Uplink
- Too High Timing Advance
- Antenna problems
- Low BTS Output Power
- Missing Neighboring Cell Definitions
- Unsuccessful Outgoing Handover
- Unsuccessful Incoming Handover

The busy hour drop rate as set by NCC is below 2%.

5.2. Handover Success Rate

The handover success rate shows the percentage of successful handovers of all handover attempts. A handover attempt is when a handover command is sent to the mobile station. Poor handover success rate arises as a result of the following factors;

- Congestion
- Link Connection or HW Failure
- Bad Antenna Installation
- Incorrect Handover Relations
- Incorrect Locating Parameter Setting
- Bad Radio Coverage
- High Interference, Co-channel or Adjacent.

The busy hour Handover Success Rate set by NCC at all hours = 99%.

6. SERVICE AVAILABILITY

Availability is defined as the percentage of time that the basic physical channels are available for use. The path used to carry information between a Mobile station and the base transceiver stations is known as the physical channel. It is embedded in the air interface between the BTS and MS. The different information carried on the physical channels is classified as logical channels. The logical channels are divided into two categories; the control channels and the traffic channels. The percentage traffic channels, PTTCH available in a cell defines the availability of the cell. Thus for a BTS that is made up of three cells, the sum total of the PTTCH for all the cells makes up the availability of the BTS. The BTSs in the network must be available for that network to be accessible. The retainability of the network is also a function of PTTCH availability because we cannot retain what cannot be accessed. Network availability is therefore a pedestal by which the QoS of an operational network are measured. It is affected by faulty base station equipment, bad transmission links or wrong configuration parameters defined at the BSC. The target for this KPI as set by the NCC is 99%.

With the benchmark or KPIs defined by NCC as a baseline, juxtaposed with the data from an operating GSM network service provider, a comparison was made using several parametric indices of network assessment, enumerated above to analyze the performance of the network by cell clusters where there is mobility of people for an event and when the event is not holding in the area.

7. RESEARCH METHODOLOGY

The research was undertaken using a comparative process where the network statistics of an operational GSM service provider was investigated under the following metrics; Call Setup Success Rate (CSSR), Percentage Drop Call Rate (PDROP), Handover Success Rate (HOSR), Percentage TCH Congestion Rate (PCONG) and Percentage of unsuccessful Control Channel Setup (PCTRLFAIL) which shows the control channels that could not be setup or dropped, as an effect of Standalone Dedicated Control Channel congestion (SDCCH). These counters are taken together for QoS evaluations relative to the sites/cells covering an area of event while the event is taking place. The result is compared with the data obtained when there is no event and hence, fewer number of people in the same area.

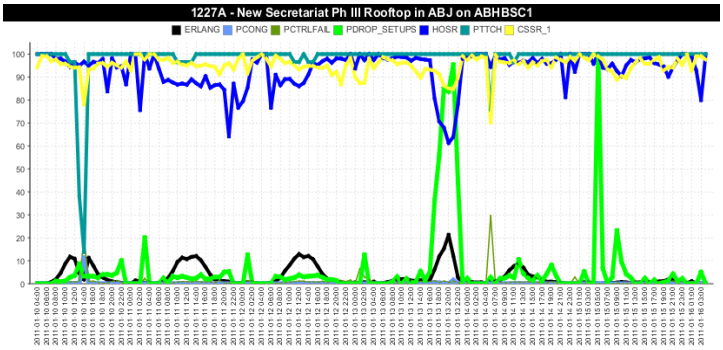
Typically, since the important KPIs for QoS evaluation describe the success/failure rates of the metrics outlined above and all of them are affected by PTTCH availability, this metric was also included in the analysis.

By using the network statistics, which gives a more accurate picture of the events in the network [4] in raw data, the metrics were investigated relative to the benchmark defined by NCC, for the period when there was heavy mobility of people within an area such as obtained This was done for the period while the event was taking place and when there was no event within the area specified.

The period and time selected for investigation were when there was high mobility or concentration of people specifically during the Presidential primaries of the People's Democratic Party, PDP, on 13th January 2011, at Eagles Square, Abuja. The BTSs covering these areas were critically examined at cell levels to estimate any change or patterns of behaviour when there is less concentration of human traffic and when there is an upsurge of crowd.

9. ANALYSIS OF DATA AND RESULT

The network data for the BTS covering the Eagle's Square at Abuja during the Presidential primaries of the People's Democratic Party, (PDP), held on the 13th of January 2011, was analysed. Table 2, Table 3 and Table 4 in the appendix gives the raw data corresponding to the graphs in Figure 1, Figure 2 and Figure 3 below for cell A, Cell B and Cell C of the BTS respectively.



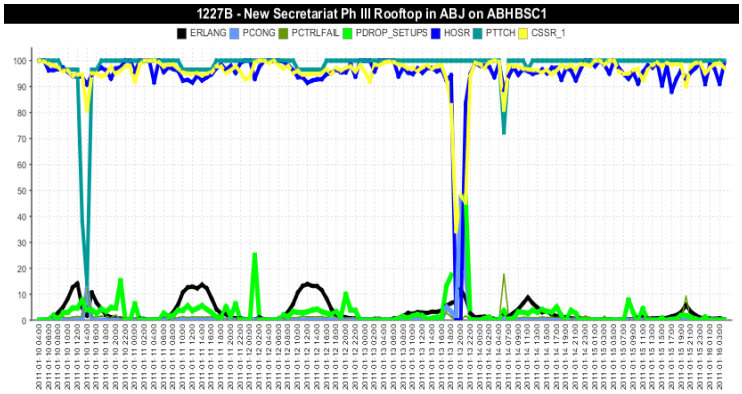


Figure 1: Graphical representation of results for stats, before, during & after PDP Primaries of 13th & 14 Jan. 2011(Cell A)

Figure 2: Graphical representation of results for stats, before, during & after PDP Primaries of 13th & 14 Jan. 2011(Cell B).

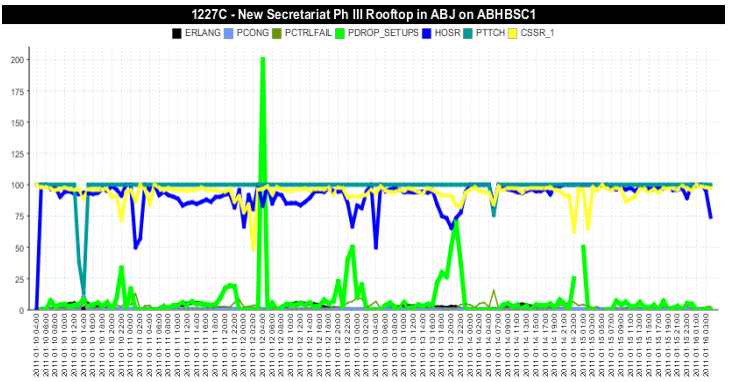


Figure 3: Graphical representation of results for stats, before, during & after PDP Primaries of 13th & 14 Jan. 2011(Cell C)

It was observed that between 1600hrs and 2200hrs on the 13th of September, 2011 the KPIs for the cells covering the area (Figure 1 and Figure 2) was at its worst. This was as a result of the upsurge of crowd for the Presidential primaries and apparently the quality of service of GSM network experienced within this area during this period would be anything but optimal. Consequently, the network quality and performance within an area is seriously affected by the mobility or upsurge of people in the locality.

As illustrated in the data analysis above, the network statistics of the operational GSM network were pooled under a measurement period of one hour for all hours of operation. The results were analysed through a comparative process by comparing the data obtained from the sample areas under a normal day occurrence and during events (where there is an upsurge of crowd) with the KPI targets as benchmarked by NCC. The summary of the results are shown below:

Table1: Coverage at Eagle's Square, Abuja.

KPIs	NCC	NORMAL DAY OCCURENCE %	STATISTICS DURING EVENTS %
PCONG	≤ 2.0%	0	1.5
PCTRLFAIL	≤ 1.2%	0.98	1.15
PDROP	≤ 2.0%	12.5	95.36
HOSR	≥ 99.0%	91.0%	61.29
CSSR	≥ 98.0%	90.2	84.72
PTTCH	≥ 98.5%	100	100

The results show that even for a normal day occurrence, that is, without any event attracting the upsurge of a crowd, the KPIs show a marked departure from the benchmark defined by NCC. The situation became worse during major events with the upsurge of people within the area. The percentage TCH congestion increases sharply within the period of events while the CSSR reduces. The percentage of unsuccessful control channel setup, which shows the control channels that couldn't be set up or dropped, increases within the period to show that there was high level congestion within the area as the available network elements servicing the area was not enough to meet up with the demand for signalling channels within the period. Overall, the accessibility to the network within the period reduces drastically and this explains why subscribers in that area cannot readily get a call through with their mobile stations.

10. CONCLUSION AND RECOMMENDATIONS

We can conclude that the quality of service of an operational GSM network in a given area like the area under investigation is mainly affected by the mobility or upsurge of people within the area at any given time. Therefore, network quality and performance within an area can be improved by a proactive optimization of the network and provision of contingencies like the deployment of mobile BTSs to accommodate any upsurge of human traffic especially during major events that attracts the mobility of people.

Poor handover success rates, low call setup success rate, frequent call drops etc, which affects the quality of service in an operational cellular network are pointers of an optimization head room. Due the many defects of GSM network such as poor handover success rates, low call setup success rate, frequently call drops just to mention but a few as pointed out by [26], GSM is not yet optimised. As a result of this, the following panacea are hereby recommended to enhance better quality of service of GSM network in Abuja in particular and Nigeria at large:

- The various GSM network providers should ensure a robust and vigorous optimization of its network for better service delivery to its numerous subscribers.
- There should not be reactive rather be proactive in the optimization models for the GSM network providers. This can be actualized for example before any major event in an area, the respective and various GSM network providers should deploy an I-site or a mobile BTS to such areas before the commencement of the event.
- The regulatory body that is NCC should wake up to its responsibility in the area of proper and appropriate supervision of the GSM networks to catholicon and ensure better quality of service for the generality of the subscribers.

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12. APPENDIX

Table 2: Statistics for BTS covering the Eagles Square before, during & after PDP Primaries of 13th & 14th Jan.2011 (Cell A)

ERLANG	PCONG	PCTRLFAIL	PDROP	HOSR	PTTCH	CSSR	DISPLAY				
0.22	0	0	0	100	100	94.23	01/10 04:00	0	0	100	100
0.03	0	0.4	0	100	100	99.21	01/10 05:00	0	0	75.64	100
0.12	0	0	0	100	100	99.15	01/10 06:00	2.27	20	100	100
0.75	0	0.17	0	100	100	96.84	01/10 07:00	0	0	93.75	100
2.01	0	0.41	1.17	98.02	100	97.09	01/10 08:00	0	0	100	100
4.63	0	0.67	0.85	98.01	100	95.62	01/10 09:00	0.27	0	93.75	100
8.7	0	0.52	1.23	96.76	100	95.18	01/10 10:00	0.67	2.44	87.91	100
11.73	0	0.81	2.79	94.42	96.55	94.25	01/10 11:00	0.36	0.52	88.74	100
10.83	0.04	0.75	3.63	96.41	96.55	94.5	01/10 12:00	0.39	3.2	87.64	100
4.5	0.09	0.98	8.51	94.94	37.93	94.34	01/10 13:00	0.67	2.68	86.76	96.55
1.89	11.25	19.97	3.28	96.71	13.79	78.1	01/10 14:00	0.91	3.19	87.15	96.55
11.24	0	0.94	3.31	95.02	100	93.29	01/10 15:00	0.76	2.67	86.7	96.55
7.82	0	1.09	3.21	96.59	100	93.71	01/10 16:00	0.69	2.1	89	96.55
4.16	0	0.6	2.6	96.12	100	95.29	01/10 17:00	1.05	2.42	87.32	100

10.2	0	0.73	3.88	85.95	100	940.762	01/10 15:00	0.15	0	97.69	100
7.27	0	0.72	2.04	90.36	100	951.524	01/10 16:00	0.41	0.98	98.19	100
4.01	0	0.82	2.12	85.36	100	941.795	01/10 17:00	0.36	2.99	98.94	100
1.89	0	0.4	2.84	86.47	100	941.398	01/10 18:00	0.33	0	98.76	100
1.35	0.27	1.25	2.83	86.74	100	912.17	01/10 19:00	0.25	2.17	98.49	100
1.13	0	0.3	5	84.46	100	951.034	01/10 20:00	1.52	0	97.14	100
0.89	0	0.22	5.26	64.22	100	961.026	01/10 21:00	0.39	0.91	98.39	100
0.3	0	0.42	0	87.1	100	931.244	01/10 22:00	1.04	5.36	97.89	100
0.19	0	0.69	0	76.67	100	971.953	01/10 23:00	0.72	1.43	97.6	100
0.32	0	0	0	79.49	100	991.953	01/11 00:00	0.93	5.3	97.32	100
0.58	0	1.22	12.5	85.42	100	916.54	01/11 01:00	1.2	36.16	80.59	100
0.51	0	1.43	0	97.62	100	971.1589	01/11 02:00	0.57	56.15	70.69	100
0.12	0	0	0	96.3	100	981.5229	01/11 03:00	1.15	85.51	67.92	100
0.03	0	0	0	100	100	992.1924	01/11 04:00	0.53	83.77	61.29	100
0.11	0	0	0	100	100	981.2323	01/11 05:00	1.17	95.36	63.94	100
0.37	0	0.13	0	76.67	100	942.678	01/11 06:00	0.44	44.55	78.21	100
1.08	0	0.16	3.17	90.96	100	990.325	01/11 07:00	0	0	97.96	100
2.59	0	0.34	2.91	86.44	100	970.975	01/11 08:00	0.43	2.33	99.11	100
5.59	0	0.52	1.75	89.08	100	960.163	01/11 09:00	0	0	99.14	100
8.12	0	0.64	2.21	89.17	100	960.651	01/11 10:00	0	0	100	100
10.91	0	0.88	2.65	87.11	96.55	950.057	01/11 11:00	0	0	100	100
12.87	0.03	1.11	3.76	86.05	96.55	930.319	01/11 12:00	0	0	100	100
11.6	0	1.07	3.02	87.44	100	941.483	01/11 13:00	29.66	2.78	94.44	75.86
12.04	0.03	0.66	3.23	91.11	96.55	940.797	01/11 14:00	0.21	0	99.39	100
10.62	0	0.76	3.37	96.02	96.55	941.859	01/11 15:00	0.67	2.24	97.71	100
7.5	0	0.65	3.67	95.28	100	943.217	01/11 16:00	0.38	2.48	98.19	100
4.26	0	1.02	2.8	96.9	100	945.026	01/11 17:00	0.58	3.49	95.33	100
2.25	0	0.48	1.91	97.99	100	957.065	01/11 18:00	0.68	2.62	96.97	96.55
1.11	0	0.93	1.79	96.26	100	908.974	01/11 19:00	0.7	10.45	96.25	100
0.81	0	1.35	1.33	98.11	100	926.278	01/11 20:00	0.58	4.5	97.14	100
0.57	0	1.4	0	98.04	100	863.925	01/11 21:00	0.85	2.56	96.42	100
0.34	0	0.9	0	97.4	100	953.086	01/11 22:00	0.58	1.43	98.32	100
0.11	0	1.6	0	100	100	982.394	01/11 23:00	0.61	3.57	96.03	100
0.52	0	0	0	93.75	100	901.64	01/13 00:00	0.48	1.12	97.92	100
0.26	0	6.54	0	100	100	870.847	01/13 01:00	0.31	4.35	95.82	100
0.58	0	2.94	12.5	97.37	100	870.548	01/13 02:00	0.82	8.06	96.06	100
0.13	0	1.85	0	100	100	980.165	01/13 03:00	0.42	3.45	97.58	100
0.83	0	0	0	97.44	100	930.839	01/13 04:00	0.49	0	100	100
0.09	0	0.49	0	100	100	960.613	01/13 05:00	0	0	81.25	100
0.34	0	0.44	0	98.31	100	980.693	01/13 06:00	0	0	100	100

0.09	0	2.86	0	92.31	100	97.13	01/15 00:00	1.53	4.29	97.29	100
0.23	0	0	0	100	100	99.99	01/15 01:00	1.48	3.38	96.2	100
0.53	0	0	5.26	100	100	98.74	01/15 02:00	0.95	4.82	93.06	100
0.48	0	0	0	100	100	97.32	01/15 03:00	2	4.65	96.97	100
0.44	0	0	0	95.83	100	99.96	01/15 04:00	0.42	15.15	97.46	100
0.04	0	0	100	100	100	99.03	01/15 05:00	0.96	0	100	100
0.11	0	0	6.67	94.12	100	97.54	01/15 06:00	1.01	0	100	100
0.19	0	0	0	93.48	100	93.42	01/15 07:00	0.79	6.25	95.65	100
0.35	0	0	2.94	95.83	100	92.37	01/15 08:00	0	0	100	100
0.49	0	0.35	23.08	92.68	100	88.86	01/15 09:00	0	0	100	100
0.73	0	0	9.52	90.42	100	90.54	01/15 10:00	0	0	100	100
0.54	0	0.18	4.26	95.07	100	89.53	01/15 11:00	0	0	91.67	100
0.39	0	0.22	2.56	97.44	100	93.96	01/15 12:00	0	0	100	100
0.51	0	0.16	0	96.55	100	96.42	01/15 13:00	1.7	2.63	95.59	100
0.54	0	0.54	0	97.8	100	98.26	01/15 14:00	0.16	1.5	97.44	100
0.49	0	0.19	2.38	98.17	100	95.48	01/15 15:00	0.67	1.92	96.74	100
0.54	0	0	0	98.6	100	95.69	01/15 16:00	0.99	3.76	96.06	100
0.53	0	0.41	1.61	96.13	100	97.48	01/15 17:00	1.34	3.78	92.32	96.55
0.95	0	0.62	0	95.49	100	98.26	01/15 18:00	1.02	5.52	92.58	96.55
1.16	0	0.32	0.61	94.59	100	92.89	01/15 19:00	1.26	3.7	91.56	96.55
1.74	0	2.27	1.25	90.15	100	94.29	01/15 20:00	1.17	4.59	94.23	96.55
						13.64	0.03	1.15	5.51	92.39	96.55
						12.23	0	1.18	4.17	93.55	96.55
						8.4	0	1.29	2.87	94.77	96.55
						4.27	0	0.54	1.26	97.08	100
						2.5	0	0.62	0.96	98.52	100
						2.26	0	0.52	5.13	96.46	100
						1.01	0	0.68	1.49	97.98	100
						0.78	0	0.31	6.25	95.29	100
						0.64	0	0.76	0	99.08	100
						0.4	0	0.37	0	100	100
						0.14	0	0	0	100	100
						0.22	0	0	25	92.98	100
						1.04	0	0	0	97.7	100
						0.28	0	0	0	100	100
						0.01	0	0.87	0	100	100
						0.04	0	0	0	100	100
						0.32	0	1.37	0	100	100
						1.26	0	0.38	1.96	99.62	100
						3.33	0	0.54	1.49	98.21	100
						6.25	0	0.94	3.31	96.32	100
						10.69	0	0.99	3.02	93.64	96.55
						13.18	0	1.5	2.89	93.57	96.55
						13.89	0.05	1.25	3.28	91.48	96.55
						13.24	0	1.27	3.91	92.33	96.55
						13.08	0	1.26	4.19	92.79	96.55
						11.52	0	1.41	3.3	92.89	96.55
						8.27	0	0.99	2.69	94.79	100
						4.3	0	1.65	2.23	95.31	100

Table 3: Statistics for BTS covering the Eagles Square before, during & after PDP Primaries of 13th & 14th Jan.2011 (Cell B)

ERLANG	PCONG	PCTRLFAIL	PDROP	HOSR	PTTCH	CSSR_1	DISPLAY
0.06	0	0	0	100	100	99.98	01/10 04:00
0.03	0	0	0	100	100	99.66	01/10 05:00
0.21	0	1.07	0	96.3	100	98.75	01/10 06:00
1.14	0	0.38	1.89	96.39	100	98.1	01/10 07:00
3.02	0	0.72	0	96.77	100	97.39	01/10 08:00
5.08	0	1.13	2.82	97.27	96.55	95.91	01/10 09:00
8.33	0	0.86	3.13	95.69	96.55	94.29	01/10 10:00
12.64	0	1.17	4.65	94.13	96.55	94.12	01/10 11:00
14.15	0	1.4	4.76	93.87	96.55	94.71	01/10 12:00
4.72	0.16	1.21	7.72	93.79	37.93	94.6	01/10 13:00
1.75	11.76	12.3	4	90.8	13.79	80.78	01/10 14:00
10.63	0	1.14	3.9	94.49	96.55	95.11	01/10 15:00
6.69	0	1.29	2.62	96.23	96.55	95.17	01/10 16:00

2.22	0	0.99	3.24	96.54	100	97.84	01/12 18:00	0.41	0	94.87	100
1.65	0	1.14	1.32	95.56	100	96.38	01/12 19:00	0.19	7.69	93	100
1.04	0	0.77	9.89	95.53	100	97.45	01/12 20:00	0.3	2.86	95.48	100
0.72	0	0.9	4	98.68	100	97.85	01/12 21:00	0.23	0	91.1	100
0.58	0	0.94	3.7	93.85	100	95.78	01/12 22:00	0.22	4.4	95.63	100
0.2	0	0	0	100	100	98.56	01/12 23:00	0	0	98.14	100
0.37	0	0	0	100	100	96.62	01/13 00:00	0.38	0	97.37	100
0.2	0	0.51	0	100	100	99.78	01/13 01:00	0.11	0	99.12	100
0.48	0	0.52	0	95.83	100	98.74	01/13 02:00	0.55	0.77	90.42	100
0.48	0	0.86	0	100	100	98.27	01/13 03:00	0.09	0	98.32	100
0.13	0	0	0	100	100	99.57	01/13 04:00	0.33	0.35	88.07	100
0.07	0	0	0	100	100	99.94	01/13 05:00	0.46	0.54	92.96	100
0.59	0	0.27	0	100	100	99.46	01/13 06:00	0.47	1.91	96.45	100
0.81	0	0.33	0.77	93.94	100	98.79	01/13 07:00	0.09	1.76	92.88	100
1.64	0	0.79	1.44	97.35	100	98.31	01/13 08:00	0.26	1.13	95.51	100
2.72	0	0.99	0.73	95.41	100	96.92	01/13 09:00	0.2	0.55	97.22	100
2.49	0	1.28	1.7	94.89	100	97.24	01/13 10:00	0	0	99.09	100
3.04	0	1.3	2.18	97.01	100	96.92	01/13 11:00	0.18	1.13	91	100
2.91	0	0.99	1.78	95.35	100	97.58	01/13 12:00	0.24	0	98.95	100
2.8	0	0.88	0.3	97.11	100	98.52	01/13 13:00	0.26	0	96.67	100
3.24	0	1.03	0.76	97.08	100	96.48	01/13 14:00	0.32	0	91.07	100
3.23	0	0.75	1.16	95.91	100	98.02	01/13 15:00	0	0	99.14	100
3.7	0	0.65	1.06	96.58	100	98.07	01/13 16:00				
5.61	5.13	2.82	13.1	92.28	100	92.95	01/13 17:00				
6.56	3.22	1.23	17.35	94.38	100	82.87	01/13 18:00				
7.33	0	0		0	100	34.31	01/13 19:00				
11.99	47.06	0		0	100	48.09	01/13 20:00				
8.45	18.18	1.65	47.83	83.54	100	45.31	01/13 21:00				
2.64	0	0	0	94.99	100	94.35	01/13 22:00				
1.09	0	0.23	0	99.14	100	99.18	01/13 23:00	0	0	0	100
1.25	0	0	0	98.1	100	98.54	01/14 00:00				
1.33	0	0.31	0.75	97.94	100	97.28	01/14 01:00	1.85	0	100	100
0.84	0	0.21	1.09	97.48	100	99.38	01/14 02:00				
0.48	0	0	0	93.64	100	100	01/14 03:00	1.93	0	100	100
0.28	0	0	0	99.07	100	99.56	01/14 04:00				
2.44	0	17.57	3.66	88.62	72.41	81.12	01/14 06:00	0.39	7.27	96.67	100
1.52	0	0.91	0.4	94.12	100	98.23	01/14 07:00				
2.79	0	0.53	0.73	97.48	100	97.75	01/14 08:00	0.56	2.19	97.73	100
4.28	0	0.76	3.27	94.56	100	97.88	01/14 09:00				
6.47	0	1.12	3.04	96.68	100	96.89	01/14 10:00	1.05	3.91	90.34	100
8.74	0	0.99	2.61	95.93	96.55	96.68	01/14 11:00				
6.53	0	0.94	3.81	94.94	100	96.37	01/14 12:00	0.58	4.26	94.3	100
4.86	0	0.92	3.12	95.54	100	96.27	01/14 13:00				
3.1	0	1.22	4.04	96.59	100	95.62	01/14 14:00	1.03	2.86	94.57	100
3.45	0	0.98	3.36	95.13	100	96.29	01/14 15:00				
2.19	0	1.17	3.03	97.24	100	94.69	01/14 16:00	1.2	3.74	93.02	100
1.58	0	1.06	5.11	97.21	100	96.2	01/14 17:00				
0.93	0	0.73	1.83	92.63	100	98.18	01/14 18:00	0.95	4.35	92.62	37.93
1.1	0	0.2	0	97.14	100	97.33	01/14 19:00				
0.69	0	0.29	3.77	96.24	100	98.28	01/14 20:00	5.57	8.47	93.51	13.79
0.51	0	0.63	2.56	92.38	100	96.54	01/14 21:00				
0.54	0	0.92	0	96.7	100	98.62	01/14 22:00	1.64	3.25	93.13	100
0.12	0	1.53	0	100	100	98.47	01/14 23:00				
0.06	0	1.02	0	100	100	97.96	01/15 00:00	1.5	4.04	92.7	100
0.14	0	0	0	97.87	100	99.99	01/15 01:00				
0.11	0	0	0	100	100	99.98	01/15 02:00	1.64	5.41	93.54	100
0.36	0	1.45	0	98.33	100	98.54	01/15 03:00				
0.27	0	0	0	95	100	99.99	01/15 04:00	1.75	3.06	96.5	100
0.01	0	0	0	100	100	99.99	01/15 05:00				
0.15	0	0	0	97.14	100	95.94	01/15 06:00	2.77	6	95.03	100

Table 4: Statistics for BTS covering the Eagles Square before, during & after PDP Primaries of 13th & 14th Jan.2011 (Cell C)

0.37	0	3.23	0	98.99	100	900329	01/10 20:00	3.45	0	80.56	100
0.26	0	3.83	9.52	96	100	910167	01/10 21:00	3.85	0	100	100
0.09	0	2.47	33.33	91.3	100	710857	01/10 22:00	0	200	83.33	100
0.01	0	6.09	0	100	100	9309	01/10 23:00	1.2	0	100	100
0.04	0	4.17	16.67	100	100	950828	01/11 00:00	1.01	5.56	85	100
0.14	0	13.04	0	50	100	860959	01/11 01:00	1.34	0	92.86	100
0.12	0	0	0	57.14	100	991976	01/11 02:00	1.28	2.05	91.51	100
0.07	0	3.33	0	100	100	962688	01/11 03:00	1.22	4.25	84.95	100
0.11	0	3.45	0	96	100	844425	01/11 04:00	0.78	4.32	85.24	100
0.01	0	0	0	100	100	995989	01/11 05:00	0.68	3.88	85.24	100
0.15	0	2.17	0	91.67	100	975829	01/11 06:00	0.95	5.24	83.59	100
0.51	0	4.42	2.56	94.26	100	954399	01/11 07:00	1.06	4.06	86.32	100
1.51	0	1.29	1.4	91.67	100	97534	01/11 08:00	1.39	5.41	89.54	100
2.98	0	1.65	3.33	90.44	100	954797	01/11 09:00	1.13	2.68	94.54	100
3.88	0.08	1.06	3.77	88.74	100	953626	01/11 10:00	1.11	3.3	94.64	100
4.21	0	1.25	5.61	83.38	100	962342	01/11 11:00	1.06	7.94	94.31	100
4.94	0	1.17	4.35	85.06	100	951131	01/11 12:00	1.02	5.03	97.34	100
5.7	0	1.18	6.49	85.92	100	950685	01/11 13:00	2.83	7.14	94.87	100
5.54	0	1.11	4.75	84.72	100	960343	01/11 14:00	2.14	22.58	94.44	100
4.81	0	0.82	4.87	86.3	100	970821	01/11 15:00	2.9	3.03	95.08	100
3.78	0	1	4.05	87.96	100	950966	01/11 16:00	5.65	40	85.37	100
2.1	0	1.58	3.76	86.44	100	950925	01/11 17:00	6.8	50	66.67	100
1.48	0	1.82	4.32	90.1	100	950924	01/11 18:00	9.48	10	83.33	100
0.7	0	2.56	9.72	90.45	100	940564	01/11 19:00	9.09	20	81.25	100
0.45	0	2.64	17.14	92.19	100	940379	01/11 20:00	2	0	94.44	100
0.32	0	2.13	19.23	92.68	100	960981	01/11 21:00	4	0	100	100
0.18	0	5.8	18.75	81.82	100	860282	01/11 22:00	6.67	0	50	100
0.12	0	8.2	0	95.65	100	910041	01/11 23:00	1.18	0	100	100
0.01	0	2.25	0	66.67	100	770981	01/12 00:00	4.47	3.45	94.74	100
0.05	0	2.7	0	91.67	100	840139	01/12 01:00	2.77	5.36	96.19	100

1.12	0	2.86	2.5	97.23	100	94.2781	01/13 08:00	0.8	3.83	94.79	100
2.06	0	1.85	1.22	95.98	100	95.2834	01/13 09:00	0.95	3.46	95.01	100
2.81	0	1.97	5.88	94.01	100	95.1057	01/13 10:00	1.06	3.43	96.91	100
2.77	0	1.79	1.51	94.31	100	97.0748	01/13 11:00	1.12	4.6	92.24	100
2.65	0	1.7	2.02	93.87	100	95.0952	01/13 12:00	2.58	2.08	99.22	100
2.44	0	2.36	3.89	94.07	100	94.0259	01/13 13:00	3.73	8	98.78	100
2.75	0	2.25	2.76	94.43	100	93.032	01/13 14:00	3.5	4.55	100	100
2.52	0	1.71	4.43	93.72	100	97.011	01/13 15:00	6.83	0	100	100
1.89	0	1.96	3.82	95.38	100	95.0708	01/13 16:00	6.06	25	100	100
1.84	0	1.76	21.49	84.12	100	93.0581	01/13 17:00	3.45		100	100
1.89	0	0.69	29.79	75	100	91.0304	01/13 18:00	4.26	50	100	100
1.53	0	0	26.47	73.18	100	91.0421	01/13 19:00	2.86	0	100	100
2.23	0	1.32	50.59	65.51	100	90.0839	01/13 20:00	1.85	0	100	100
1.97	0	1.29	71.43	73.36	100	83.0915	01/13 21:00	2.38	0	100	100
0.49	0	4.17	37.04	77.88	100	82.025	01/13 22:00	0		100	100
0.06	0	4.8	0	94.12	100	93.0673	01/13 23:00	0.53	0	100	100
0.07	0	4	0	100	100	95.0991	01/14 00:00	0.15	0	96.67	100
0.06	0	1.89	0	100	100	98.0197	01/14 01:00	0.47	7.14	96.23	100
0.04	0	5.13	0	100	100	94.0857	01/14 02:00	0.22	4	97.92	100
0.05	0	5.71	0	100	100	94.026	01/14 03:00	0.75	6.25	96.2	100
0.06	0	2.17	0	100	100	93.053	01/14 04:00	1.88	2.63	97.47	100
0.6	0	15.65	0	82.93	75.86	84.0263	01/14 06:00	2.78	2.44	94.83	100
0.34	0	1.24	0	100	100	98.076	01/14 07:00	1.73	6	97.94	100
1.24	0	1.23	3.81	97.73	100	95.0789	01/14 08:00	1.73	1.92	98.28	100
1.73	0	1.4	4.94	96.32	100	97.0462	01/14 09:00	2.22	1.64	96.75	100
2.88	0	1.04	2.61	95.45	100	97.0248	01/14 10:00	1.9	3.75	96.77	100
3.45	0	0.52	3.82	94.09	100	96.0933	01/14 11:00	2.02	0	97.39	100
4.14	0	0.69	1.43	93.26	100	93.0652	01/14 12:00	2.15	6.94	97.12	100
3.4	0	0.89	3.07	95.02	100	96.0549	01/14 13:00	1.96	0	99.28	100
2.51	0	0.88	0.84	96.29	100	97.027	01/14 14:00	2.51	1.28	95.81	100

0.46	0	0.92	2.78	95.97	100	95.032	01/15 21:00	0	0	100	100
0.19	0	0.46	0	97.1	100	99.086	01/15 22:00	1.41	0	100	100
0.09	0	2.78	5	89.47	100	97.022	01/15 23:00	2.11	0	95.24	100
0.1	0	0.78	4.55	100	100	95.034	01/16 00:00	2.8	0	74.29	100