A Comparative Study of the Quality of Service of GSM Network during Crowd Upsurge in University of Benin, Nigeria.

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ABSTRACT: Despite the fact that GSM network have been in Nigeria for more than a decade, it is widely observed that each time there is a major event in a certain location and there is movement of people to that area, it is always very difficult to get a call through within the period by which the event is holding. 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 and 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.

Keywords: GSM, crowd upsurge, quality of service.

1. INTRODUCTION

Communications in Nigeria have witnessed a tremendous boost over the past few years. Deregulation of the telecommunications sector led to the introduction of major Global System of Mobile Communications (GSM). When the GSM license was auctioned by the Nigeria Communications Commission (NCC) in February 2001, for the roll out of a GSM network in Nigeria, it was a sigh of relief for the Nigeria population having been denied access to efficient telecommunication services for quite some 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.

After more than ten years of operation in Nigeria, the network having been launched in August 2001, 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.

2. RELATED WORKS

Due to the high number of counters or metrics that can be used as a benchmark in evaluating network performance and the fact that in emerging networks, subscriber base is dynamic, there has been a lot of literature and models aimed at evaluating network performance for an improved quality of service.

In the dynamic ontological model, [22] performed a chi-square test on the data and results obtained from subscribers of the various GSM networks in Nigeria as a feedback mechanism to measure for QoS. They opined that their ontological model will

function well and efficiently in any web based information system but did not actually recommend the measures to be adopted by the network service providers towards an improved QoS.

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.

This work on Performance Evaluation and Improvement in QoS of GSM networks in Nigeria was an extension of the research conducted by [16] in evaluating and improving the Quality of service of second-generation cellular systems. He reported that three parameters: network accessibility, network retainability and connection quality are sufficient to evaluate the QoS of any network undergoing constant changes in response to increasing coverage and capacity.

However [11], 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.

3. PERFORMANCE MONITORING

From related literature outlined above, we see that there are three methods commonly used to monitor network performance. These are; drive tests, network statistics and customer complaints [16].

Customer complaints are the most commonly used method since the customer is always ready to give an input whether valid or not. Though performance evaluation by this method is easily achievable, it is not the best option because the customer experience can be emotional and subjective.

The drive test method, as embarked by NCC in 2005 to measure QoS of the GSM networks in Nigeria, is another mechanism for performance evaluation. Apart from network performance assessment, it can also be used for the identification of network problem areas, validation of effects of optimization changes and analysis of the root cause of problems in an operational network. But really, the only activities for which drive testing is well suited for is problem root cause analysis and competitive bench marking.

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. We were 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.

4. 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 [16].

5. 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:

5.1. 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.

5.2. 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%.

5.3. 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%.

5.4. 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%.

5.5. 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.

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%.

6. 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:

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

The KPIs connected to service retainability are listed below.

6.1. Call Drop Rate

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

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%.

6.2. 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%.

7. 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 Quality of Service (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 [22] 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 during church programmes, football matches, political gatherings, convocation or matriculation ceremonies and important market days. This was done for the period while the event was taking place and when there was no event within the area specified.

The areas used for investigation were locations where there is high mobility or concentration of people within a specified period of time. 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.

Typical examples are:

a. During the Convocation Ceremony of the University of Benin on November 12 and 13th, 2010 at Ugbowo Campus of the University, Ugbowo, Benin City.

b. During the last matriculation ceremony of the University of Benin on May 12, 2011 at the same location.

8. DATA ANALYSIS

During the 36th convocation ceremony at the Ugbowo Campus of the University of Benin between the 12th and 13th of November 2010. The measurement period was taken from 0300hrs on the 11th of November 2010 till 0300hrs on the 15th of November 2010 on an hourly basis, to give a wide span for analysis. Table1, Table 2 and Table 3 in the appendix gives the network statistics, so obtained, for the BTS covering the Campus environment just before the convocation, during the convocation when we expect an influx of crowd and after the convocation when the crowd had gone. This is depicted in Figure 1, figure11 and figure12 below.

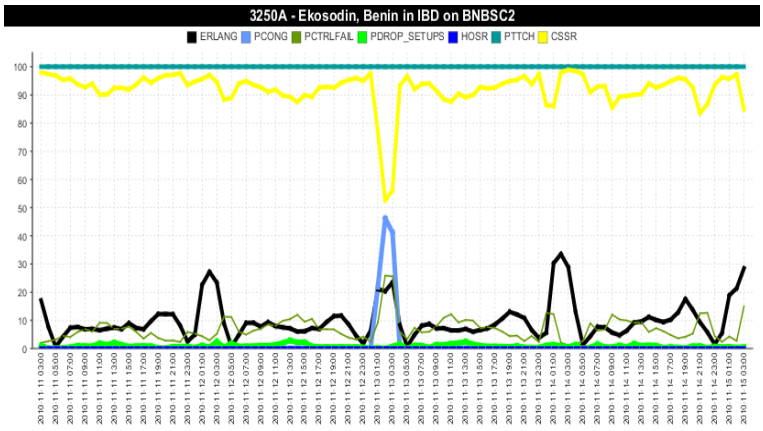

Figure 1: Graphical representation of Results for Stats before, during & after Convocation of 12th & 13 Nov. 2010 (Cell A)

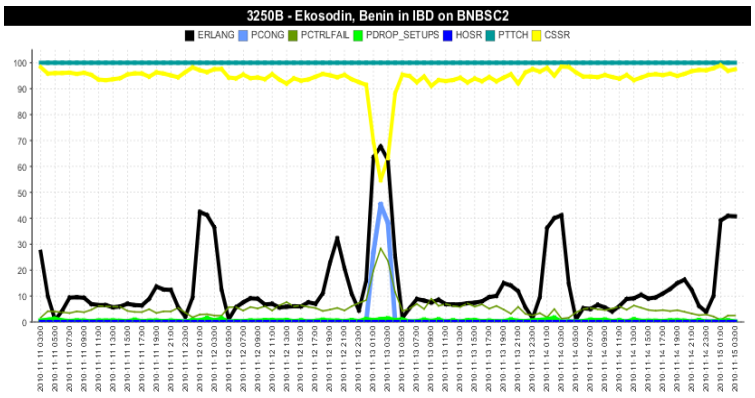

Figure 2: Graphical representation of results for stats before, during & after Convocation of 12th & 13 Nov. 2010 (Cell B)

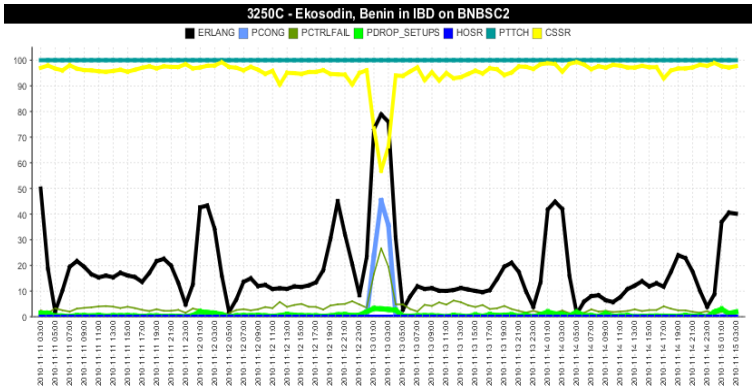

Figure 3: Graphical representation of results for stats, before, during & after Convocation of 12th & 13 Nov. 2010 (Cell C)

We see that from 0300hrs on 11/11/2010 when the measurement started till 0300hrs of 15/11/2010 when it stopped, it was only between 0100hrs and 0400hrs on 13/11/2010 that we observe an unusually high percentage congestion on the traffic channel and also on the signalling for the BTS at Ekosodin, while CSSR dropped to an all time low value of about 52.58% at 0200hrs for all the cells. What happened, one may wish ask?!

The simple answer is as a result of the influx of people into and around the campus environment for the convocation ceremony, which underscores the effect of crowd upsurge on QoS in an operational GSM network.

10. PERFORMANCE EVALUATION

In this research, as illustrated in the data analysis above, the network statistics of an operational GSM network under study 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:

Table 4: Coverage at UNIBEN, Benin.

KPIs	NCC	NORMAL DAY OCCURENCE %	STATISTICS DURING EVENTS %
PCONG	≤ 2.0%	0	46.14
PCTRLFAIL	≤ 1.2%	4.96	25.88
PDROP	≤ 2.0%	0.86	0.7
HOSR	≥ 99.0%	0	0
CSSR	≥ 98.0%	97.48	57.0
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.

11. CONCLUSION

Conclusively, the quality of service of an operational GSM network in a given area is 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 crowd especially during major events that attracts the mobility of people.

12. RECOMMENDATIONS

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. As pointed out by [26], GSM is not yet optimised. Against this background, the following strategies are hereby recommended to safeguard good quality of service:

- Each of the different GSM networks must ensure a robust optimization of its network for good service delivery to its subscribers.
- The optimization models for the network should be proactive and not reactive. For instance, before any major event in an area, the respective networks should deploy an I-site or a mobile BTS to such areas before the commencement of the event.

- The NCC should step up its game in the area of proper supervision of the networks to ensure good quality of service.

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14. APPENDIX

Table 1: Statistics for BTS covering Ugbowo Campus of UNIBEN before, during and after its convocation of 12th&13th Nov. 2010 (Cell A)

ERLANG	PCONG	PCTRLFAIL	PDROP	HOSR	PTTCH	CSSR	DISPLAY
17.09	0	2.06	1.08	0	100	97.94	11/11 03:00
7.66	0	2.6	0	0	100	97.4	11/11 04:00
0.56	0	3.13	0	0	100	96.87	11/11 05:00
4.21	0	4.48	0.19	0	100	95.34	11/11 06:00
7.35	0	4.09	0.43	0	100	95.7	11/11 07:00
7.62	0	5.87	0.96	0	100	93.73	11/11 08:00
6.84	0	6.81	0.84	0	100	92.75	11/11 09:00
6.94	0	6.05	0.83	0	100	93.95	11/11 10:00
6.51	0	9.11	1.82	0	100	90.07	11/11 11:00
7.03	0	9.05	1.33	0	100	90.25	11/11 12:00
7.41	0	6.96	2.05	0	100	92.44	11/11 13:00
6.89	0	7.01	1.31	0	100	92.5	11/11 14:00
8.99	0	7.76	0.68	0	100	91.88	11/11 15:00
7.3	0	5.86	0.82	0	100	93.7	11/11 16:00
6.85	0	3.51	0.88	0	100	96.18	11/11 17:00
9.68	0	5.53	0.81	0	100	94.31	11/11 18:00
12.23	0	3.73	0.2	0	100	95.94	11/11 19:00
12.22	0	2.81	0.08	0	100	96.96	11/11 20:00
12.16	0	2.82	0.61	0	100	97.11	11/11 21:00
8.12	0	2.34	0.63	0	100	97.66	11/11 22:00
2.49	0	5.86	0.73	0	100	93.46	11/11 23:00
4.93	0	5.26	0.29	0	100	94.74	11/12 00:00
22.61	0	4.33	1.06	0	100	95.67	11/12 01:00
27.2	0	2.93	0.47	0	100	97.07	11/12 02:00
23.39	0	5.21	2.48	0	100	94.53	11/12 03:00
8.8	0	11.34	0.39	0	100	88.32	11/12 04:00
0.7	0	11.1	1.83	0	100	88.9	11/12 05:00
4.79	0	5.99	0.74	0	100	94.01	11/12 06:00
9.06	0	4.95	0.78	0	100	94.86	0.21 11/12 07:00
9.11	0	6.31	0.82	0	100	93.59	11/12 08:00
7.77	0	7.03	1.04	0	100	92.76	11/12 09:00
9.3	0	8.57	1.01	0	100	91.09	11/12 10:00
7.96	0	8.07	1.33	0	100	91.83	11/12 11:00
7.52	0	9.79	1.96	0	100	89.86	11/12 12:00
7.12	0	10.42	2.81	0	100	89.24	11/12 13:00
6.03	0	11.96	2.18	0	100	87.45	11/12 14:00
6.14	0	9.47	2.17	0	100	89.92	11/12 15:00
7.21	0	10.51	0.78	0	100	89.26	11/12 16:00
6.96	0	6.73	0.47	0	100	92.61	11/12 17:00
9.4	0	6.84	0.59	0	100	92.85	11/12 18:00
11.47	0	6.76	0.46	0	100	92.57	11/12 19:00
11.64	0	5.13	0.61	0	100	94.3	11/12 20:00
8.57	0	3.86	0.46	0	100	95.27	11/12 21:00
4.65	0	3.22	0.52	0	100	95.85	11/12 22:00
1.79	0	4.17	0.43	0	100	95	11/12 23:00
6.25	0	2.33	0	0	100	97.67	11/13 00:00
21.02	21.87	9.25	0.25	0	100	76.9	11/13 01:00
20.35	46.14	25.88	0	0	100	52.58	11/13 02:00
23.49	41.17	25.6	0.7	0	100	56.12	11/13 03:00
8.32	0	6.02	1.49	0	100	93.28	11/13 04:00
0.66	0	3.34	0	0	100	96.66	11/13 05:00
4.84	0	7.34	1.04	0	100	92.02	11/13 06:00
8.09	0	5.75	1.02	0			
8.69	0	5.94	0.31	0			
7.15	0	7.93	1.31	0			
7.19	0	10.92	1.27	0			
6.46	0	12.18	1.69	0			
6.43	0	9.26	1.92	0			
6.91	0	10.16	2.39	0			
5.98	0	9.86	1.5	0			
6.58	0	7.02	1.05	0			
7.16	0	4.56	0.71	0			
8.55	0	7.24	0.72	0			
10.63	0	3.96	0.66	0			
13.01	0	4.09	0.57	0			
12.06	0	4.57	0.86	0			
10.81	0	2.03	0.36	0			
9.59	0	4.42	0.29	0			
9.74	0	2.92	0.34	0			
9.6	0	12.64	1.08	0			
10.24	0	12.19	1.34	0			
13.52	0	2.09	0.87	0			
28.89	0	1.13	0.54	0			
12.99	0	1.47	1.31	0			
1.29	0	2.65	0	0			
4.3	0	8.94	0.34	0			
7.71	0	6.99	1.49	0			
7.47	0	6.73	0.53	0			
5.65	0	12.03	0.44	0			
4.74	0	10.31	1.08	0			
6.35	0	9.89	0.53	0			
9.19	0	9.12	1.69	0			
9.61	0	9.9	0.96	0			
11.17	0	5.87	1.13	0			
10.13	0	3.72	1.02	0			
9.42	0	6.13	0.27	0			
10.26	0	4.76	0.48	0			
12.82	0	3.62	0.33	0			
17.56	0	4.15	0.16	0			
13.74	0	5.28	0.8	0			
9.31	0	12.47	0.86	0			
9.78	0	12.67	0.22	0			
11.48	0	4.97	0.74	0			

Table 2: Statistics for BTS covering Ugbowo Campus of UNIBEN before, during and after its convocation of 12th&13th Nov. 2010 (Cell B)

ERLANG	PCONG	PCTRLFAIL	PDROP	HOSR	PTTCH
27.08	0	1.68	0.44	0	100
9.93	0	4.15	0.69	0	100
10.75	0	3.99	1.11	0	100
4.42	0	3.76	0.42	0	100
9.38	0	3.43	0.2	0	100
9.54	0	4.08	0.4	0	100
9.32	0	3.77	0.31	0	100
6.94	0	4.67	0.11	0	100
8.51	0	6.16	0.34	0	100

6.51	0	5.99	0.34	0	100	93.28	9.62	11/11 12:00	0	3.41	0.61	0	100
5.67	0	5.91	0.37	0	100	93.62	36.27	11/11 13:00	0	1.83	0.9	0	100
5.98	0	5.83	0.26	0	100	94.05	40.05	11/11 14:00	0	4.98	1.45	0	100
7.01	0	4.26	0.14	0	100	95.48	41.16	11/11 15:00	0	1.29	0	0	100
6.51	0	3.86	0.66	0	100	95.89	14.63	11/11 16:00	0	1.64	0	0	100
6.39	0	3.82	0.12	0	100	95.85	1	11/11 17:00	0	3.71	0	0	100
8.93	0	4.92	0.29	0	100	94.63	5.29	11/11 18:00	0	4.97	0.18	0	100
13.66	0	3.46	0.33	0	100	96.29	5.02	11/11 19:00	0	5.34	0.68	0	100
12.53	0	4.1	0.16	0	100	95.83	6.59	11/11 20:00	0	4.92	0.49	0	100
12.35	0	4.06	0.31	0	100	95.13	5.55	11/11 21:00	0	4.57	0.71	0	100
5.78	0	5.42	0.18	0	100	94.41	4.06	11/11 22:00	0	5.14	0.19	0	100
2	0	3.61	0	0	100	96.39	6.14	11/11 23:00	0	5.98	0.43	0	100
9.44	0	1.8	0.57	0	100	98.2	8.85	11/12 00:00	0	4.72	0	0	100
42.44	0	2.87	0.44	0	100	97.13	9.15	11/12 01:00	0	6.33	0.82	0	100
41.22	0	2.99	1.27	0	100	96.4	10.47	11/12 02:00	0	5.48	0.25	0	100
36.52	0	2.5	0.48	0	100	97.5	9.05	11/12 03:00	0	4.62	0.28	0	100
12.64	0	2.43	1.15	0	100	97.57	9.47	11/12 04:00	0	4.32	0.28	0	100
1.01	0	5.68	0	0	100	94.32	10.97	11/12 05:00	0	4.58	0.18	0	100
5.64	0	5.74	0.15	0	100	93.98	12.7	11/12 06:00	0.07	4.19	0.4	0	100
7.57	0	4.37	0.11	0	100	95.42	14.96	11/12 07:00	0.17	4.54	0.4	0	100
9.11	0	5.76	0.37	0	100	94.07	16.31	11/12 08:00	0	3.91	0.31	0	100
8.96	0	5.21	0.3	0	100	94.31	12.31	11/12 09:00	0	3.24	0	0	100
6.76	0	6.08	0.53	0	100	93.67	6.19	11/12 10:00	0	2.62	0.53	0	100
6.98	0	4.41	0.52	0	100	95.59	3.86	11/12 11:00	0	2.88	0	0	100
5.59	0	6.38	0.38	0	100	93.5	10.06	11/12 12:00	0	2.12	0	0	100
5.88	0	7.65	0.55	0	100	91.97	39.15	11/12 13:00	0	0.79	0.35	0	100
6.05	0	6.02	0.14	0	100	93.98	40.9	11/12 14:00	0	2.48	0.42	0	100
6.01	0	6.38	0.42	0	100	93.1	40.75	11/12 15:00	0	2.5	0	0	100
7.57	0	5.81	0	0	100	93.56		11/12 16:00					
7.01	0	5.37	0.25	0	100	94.63		11/12 17:00					
11.07	0	4.24	0.66	0	100	95.68		11/12 18:00					
22.84	0	4.75	0.35	0	100	95.16		11/12 19:00					
32.26	0	5.41	0.35	0	100	94.42		11/12 20:00					
20.7	0.05	4.43	0.15	0	100	95.31		11/12 21:00					
10.82	0	6.08	0.51	0	100	93.64		11/12 22:00					
4.43	0	7.33	0.18	0	100	92.5		11/12 23:00					
15.99	0	8.4	0.98	0	100	91.45		11/13 00:00					
63.54	26.92	19.82	0.51	0	100	69.5		11/13 01:00					
67.71	45.25	28.4	0.91	0	100	54.68		11/13 02:00					
62.51	38.23	23.55	1.16	0	100	63.15		11/13 03:00					
25.38	0	11.53	0.55	0	100	88.23		11/13 04:00					
1.56	0	4.23	0.82	0	100	95.38		11/13 05:00					
5.33	0	5.14	0	0	100	94.86		11/13 06:00					
8.86	0	6.95	0.1	0	100	92.48		11/13 07:00					
8.25	0	4.98	0.69	0	100	94.7		11/13 08:00					
7.54	0	8.94	0.24	0	100	91.06		11/13 09:00					
8.55	0	6.22	0.77	0	100	93.3		11/13 10:00					
6.87	0	6.92	0	0	100	92.96		11/13 11:00					
6.75	0	6.15	0.42	0	100	93.33		11/13 12:00					
6.8	0	5.79	0	0	100	94.21		11/13 13:00					
7.23	0	7.14	0.47	0	100	92.42		11/13 14:00					
7.43	0	5.9	0.55	0	100	93.89		11/13 15:00					
7.96	0	6.78	0.12	0	100	92.88		11/13 16:00					
9.6	0	5.13	0.3	0	100	94.49		11/13 17:00					
10.07	0	6.18	0.09	0	100	92.84		11/13 18:00					
14.99	0.13	4.79	0.13	0	100	94.27		11/13 19:00					
14.05	0	3.2	0.74	0	100	95.58		11/13 20:00					
11.86	0	5.83	0.26	0	100	92.02		11/13 21:00					
5.68	0	3.12	0.17	0	100	96.23		11/13 22:00					
1.43	0	2.48	0.48	0	100	97.52		11/13 23:00					

Table 3: Statistics for BTS covering Ugbowo Campus of UNIBEN before, during and after its convocation of 12th&13th Nov. 2010 (Cell C)

ERLANG	PCONG	PCTRLFAIL	PDROP	HOSR	PTTCH	
49.97	0	2.47	1.42	0	100	9
18.74	0	1.44	1.35	0	100	9
2	0	3.25	0.4	0	100	9
10.18	0	2.53	0.27	0	100	9
19.4	0	1.99	0.1	0	100	9
21.69	0	3.15	0.45	0	100	9
19.46	0	3.45	0.43	0	100	9
16.57	0	3.67	0.32	0	100	9
15.34	0	4	0.57	0	100	9
16	0	4.15	0.24	0	100	9
15.38	0	3.92	0.4	0	100	9
17.1	0	3.37	0.39	0	100	9
16.08	0	3.88	0.43	0	100	9

15.46	0	3.36	0.34	0	100	96.26	11/11 16:00						
13.58	0	2.67	0.12	0	100	97.04	78.86 11/11 17:00	45.26	26.67	3.09	0	100	5
17.06	0	2.21	0.31	0	100	97.59	75.96 11/11 18:00	35.62	19.46	2.85	0	100	6
21.66	0	2.92	0.32	0	100	96.81	30.77 11/11 19:00	0.39	4.82	2.56	0	100	9
22.56	0	2.29	0.12	0	100	97.59	2.74 11/11 20:00	0	4.77	0.29	0	100	9
19.89	0	2.3	0.22	0	100	97.39	7.88 11/11 21:00	0	3	0.21	0	100	9
13.15	0	2.66	0.17	0	100	97.34	11.85 11/11 22:00	0	2.07	0.38	0	100	9
4.75	0	1.55	0	0	100	98.45	10.84 11/11 23:00	0	4.64	0.41	0	100	9
12.55	0	3.19	0.52	0	100	96.81	11.12 11/12 00:00	0	4.19	0.39	0	100	9
42.61	0	2.58	1.97	0	100	97.15	10.14 11/12 01:00	0	5.58	0.26	0	100	9
43.32	0	1.72	1.63	0	100	97.81	10.07 11/12 02:00	0	4.71	0	0	100	9
34.36	0	1.85	1.4	0	100	97.92	10.41 11/12 03:00	0	6.3	0.54	0	100	9
16.09	0	0.76	0.87	0	100	99.24	11.19 11/12 04:00	0	5.65	0.27	0	100	9
1.82	0	1.42	0	0	100	97.36	10.61 11/12 05:00	0	4.45	0.08	0	100	9
6.7	0	2.59	0.39	0	100	97.04	10.05 11/12 06:00	0	3.8	0.7	0	100	9
13.58	0	2.94	0.44	0	100	96.07	9.58 11/12 07:00	0	4.56	0.19	0	100	9
14.95	0	2.49	0.41	0	100	97.38	10.39 11/12 08:00	0	3	0.82	0	100	9
11.95	0	2.9	0.54	0	100	96.28	14.69 11/12 09:00	0	3.31	0.48	0	100	9
12.38	0	3.77	0.36	0	100	94.65	19.5 11/12 10:00	0.05	4.18	0.57	0	100	9
10.83	0	3.35	0.16	0	100	95.81	21.02 11/12 11:00	0	3	0.77	0	100	9
11.08	0	5.75	0.42	0	100	90.46	17.44 11/12 12:00	0	2.27	0.26	0	100	9
10.87	0	3.85	0.89	0	100	95.07	9.84 11/12 13:00	0	1.64	0.73	0	100	9
11.79	0	4.57	0.6	0	100	94.93	3.85 11/12 14:00	0	2.3	0	0	100	9
11.6	0	4.99	0.45	0	100	94.65	13.47 11/12 15:00	0	1.6	0.82	0	100	9
12.21	0	3.87	0.37	0	100	95.36	41.8 11/12 16:00	0	1.16	1.86	0	100	9
13.43	0	3.83	0.36	0	100	95.42	44.85 11/12 17:00	0	1.5	1.1	0	100	9
18.14	0	2.81	0.16	0	100	96.08	41.97 11/12 18:00	0	2.4	1	0	100	9
30.34	0	4.35	0.34	0	100	94.64	15.76 11/12 19:00	0	1.37	0.4	0	100	9
45.05	0.02	4.8	0.74	0	100	94.47	1.16 11/12 20:00	0	0.72	1.83	0	100	9
32.11	0	4.99	0.83	0	100	94.32	5.87 11/12 21:00	0	1.54	0.49	0	100	9
20.55	0	6.03	0.47	0	100	90.5	8.01 11/12 22:00	0	2.86	0.44	0	100	9
8.42	0	4.75	0.64	0	100	95.01	8.35 11/12 23:00	0	2.01	0.12	0	100	9
23.25	0	3.51	1.95	0	100	96.05	6.43 11/13 00:00	0	2.28	1.29	0	100	9
73.15	23.85	16.67	3.19	0	100	73.51	5.71 11/13	0	1.82	0.15	0	100	9

7.64	0	2.03	0.31	0	100	97.87	22.84	11/14 14:00	0	2.48	0.52	0	100
10.77	0	2.24	0.47	0	100	97.15	17.52	11/14 15:00	0	1.92	0.22	0	100
12.14	0	2.88	0	0	100	97.12	10.13	11/14 13:00	0	1.57	0.37	0	100
13.82	0	2.21	0.13	0	100	97.79	3.84	11/14 14:00	0	2.18	0	0	100
11.86	0	2.6	0.22	0	100	97.25	8.75	11/14 15:00	0	1.06	1.86	0	100
13.02	0	2.61	0.27	0	100	97.25	36.62	11/14 16:00	0	1.95	2.96	0	100
11.71	0	4.05	0.22	0	100	92.89	40.57	11/14 17:00	0.35	1.77	1.27	0	100
17.46	0	3.12	0.21	0	100	95.96	40.18	11/14 18:00	0	2.34	1.89	0	100
23.98	0.08	2.5	0.2	0	100	96.76		11/14 19:00					