
PERFORMANCE APPRAISAL OF MOBILE TELECOMMUNICATION NETWORK (MTN) TRAFFIC CONGESTION IN DUTSE, JIGAWA STATE

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ABSTRACT

This is an analysis of traffic congestion in the MTN Mobile Network of Dutse metropolis due to unplanned event with a view to reducing its effect. Drive and Pulled data test methods were adopted for the network performance during peak and off-peak periods. The Drive Test gave a 20% and 10% deviation from the recommended KPIs set by MTN during peak and off-peak hours respectively, while the Data Pulled test during an unplanned public event indicates that the cells near the scene of the event experienced high congestion level with a 32% (PCong), 3.5-6% (Pdrop), 76.59% (TCH availability), and 96.18% (SDCCH) which is a great deviation from the MTN acceptable KPIs of $\leq 5\%$, $\leq 2\%$, $\geq 99\%$ and $\geq 98\%$ respectively. Thus, this paper finally, proposed both hardware and software solutions that will help minimized these distributed congestion challenges within the network system.

Keywords: GSM, GPRS, CDMA, PSTN, PCong, Pdrop, TCH and SDCCH

INTRODUCTION

The demand of wireless communication has been on the increase from generation to generation. Most common ones are the data and/or voice communication that includes Infrared, Bluetooth, Mobile Ad hoc Networks (MANETs), Vehicular Ad hoc Networks (VANETs), Voice Over Internet Protocol (VoIP), Global System for Mobile Communication (GSM), etc. [1]. GSM is the most popular among them because it is easy to acquire and maintain, has clarity of voice communication and ease of data communication among others. However, the effective performance of the GSM is greatly challenged by the added features of data communications (i.e. General Packet Radio Service (GPRS)) on the same system though, third Generation (3G) Technology has greatly reduced this challenge to the barest [2]. Another degrading factor facing GSM power throughput is the traffic congestion that takes multifarious dimensions. Therefore, this paper aimed at identifying some of the causes of this congestion as they affect the service

performance of the MTN mobile network a case study of Dutse metropolis, Jigawa State, Nigeria.

LITERATURE REVIEW

The history of communication started since 1800s of which Samuel Morse invented the Telegraph and Alexandra Bell in 1876 came up with the Telephone which was later followed by various inventions that leads to cellular communication in 1983. In 1982 through 1985 the European digital telecommunications standard use the 900MHz frequency band as the first Global System for Mobile Communication (GSM) technology. Nordic Mobile Telephony NMT 450 was the first analogue technology by the Europe (Middle East) in 1981, which was followed by the Advanced Mobile Phone System that is also analogue in nature by North and South America in 1983. Other analogue telephones are the Total Access Communication System TACS (1985) by Europe and China and the Nordic Mobile Telephony NMT 900 in 1986 by Europe (Middle East) [13].

In an effort to select the best digital transmission technology to use in Paris in 1986, a field tests was conducted and a choice was made to use

Time Division Multiple Access TDMA and/or Frequency Division Multiple Access FDMA. A combination of the two technologies were made and put to use by worldwide telephone operators introducing the first digital telephony known as Global System for Mobile Communication (GSM) in 1991. The same year, Digital AMPS IS136 was introduced by North and South America. In 1992, GSM 1800 was introduced by Europe; Code Division Multiple Access CDMA IS095 was introduced by North America and Korea 1993. In 1994 and 1995 respectively Personal Digital Cellular PDC and Personal Communication Services PCS 1900 were introduced by Japan and North America respectively [13].

The Generation of GSM

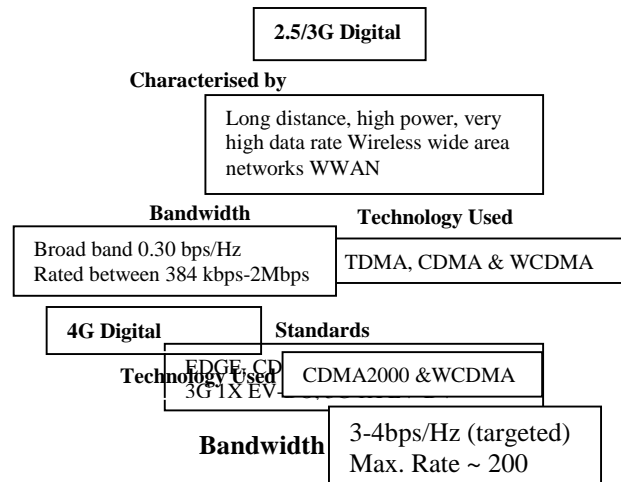
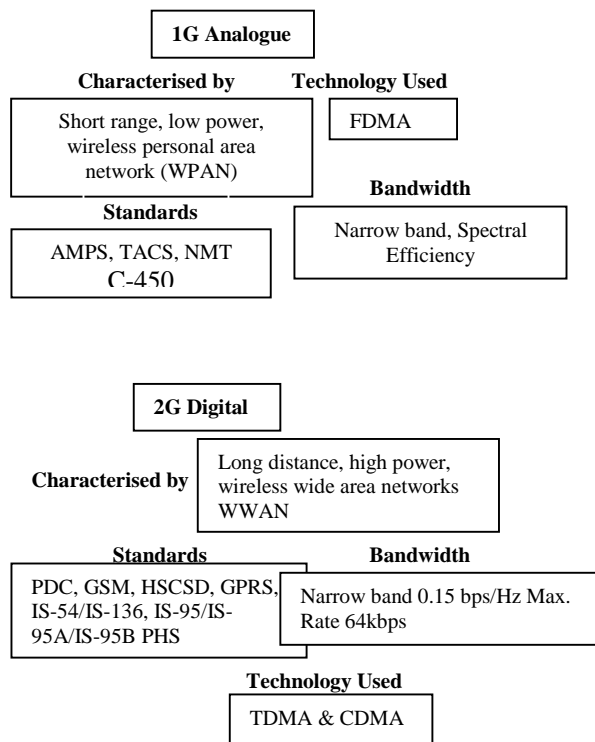
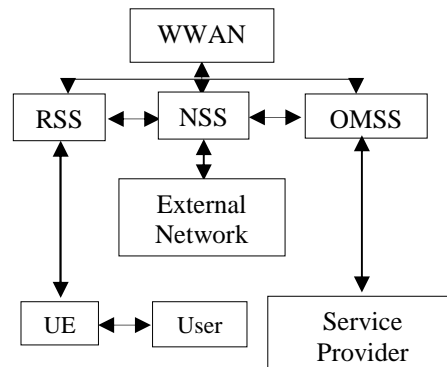


Figure (l) GSM generation and features.

GSM Architecture

The composition of local area network (LAN) and metropolitan area network (MAN) give rise to a wide area network (WAN). WAN is often characterised by wireless means of communication with other networks, thus, given rise to Wireless Wide Area Network (WWAN). Generally, wireless does not operate in isolation (in Nigeria); it uses resources of Public Switched Telephone Networks (PSTN) to establish and receive calls from wireless users. Fig. 2.2 shows the model of WWAN system that establishes the working principle of an operational cellular network.



RSS: Radio Station Subsystem
 NSS: Networking and Switching Subsystem
 OMSS: Operational & Maintenance Subsystem
 UE: User Equipment

Figure: (b) Model of WWAN System

Radio Station Subsystem (RSS)

The radio station subsystem RSS is sometimes referred to as the Base Station Subsystem (BSS) and is responsible for providing and managing transmission paths between the User Equipment (UE) and the Network Station Subsystem (NSS) [2]. This involves the management of the radio interface between the UE and other WWAN system.

User Equipment (UE)

The telecommunication services can only be accessed by the user via radio transceiver called the User Equipment (UE) [2]. The UE can be portable or handheld station with hardware part and software that is responsible for the interface between the user and the Base Station. A subscriber identity module (SIM) is the second part of the UE that hold user's specific data in the form of smart card, which effectively functions as a logical terminal. When UE is portable it is called a Mobile Station (MS).

Base Transceiver Station (BTS)

The Base Transceiver Station (BTS) is the physical equipment that facilitates radio signal transmission and reception, signal measurement, encryption and communication with the Base Station Controller (BSC). Usually, the BTS is located at the centre of the cell which communicates with the network through the BTS. A base station can have a minimum number of BTS and at the same time can have its multiples in single station [2].

Base Station Controller BSC

The Base Station Controller, BSC is another component of the BSS that serves as the concatenation base of several BTSs. The radio channel used by every BTS is allocated by the BSC. In addition, the BSC connects speech and signalling channel to MSC and handles frequency administration, transfers and handovers of mobile station between different BTSs [2].

Networking and Switching Subsystem NSS

The UE is managed and connected to the entire network facilities via the NSS. The NSS is neither directly connected with the UE, nor the BSS, but has a direct contact with the external networks. The UE/MS, BSS and the NSS form the operational part of the entire wireless wide area network WWAN. The main switching function of the WWAN (Mobile Switching Centre MSC), data basis required by the subscriber (Home Location Register HLR) and mobility management (Visitor Location Register VLR) are the basic parts of the NSS and has its major role as to manage communication between the WWAN and other networks.

Mobile Switching Centre MSC

The Mobile Switching Centre MSC performs the following functions in a WWAN system [12]:

- Performs necessary switching function required for the user equipment located within the associated geographical area, called an MSC area.
- Monitors the mobility of its subscribers and manages necessary resources required to handle and update the location registration procedures and to carry out the handoff functions.
- Involved in the networking function to communicate with other networks such as PSTN and ISDN.

The interworking function of the MSC depends upon the type of the network to which it is connected and the service to be performed. The call routing, call control and echo control functions are also performed by the MSC.

Home Location Register HLR

The Home Location Register HLR is a functional unit used for management of mobile subscribers. The HLR stores basic information about subscriber's information and part of the mobile information to allow incoming calls to be routed to the

MSC for the particular mobile. It is also responsible for administrative operations like changes in service profile etc. by a service provider on subscriber data.

Visitor Location Register VLR

The Visitor Location Register VLR retrieve subscriber's information covered by the current MSC's service area from the subscriber's HLR. The VLR usually recognises that the MS is from another network, if roaming is allowed, the VLR finds the MS's HLR in its home network thereby constructing a global title from the IMSI to allow signalling from VLR to the MS's HLR via the PSTN/ISDN networks.

Gateway MSC

In order to setup a call, the NSS requires more than an MSC, HLR and VLR, because the call is first routed to a gateway switch, referred to as GMSC. The GMSC is responsible for collecting the location information and routing the call to the MSC through which the subscriber can obtain service at that instant.

Operation and Maintenance Subsystem OMSS

The OMSS is responsible for handling system security base on the validation of identities of various telecommunications entities. It is also in charge of remote operation and maintenance of the network. Functions are monitored and controlled in the OMSS and may have one or more Network Management Centres NMCs to centralise network control.

Authentication Centre AUC

This is responsible for information used for encrypting and authenticating the mobile station. The AUC provides the HLR with different sets of parameters in order to complete the authentication of the mobile station. The AUC is accessed by the HLR to determine whether an MS will be granted service.

Equipment Identity Register EIR

This is an additional feature to the GSM security system that also form part of the OMSS

equipment. The EIR is an optional feature that the network operator can opt for and when implemented denied all stolen and/or MS with defect access to the network. This is possible via identifying and storing all their serial numbers. The AUC and EIR are implemented either as stand-alone nodes or as a combined AUC/EIR node.

METHODOLOGY

The network topology depicts that its performance depends on the base stations which communicate with the mobile stations by sending and receiving signals at regular interval. However, the Cellular Network System working condition is hinged around a number of parameters such as the coverage area of the Cell, the transmitting power of the Cell, the capacity (i.e. Erlang) of the base station etc.

The approach to this paper was carrying out traffic congestion audit of MTN cells located within Dutse metropolis, which involves following routes between the cells and assessing the quality of service (QoS).

The Base Transceiver Station (BTS) power throughput was measured and its maximum carrying capacity of Mobile Stations (MSs) was identified which enable the determination of the amount of deviation from the expected power. The paper proposes to identify the channels and/or interface(s) that mostly contributed to this traffic congestion by comparing the findings with the Key Performance Indicators (KPIs); based on these, possible solutions for improvement were proffered.

Network Performance Analysis

The performance of every network can therefore be analysed and enhanced (optimised) for the betterment of end users. The processes involved in optimising every network can either be software or hardware based. The software based is simply adjusting some parameters of the BTS for better coverage and QoS. Besides that, there are various key performance indicators which have to be constantly

monitored and maintained. Necessary changes might be proposed in order to keep the KPIs within the threshold of the mobile operators.

For the hardware based, it can either be an Electrical Tilt or Mechanical Tilt. Thus, this project focuses on the software aspect of the network.

Key Performance Indicators (KPIs)

The KPIs served as the gauge to those parameters of the network that determine its performance. The system will be at its optimum when these performance parameters are all measured to be operating at the KPIs. This research considers the following as key performance parameters of the system:

- 1) Paging Success Rate
- 2) Immediate Assignment Success Rate
- 3) Random Access Success Rate
- 4) TCH Assignment Success Rate
- 5) Call Drop Rate
- 6) Handover Success Rate

KPIs as previously stated may have an International Standard as such mobile operators may have their own reference point due to their peculiarities and the condition under which they are operating. This thesis focuses on MTN operators.

Table 1: KPIs for MTN Operators

Metric	KPI
Percentage Congestion (Pcong)	≤5%
Percentage Drop (Pdrop)	≤2%
Erlang	According to site design
Traffic Channel (TCH) Availability	≥99%
Percentage Control Congestion (PCCong)	≤1%
PBADICM	≤2%
Percentage Traffic (PTFail)	≤5%
Percentage Setup (PSFail)	≤5%
Percentage Control Fail (PCFail)	≤5%
Handover (HO) Success Rate	≥95%
Call Setup Success Rate CSSR	≥95%

DATA COLLECTION PROCEDURE

In an effort to arriving at the research aim and objectives, there are two basic methods used in data collection to this project, these are:

- a) Drive Test
- b) Record tracking from the network stack counters. In addition to the above, a verbal discussion was also adopted for more information about some standards used by MTN operators where the need arises. The traffic congestion audit of MTN cells located within Dutse metropolis was therefore conducted via the drive test and record tracking methods. The details of the results are as follows:

Drive Test

The drive test is a means of data collection on moving vehicle. This type of test is done regardless of the technology involved e.g. GSM, CDMA, UMTS, and LTE etc. the analysis of the drive test data is the inhibiting factor toward evaluating a network and in return may make some changes in an effort to optimising the entire system. The following equipment are needed to carry out a successful drive test.

- a) Laptop Computer
- b) Data Collection Software (e.g. TEMS 9.0 for this case)
- c) Dongle Key (Serve as security for unlocking the software inform of flash memory)
- d) Mobile Phone (at least one mobile phone)
- e) A GPS (Global Positioning System) worldwide navigation system that uses information received from orbiting satellites.
- f) A Scanner (Optional).

Drive Test Types

Basically there are numerous types/reasons for which a drive test was conducted among others are:

- Performance Analysis
- Integration of new sites and change parameters of existing ones
- Marketing

- Benchmarking

The most popular among these are the Performance Analysis (for an individual operator) and the Benchmarking (Compares between two or more operators). Test for performance analysis is the most common, and usually made in areas/sites of interest. Drive test for data collection and/or analysis allows test data to be collected while moving. The data can be viewed or analysed in real time allowing a view of network performance on the field. Data from all units are grouped by collection software and stored.

The GPS is meant to collect the data latitude and longitude of every point of measurement like time,

speed etc. In other word, it also helps in locating a predefined route. The mobile station (MS) is meant for call initiation at regular interval via a predefined frequency so that data like signal strength, best cell handover success, etc. can be recorded.

The area in essence Dutse is the capital city of Jigawa State one of the developing States located at the North-western part of Nigeria, with an estimated population of 17,697 (2007). MTN operators had about ten different BTS sites within the metropolis as shown in the Table (2).

Table 3.2: List of Dutse Sites Configuration

Site ID	Site Name	Configuration	No of Transceivers (TRX)
JG0004	JG0004_Limawa Ward	222/222	12
JG0021	JG0021_Inuwa Dutse Housing Est.	222/666	24
JG0023	JG0023_Jigawar_Tsada	222/444	18
JG5391	JG5391_Galamawa_Pri_Sch	222/666	24
JG5748	JG5748_Fanisau_Junction	222/666	24
JG0013	JG0013_Kasuwan_Katako	222/222	12
T5360	T5360_NipostDutse	233/666	26
T5351	T5351_Gadade	442/666	28
T5361	T5361_SecretariatRD	332/646	24
T5565	T5565A_MopolStation_Dutse	244/466	26

Each BTS contains six different cells with transceivers ranging from 12 to 48. All the said BTS are controlled by one BSC with a capacity of about fifty BTS. The cells operate via two different Radio Frequencies (i.e. 900MHz and 1800MHz). The radio frequency (RF) planning and optimisation teams of MTN operators predefine a drive test route for a newly designed MSC coverage area and updated the existing one in the case where an additional site was added.

Tracked Traffic Record

This method was adopted due to the fact that the drive test is usually a scheduled activity. Looking

forward to the aim of this project, it might be a difficult task to have DT coinciding with any of the type of an unscheduled event necessary to make the network congested, thus, it become necessary to put the area under consideration to surveillance until such activity was experienced. Many parametres were recorded, but for the sake of this work most relevant parametres includes:

- i) Erlang
- ii) Call Setup Success Rate CSSR
- iii) Percent Call Congestion PCCong
- iv) Percent Call Fail PCFail
- v) Percent Setup Fail PSFail
- vi) Percent Traffic Fail PTFail

- vii) BADICM
- viii) Percent Drop Pdrop
- ix) Stand Alone Dedicated Control Channel SDCCH
- x) Traffic Channel TCH

- ii) Receive Quality
- iii) Congestion Level

RESULTS ANALYSIS AND DISCUSSION

Drive Test at Dutse (Peak Hour)

As previously discussed in chapter three

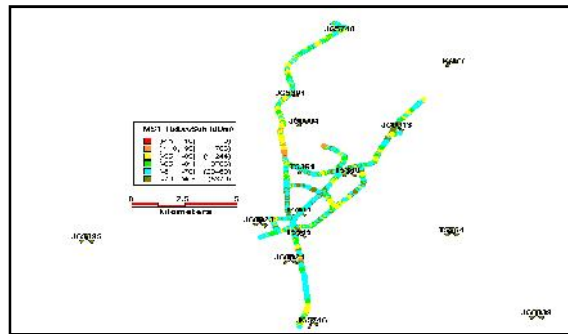
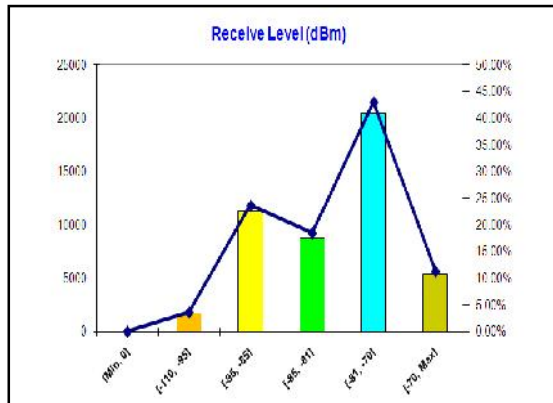
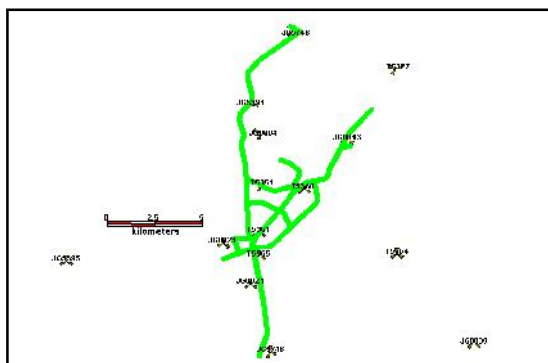


Figure (4) MSI Rx Level Plot

sections 3, drive test is the first adopted method of data collection in this project. The Drive Test (DT) was conducted during the peak hour to verify the level of congestion, the signal strength as well as the receive quality within this hour.

Following the predefined drive test route by the MTN operators, the DT was undertaken following

For the sake of clarity, the receive level plot is further Tabulated in Table 3 below:



the predefined test route is shown in figure (4) below:

Figure (3) Test Route (In Dutse Metropolis)

Table 3: MSI Rx Level Count

Ranges (in dB)	Call Samples	% usage	Cumulative Percentage
[Min, -110]	0	0.00%	0.00%
[-110, -95]	1706	3.59%	3.59%
[-95, -85]	11244	23.63%	27.22%
[-85, -81]	8786	18.46%	45.68%
[-81, -70]	20469	43.02%	88.70%
[-70, Max]	5379	11.30%	100.00%
Total	47584	100.00%	100.00%

Figure (5) MSI Rx Level Chart

On the basis of the drive test via the route shown above, the relevant logged data are obtained as follows:

- i) Receive Level

Figure (5) represent the MSI Rx level chart with the sampled call (Vertical Left) in percentage (Vertical Right) The call samples obtained with better attenuation level -70, max (5379) is the list compared to the other dB levels, with an exception of -110, -95 (1706) which is indeterminate. Hence, the MSI Rx level chart above indicated poor signal strength receives level as compared with recommended MTN KPIs.

Receive Quality (dB)

The receive quality indicates in quantitative terms the quality of the received signal. Although a signal Rx level might be strong, yet, the signal quality could be poor. At times user may have experienced a breakage in voice while communicating but still the Rx level seem to be good.

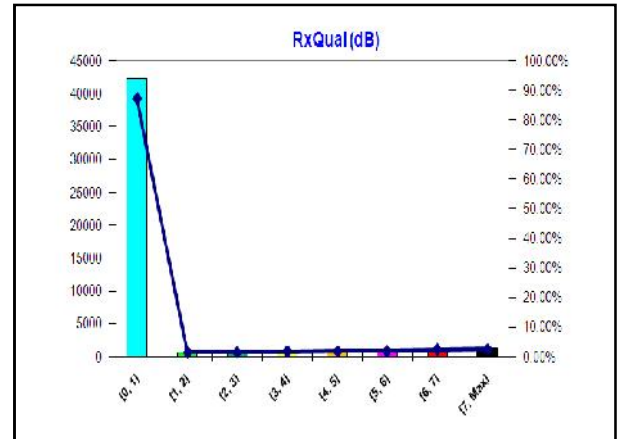


Figure (6) MSI Rx Level Chart

Similar procedures were followed as in the case of receive level to come up with the chart in figure 6 and clearly shows that the lower level 0,1 the call samples read up to 42352 and continued to degrade with an increase of the level until level 6,7 with 1122 and 7, max with 1243 sample calls. Compared

with the recommended KPIs by the MTN operators, it clearly shows that poor quality was signal received during this time because it is considered good at 1,2 and 2,3 respectively; as such optimization is required to ensure optimal performance of the cell sites.

Congestion

Congestion according to Syski in [1] is defined as the unavailability of network to the subscriber at the time of making a call. It is the situation when the blocking occurs and no free path can be provided for an offered call. That is, when a

subscriber cannot obtain a connection to the wanted subscriber immediately. Figure 4.5 is the sample of one out of six blocked calls experienced during the test.

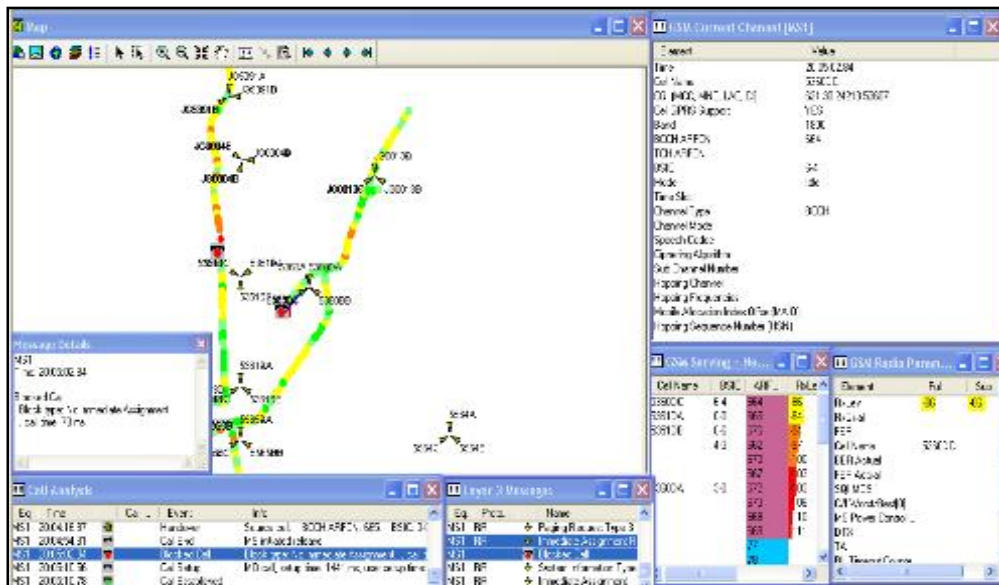


Fig. (7) Blocked Call2 experienced on cell 53600C

Table (4) Network Analysis Summary

Events	MTN (Dedicated Long Call Mode)
Call Initiation	32
Call Attempt	30
Call Setup success	25
Drop Call Count	0
Block Call Count	6
Total Good Calls - /Call End	25
Established Calls	25
Total Handover Success	58
Total Handover Failures	3
Cell Reselection	5
% Call Setup Success	83.33%
% Blocked Calls	20.00%
% Dropped Calls	0.00%
% Established Calls	100.00%
% Good Calls	100.00%
% Handover Success	94.83%
% Handover Failure	5.17%

Table (4) displays the Network analysis summary of the entire Drive Test and the resulting effect. The result shown by the DT has the following observed issues:

- i) The CSSR of the first DT was 83.33%, which is less than the acceptable KPI threshold of $\geq 95\%$.
- ii) Handover success rate was less by 0.17% to the minimal accepted KPI.
- iii) There were six blocked calls by different cells (five on 900MHz band and only one is on 1800MHz band). Four of the blocked calls are caused by "absence of immediate assignment" and the rest as a result of "non mobility management connection".
- iv) Low Rx level was recorded as shown in table 4.2.
- v) Rx quality is also very poor as recorded.

vi) There are no dropped calls throughout the calls established.

Drive Test (Off Peak Period)

The first DT was conducted during the peak hour whereas the record track was conducted to monitor the effect of congestion due to the unscheduled event. An attempt was also made to evaluate the network during off peak hour. This was done in an effort to ascertain the level of congestion that may likely occurred during this hour. This was conducted on Wednesday 13th February, 2013 by 11:27 am. TEMS investigation (9.0) software for data collection was used hence; Table 4.4 shows the result summary produced.

Table 4.4 TEMS 9.0 Result Summary

The network experienced three dropped call and only one handover failure was recorded. This goes to show that the congestion level as compared to the peak hour is less.

Possible Courses

a) CSSR might be affected and degraded due to the following issues:

- i) Due to radio interface congestion
- ii) Due to lack of radio resources allocation like SDCCH.
- iii) Increase in radio traffic in inbound network.
- iv) Faulty BSS hardware.

b) Call Drop Rate might be as a result of the following:

- i) Priority call initiation
- ii) Interference (either external or internal) being observed over air interface. Internal interference corresponds to in-band (900/1800MHz) while external interference corresponds to other wireless (usually military) networks.
- iii) Coverage limitation
- ii) Hardware faults

c) TCH: Traffic Channel Congestion might be as a result of the followings:

- i) Low TRX in the site
- ii) Increased the number of users beyond the site pre-planned capacity.
- iii) TRX hardware faults.

d) Rx Level: low signal received level could arouse as a result of the followings:

- i) Low transmission power.
- ii) Hardware (Mechanical and/or Electrical tilt orientation).

e) Rx Quality: This can be as a result of the following:

- i) Low receiving level.
- ii) Internal and/or external interference.
- iii) Assignment failure.
- iv) Hardware problem.

Event	#[No.o f]	Relationsh ip	#Cell	#Log
Missing Neighbour Detection, GSM Symmetry	4	-	-	↓
Call Attempt	27	-	-	↓
Call Attempt Retry	2	-	-	↓
Call Setup	27	-	-	↓
Dropped Call	3	-	-	↓
Handover	71	-	-	↓
Handover Failure	1	-	-	↓
Routing Area Update	2	-	-	↓

Tracked Traffic Record

Appendix A revealed that the first three Cells (in Table 6, 7 and 8) are among the six Cells found in BTS0 with site name "NipostDutse". While the remaining three (cells in Table 9, 10 and 11) are part of those attached to BTS1 i.e. "Secretariat Road". These sites were given preference due to their closeness to the scene of the event as such, they have higher probability to traffic congestion effect.

The Analysis

The success of RF optimisation of operational cellular network is based on the findings, observations and improvement made to the entire system and then the result propagated to the end user. [14] sees the followings as the most important KPIs for GSM for radio network optimisation and benchmarking as to achieve remarkable QoS:

- a) CSSR (Call Setup Success Rate)
- b) CDR (Call Drop Rate)
- c) HSR (Handover Success Rate)

- d) TCH (Traffic Channel) Congestion Rate
- e) Rx Level
- f) Rx Quality

All the key parameters responsible for traffic and the Qos are therefore compared to the KPIs applicable to MTN operators as shown in figure (8) to (17).

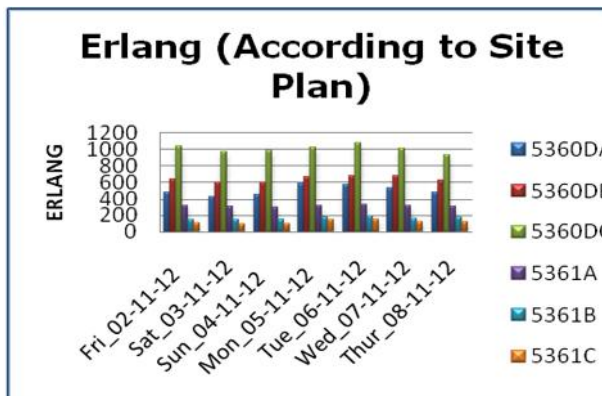


Figure (8) Erlang (According to Site Plan)

Figure (8) shows the erlang of every cell and no deviation was recorded as it depend on the site plan of their corresponding BTS as manifested in the chart above, thus no deviation was recorded.

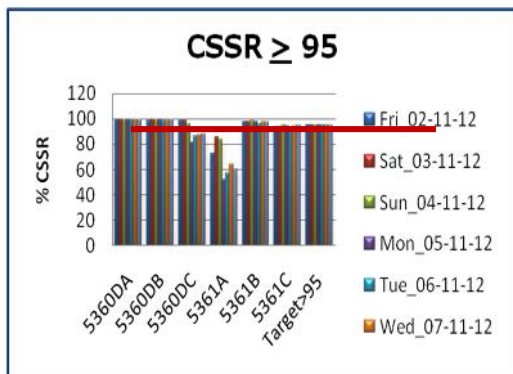


Figure (9) Call Setup Success Rate

Observations:

The corresponding CSSR in figure 4.7 of all the cells are as follows:

- i) All the Call Setup Success Rate on cell 5361A are very poor during the week days with Monday having the least value of 51.4% less with more than 40% of the acceptable KPI threshold.

- ii) Cell 5360Dc record CSSR failure from Monday (81.31%) through Thursday with 6.55% less the KPI.
- iii) Others maintained good quality as compared to the target.

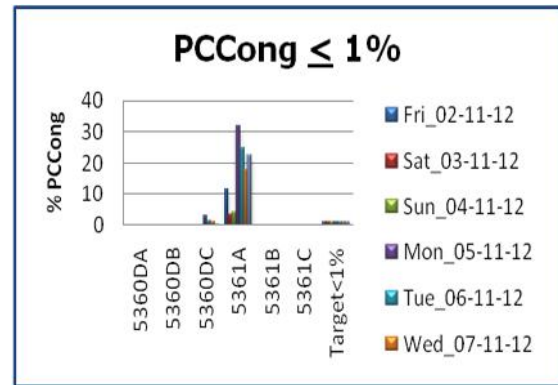
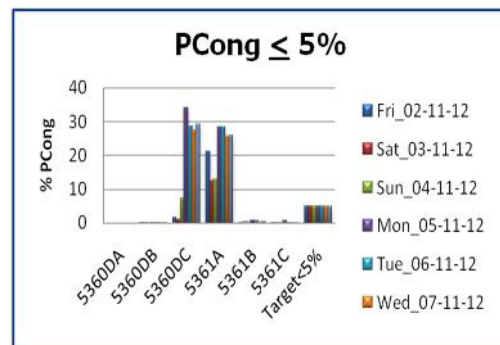


Figure (10) Percentage Control Congestion From figure 4.8 it can be seen that:

- i) 5361A experience the highest PCCong on Monday



31.98% which is incomparable with the accepted KPI of $\leq 1\%$.

- ii) Cell 5360DC recorded higher KPI acceptable value on Monday, Tuesday and Wednesday of 2.94, 1.35 and 1.14 respectively.
- iii) All others are within the threshold.

Figure (10) Percentage Congestion

Figure 4.9 shows that:

- i) The congestion level is poor on cell 5361A throughout the week.
- ii) The poor record of congestion is recorded from Monday through Thursday on cell 5360DC.
- iii) The remaining cells are within the KPIs threshold.

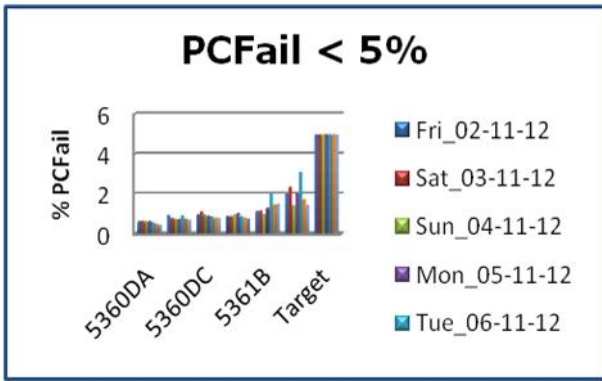


Figure (11) Percentage Control Fail

Figure above shows that all the PCFail of all c are within the threshold of <5%.

Figure (12) Percentage Traffic Fail

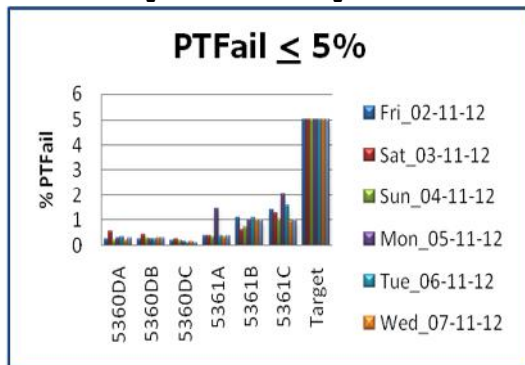


Figure (12) shows that the percentage traffic fail is within the threshold $\leq 5\%$.

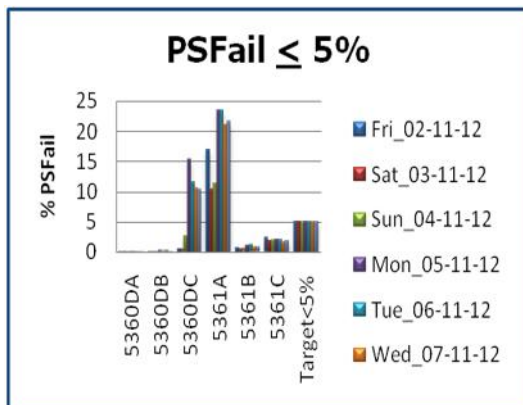
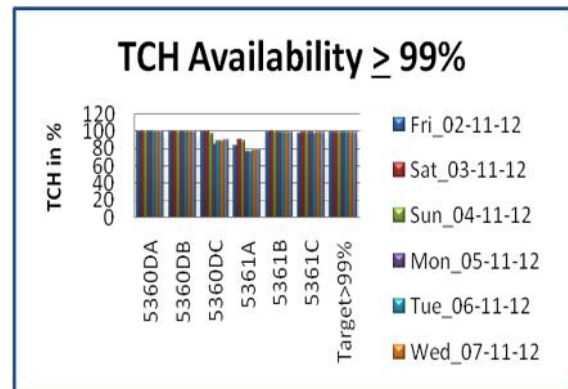


Figure (13) Percentage Setup Fail

From figure 4.12 the resulted observations are:

- i) A Setup failure has higher percentage on cell 5361A most especially from Monday to Thursday.
- ii) Cell 5360DC also experienced high setup failure on Monday by 15.43% through Thursday.



- iii) All other cells maintained the recommended KPIs.

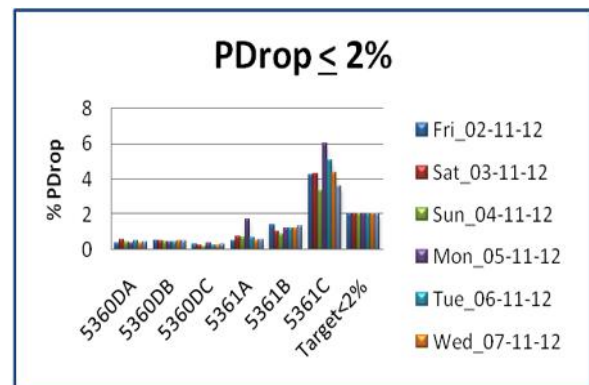


Figure (14) Percentage Drop

Figure above shows how percentage drop was only experienced above the KPI on cell 5361C most especially on Monday.

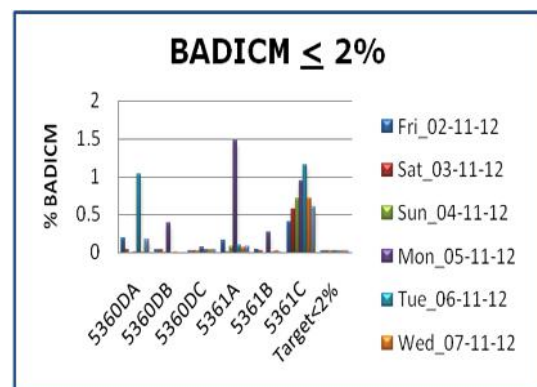


Figure (15) Percentage Bad ICM

Figure (15) shows that:

- i) 1.48 is the recorded value on Monday, cell 5361A which is more than 70 times the acceptable value of $\leq 2\%$
- ii) All but few are beyond the recommended KPI value.
- iii) It can also be observed that the BADICM is fluctuating within the weeks.

Figure (16) Traffic Channel Availability

It was observed in Figure (16) that:

- i) The TCH availability was also very poor on cell 5361A with Monday & Tuesday having the least recorded value of 76.59% and 76.53% respectively and the remaining are all less than the minimal KPIs.
- ii) TCH failure on cell 5360DC started from Monday onward with a least recorded value of 84.57%.
- ii) All other cells maintained the threshold.

Figure (17) SDCCH Estab. Succ. Rate

Figure (17) shows that:

- i) All the SDCCH record of cell 5361A (Secretarial Road) is very poor as they are by far less than the recommended KPI rated value of $\geq 98\%$.
- ii) SDCCH record of Monday 5th Nov, 2012; of cell 5360DC (NipostDutse) was 96.18% less by 1.82% to the minimal threshold.
- iii) Other cells have reasonable values compared to the KPIs.

CONCLUSION

This paper proposed a method to solving the persistent congestion problems that usually arouse due to multiple reasons amongst which are the added features that are attached to data connection services like browsing and/or multimedia activities, unplanned public events etc.

Going by the research findings, it entails that the channels that are significantly involved in call setup are at the same time played a vital role toward congestion effect. They are Broadcast Control Channel (BCCH) and the Paging Channel (PCH) all part of Control Channel (CCH). These channels communicate

with almost all the nodes of the operational GSM system during the paging process, thereby influenced by the performance of each of the node thus; paging success became the most complex among all other KPIs. If the paging success rate is improved virtually almost all other KPIs are improved.

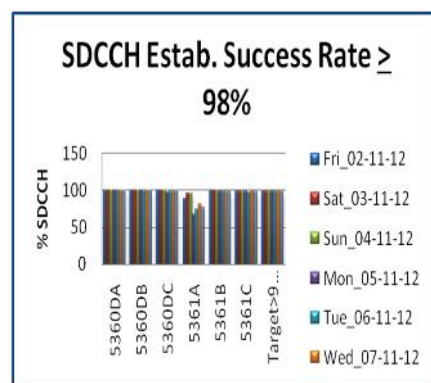
Although the congestion analysis is not a new issue to MTN network in Nigeria, the contributed toward investigating the real time effect of congestion caused by un-planned public event using non conventional approach in an area that cannot easily experience such effect under normal traffic considering the ratio of MTN facilities to the population of settlers within the metropolis.

The limitation faced while conducting this research work was the difficulty in identifying the actual numbers of subscribers that attempted a call over a period of time because of redial issue. Having access to the GSM operator’s gadgets while data collection without which the research may not be a success; is another deteriorating factor toward achieving the aim of the research.

RECOMMENDATIONS

Below are some of the recommended improvement methodologies that when implemented might either minimise the congestion problem or eliminate it entirely:

- a) There is need for improving/upgrading the existing sites’ capacity of cells (such as TRX) to forestall the avalanches of listed problems.
- b) Faulty hardware replacement (e.g. TRX) needs to be



replaced to ensure resource

- c) availability.
- d) There is need for employing National roaming agreement between the GSM operators in Nigeria.
- e) Although they might have their own congestion effect yet; there is need for a special consideration to emergency and/or priority calls to forestall health and security needs.
- f) Employing dynamic half data rate (i.e. reducing data rate) might doubled the availability of resources there by aiding congestion to minimal.
- g) Radio resources enhancement (i.e. modification of concerned parametres) need to be implemented.
- h) New site integration is also suggested in order to improve indoor and outdoor coverage, which is usually termed as "Grid enhancement".
- i) There is need for additional Radio Frequency repeaters.
- j) Physical optimisation techniques need to be made to an existing coverage optimisation.
- k) Frequency hopping need to be incorporated (where absent) to minimise effect of interference.
- l) In a nutshell there is need for deployment of portable BTS (commonly called CDW BTS) as a better solution to improve congestion in case of foreseeable special events.

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APPENDIX

Table (6) Jigawa_NipostDutse_Cell 53600C

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	475.99	99.2	0	0	0.65	0.12	0.25	0.38	0.19	99.35	99.88
Sat_03Nov	425.6	99.18	0	0	0.65	0.14	0.57	0.56	0.03	99.35	99.86
Sun_04Nov	447.05	99.2	0	0	0.66	0.11	0.22	0.44	0	99.34	99.89
Mon_05Nov	581.24	99.2	0	0	0.66	0.13	0.29	0.4	0.01	99.34	99.87
Tue_06Nov	568.59	99.27	0	0	0.59	0.11	0.33	0.49	1.03	99.41	99.89
Wed_07Nov	531.82	99.36	0	0	0.51	0.11	0.22	0.39	0.01	99.49	99.89
Thur_08Nov	473.6	99.44	0.01	0	0.46	0.08	0.28	0.43	0.17	99.54	99.92

Table (7) Jigawa_NipostDutse_Cell 53600B

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	638.09	98.88	0	0.01	0.94	0.15	0.26	0.03	0.53	99.06	99.85
Sat_03Nov	599.12	99.02	0	0.03	0.79	0.15	0.41	0.03	0.48	99.21	99.85
Sun_04Nov	596.27	99.08	0	0.02	0.76	0.14	0.27	0.01	0.47	99.24	99.86
Mon_05Nov	668.79	99	0	0.14	0.75	0.22	0.24	0.38	0.46	99.25	99.78
Tue_06Nov	682.99	98.86	0	0.09	0.92	0.2	0.26	0	0.45	99.08	99.8
Wed_07Nov	678	98.94	0	0.19	0.77	0.25	0.28	0.01	0.48	99.23	99.75
Thur_08Nov	624.93	99.13	0	0.06	0.72	0.13	0.28	0	0.51	99.28	99.87

Table (8) Jigawa_NipostDutse_Cell 53600C

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	1035.14	98.48	0	1.57	0.98	0.53	0.19	0.02	0.31	99.02	99.47
Sat_03Nov	966.84	98.48	0	1.1	1.13	0.38	0.26	0.02	0.28	98.87	99.62
Sun_04Nov	977.84	96.33	0.01	7.16	0.96	2.7	0.19	0.02	0.22	99.03	97.3
Mon_05Nov	1030.82	81.31	2.94	34.06	0.92	15.43	0.15	0.07	0.35	96.18	84.57
Tue_06Nov	1072.03	86.45	1.35	28.79	0.86	11.58	0.12	0.04	0.23	97.8	88.42
Wed_07Nov	1014.07	87.59	1.14	27.35	0.82	10.63	0.14	0.03	0.25	98.05	89.37
Thur_08Nov	931.91	88.45	0.4	29.13	0.81	10.44	0.1	0.03	0.29	98.79	89.56

Table (9) Jigawa_SecretariatRd_Cell 5361A

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	317.21	72.51	11.7	21.02	0.91	0.39	16.95	0.16	0.51	87.49	83.05
Sat_03Nov	302.38	85.57	3.52	12.35	0.89	0.39	10.36	0.01	0.73	95.62	89.64
Sun_04Nov	299.02	83.71	4.15	12.87	0.99	0.33	11.41	0.08	0.72	94.9	88.59
Mon_05Nov	325.12	51.4	31.98	28.3	1.05	1.46	23.41	1.48	1.71	67.31	76.59
Tue_06Nov	328.63	56.73	24.98	28.22	0.89	0.4	23.47	0.09	0.67	74.36	76.53
Wed_07Nov	314.31	64.19	17.79	25.77	0.81	0.35	21.06	0.06	0.53	81.54	78.94
Thur_08Nov	303.65	60.13	22.48	25.89	0.78	0.37	21.64	0.08	0.59	76.92	78.36

Table (10) Jigawa_SecretariatRd_Cell 5361B

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	143.24	97.9	0	0.15	1.14	0.73	1.08	0.04	1.37	98.86	99.27
Sat_03Nov	144.05	98.01	0	0.29	1.19	0.55	0.62	0.02	1.03	98.81	99.45
Sun_04Nov	147.22	98.25	0	0.27	0.98	0.63	0.72	0	0.86	99.02	99.37
Mon_05Nov	177.35	97.37	0	0.82	1.31	1.1	1.01	0.26	1.21	98.69	98.9
Tue_06Nov	190.56	96.38	0.02	0.59	2.05	1.18	1.1	0.01	1.2	97.93	98.82
Wed_07Nov	159.15	97.49	0	0.26	1.47	0.83	1.01	0.02	1.22	98.53	99.17
Thur_08Nov	169.34	97.44	0	0.33	1.51	0.79	0.99	0.01	1.32	98.49	99.21

Table (11) Jigawa_SecretariatRd_Cell 5361C

Day (2012)	Erlang	CSSR	PCCong	PCong	PCFail	PSFail	PTFail	BADICM	Pdrop	SDCCH	TCH
Fri_02Nov	107.38	93.61	0.02	0.01	2.02	1.41	2.36	0.4	4.24	97.96	97.64
Sat_03Nov	90.65	93.36	0	0.01	2.38	1.26	1.92	0.57	4.33	97.62	98.08
Sun_04Nov	100.26	94.7	0	0.08	1.43	1.03	1.98	0.72	3.37	98.57	98.02
Mon_05Nov	145.76	93.86	0	0.76	2.05	2.01	2.11	0.95	5.99	97.95	97.89
Tue_06Nov	150.53	92.3	0	0.15	3.11	1.57	2.12	1.15	5.08	96.89	97.88
Wed_07Nov	114.21	94.55	0	0.03	1.73	0.96	1.65	0.71	4.35	98.27	98.35
Thur_08Nov	114.52	95.22	0	0.08	1.45	1.01	1.85	0.6	3.64	98.55	98.15