KWAME NKRUMAH UNIVERSITY OF SCIENCE AND

TECHNOLOGY, KUMASI, GHANA

OPTIMIZATION FRAMEWORK FOR DEROGATING SDCCH AND TCH CONGESTIONS IN LIBERIA GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS (GSM)

BY

JUSU, TAMBA FALLAH BERNARD
(BSc Electronics Eng.)

A Thesis submitted to the Department of Electrical/Electronic Engineering, Kwame Nkrumah University of Science and Technology in fulfillment of the Requirements for the degree

Of

Master of Science (Telecommunications Engineering)

College of Engineering

MAY, 2014

DECLARATION

I hereby declare that, except for specific references which have been duly acknowledged, this work is the result of my research and it has not been submitted either in part or whole for any other degree elsewhere.

Jusu, Tamba Fallah Bernard . . . . . .

(Student) Signature Date

Certified by:

Rev. Dr. J.K. Oppong . . . . . .

(Supervisor) Signature Date

Certified by:

Prof. P.Y. Okyere . . . . . .

(Head of Department) Signature Date

ABSTRACT

In GSM communications, congestion remains a major factor and stands as a high influence in the satisfaction of subscribers and service providers[1]. Traffic Channel (TCH) and Standalone Dedicated Control Channel (SDCCH) Congestions are two major problems faced in GSM networks. This thesis attempted to investigate the causes of SDCCH & TCH congestions, and the assessment of the current state of GSM networks in Liberia by using a Liberian GSM network's KPI (key Performance indicator) as case study to develop an optimized GSM network model.

During the sampling and processing of the data in the investigation, a range of 49-0% was chosen as the worst call setup success rate (WCSSR). These WCSSR locations along with their various SDCCH & TCH congestion results were later plotted into bar chart graphs, and point graphs using OriginPro software. Finally, a Sugeno-Takagi KPI Optimization simulation setup was developed using Adaptive Network Fuzzy Inference System (ANFIS) model in MATLAB. The simulations compares and demonstrates the current and expected optimized network. The result shows that optimization is possible and can be almost at the maximum level in real cellular networks.

ACKNOWLEDGMENT

I would like to take this opportunity to thank some people for their advices and support throughout this thesis. Firstly, the department of Electrical/Electronic Engineering KNUST for giving me the opportunity to study in this great Institution, and my supervisor Rev. Dr. J.K.Oppong for all the suggestions and most importantly his motivating enthusiasm and time.

There were many others who helped me during my work on this thesis through their advice, discussions, critical analysis, and socializing. In naming some of those people, I want to thank Cletus Kpartor, Robert N.Otupiri, Mahmoud Solomon, Michael Oyibo, Ajobiewe Scott Oluwadamilola, Susan Sagde Kyorku (Deceased), Portia Addai Boadu, Cyril Zegbla, with my apologies to those I may have forgotten here.

Finally, I want to thank those who did not directly contribute to this thesis, but supported me in various ways during the writing of my thesis, and during the duration of my study. Most notably, these include my parents & entire family, my friends, and especially my fiancée Tenneh Michelle Curtis. My thanks for all their love and support.

My sincere and warmest gratitude to you all.

DEDICATION

This thesis is firstly dedicated to GOD the Father Almighty for giving me the courage to believe in myself, and also to my late dad Fayiah K. Jusu who wished and always wanted us (his children) to reach the highest peaks of education.

Secondly, I dedicate this work to one of the strongest and hard-handed mother in the world, Mrs. Olive M. Jusu. Your talking, beating, teaching and everything brought me this far. You always believe in me. You are worth so much to me. I owe you everything.

Finally, my sponsors, Advisors, and well-wishers

1. Mr. & Mrs. George M. Lahun

   Managing Director Jusmart Engineers Ltd. Liberia
2. Pastor & Mrs. Simeon F. Menso
3. Pastor & Mrs. Francis T. Colendo

   Resident Pastor Winners Chapel International, Nungua, Accra, Ghana
4. Mother Martha Lincoln, Mrs. Lorpu R. Johnson, My brothers & Sisters, Voice of Hope team and all others.

Your many patience, advice, money, food, time and most especially prayers have made me a proud son, brother, and nephew today.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AGCHC	Access Grant Channel Congestion
ANFIS	Adaptive Network Fuzzy Inference System
BSC	Base Station Controller
BTS	Base Transceiver Station
CCCH	Common Control Channel
CDR	Call Drop Rate
CKSN	Ciphering Key Sequence Number
DCHC	Dedicated Control Channel Congestion
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile communication
HO	Hand Over
IMSI	International Mobile Subscriber Identity
KPIs	Key Performance Indicators
LAPD	Link Access Protocol on Dm channel
LTA	Liberia Telecommunications Authority
MCC	Mobile Country Code
MNC	Mobile Network Code
MSIN	Mobile Subscriber Identification Number
ME	Mobile Equipment
MS	Mobile Station
MSC	Mobile Switching Center
NMC	Network Management Center
OMC	Operation and Maintenance Center

OSS	Operation Support Subsystem
PCHC	Paging Channel Congestion
QoS	Quality of Service
RACHC	Random Access Channel Congestion
SDCCH	Standalone Dedicated Control Channel
SIM	Subscriber Identity Module
SFH	Slow Frequency Hopping
SMS	Short Message Service
SS	Switching System
TCH	Traffic Channel
TMSI	Temporary Mobile Subscriber Identity
TRX	Transceiver
WCSSR	Worst Call Setup Success Rate

CHAPTER 1:

INTRODUCTION

1.0 Introduction

GSM

Global system for mobile communications (GSM), a digital cellular radio network, uses more advanced technology and handles more subscribers than the analogue cellular network due to the use of Time Division Multiple Access to divide the channel in time. High quality voice communication and low bandwidth (96kb/sec) data connections for fax and Short Message Service (SMS) are offered[2].

GSM communication aims to give communications anytime and everywhere between objects. GSM Network, usually called ‘’cellular network‟ (as the whole coverage area is divided into different cells and sectors), is comprised of a mobile Station (MS) which is connected to the Base Transceiver Station (BTS) through air interface[3]. In addition to other hardware, BTS contains the equipment called Transceiver (TRX), which is responsible for the transmission and reception of several radio frequency (RF) signals to/from the end user. BTS is then connected to the base station controller (BSC) through abis interface. The BSC is connected to the Mobile Switching Centre (MSC) and usually handles handovers of the calls from one BTS (or cell/sector) to the other BTS (or cell/sector) equipped in it and radio resource management[3].

1.1 Background of the study

The mobile industry in Africa is booming. With over 620 million mobile connections as of September 2011, Africa overtook Latin America to become the second largest mobile market in the world, after Asia and the fastest growing mobile market in the world. (New GSMA

Africa Mobile Observatory 2011 Report). GSM is one of the most demanding and wildest growing of all wireless mobile telecommunication technologies[4]. According to the Liberia Telecommunication Authority, GSM communication is the major, fastest, and simplest means of telecommunication in Liberia. Family, friends, business partners and others use mobile communications to quickly get messages across to each other locally and internationally but; there are major problems faced with the Quality of services. GSM services like emails, browsing, voice, video streaming and all multimedia demands on mobile telephone have and are still increasing tremendously. As more people subscribe to GSM network services due to the many features available, the issue of congestion on the GSM network also tends to escalate [5]. GSM networks have to deliver what these services demand, so that the performances and the user's satisfaction will be satisfactory. Standalone Dedicated Control Channel (SDCCH) Congestion and Traffic Channel (TCH) Congestion are two of the many problems faced in all GSM Networks in the quest to satisfy subscribers. When these channels are congested, successful call setup success rate (CSSR) will be at a minimum level leading to worst call setup success rate which will be at a high level. On the other hand, when there are less SDCCH & TCH congestions in a network, operators tends to generate more income from subscribers, subscribers have better quality of services, and vice versa. In order to keep subscribers, the Quality of Service (QoS) of a network should be very good that is, GSM operator's networks should be almost congestion free. Customers may decide to change their network at anytime due to high charges or most especially poor quality of Service (QoS). Operators may suffer greatly if there are congestions in these channels. The more a network is optimized, the better the quality gets, the more subscribers will be added to the network, and more incomes will be generated. Subscriber's satisfaction and generating incomes are two main reasons an operator should optimize his network.

1.2 Research Motivation & Problem Statement

From several interactions with subscribers, service personnel, mobile network engineers, and self-observations over the years, in different cities and different GSM networks in Liberia; delays in text, voice, and setting up calls have been major issues with networks. Subsequently with network coverage, subscribers usually receive signs of "Network Busy" that is, when a subscriber dial a number to call, the call don't go through but instead drops for redial. This also happens when trying to send message. Subscribers notice that even with network coverage, messages takes time to send. This inspired the current research to particularly look into SDCCH and TCH congestion in order to improve the mobile communication sectors in Liberia.

Over the years, GSM services across the country have changed positively. Its explosive growth has brought huge revenues both to the operators, subscribers, as well as the government through taxations, license fees and fast businesses. Similarly, citizens and non-citizens have benefited incalculably from those services, not only as a means of communication but; it has provided job opportunities for many people[6]. Nevertheless, the main development that spoils these benefits, are the fast-growing grievances raised by GSM subscribers regarding, quality of services (QoS) rendered by the GSM operators within the country. The unfortunate aspect of this is; the fact that, most GSM subscribers, regardless of the operator, are being affected. In Liberia, GSM subscribers/customers major complaints have been the delay in call setup, voice & text.

1.3 Objectives

1. The study intends to investigate the causes of SDCCH and TCH congestions in GSM networks.
2. To assess the current state of Liberia's GSM networks in relation to SDCCH and TCH congestion.

3. To offer likely solution(s) that will reduce the problems associated with SDCCH and TCH congestions in Liberia's GSM network.

1.4 Main Objective

In GSM, the best way to get more subscribers, and keeping them satisfied, is to make the service as easy to use and very reliable[2]. In this thesis, the main aim is to evaluate and minimize the SDCCH (Stand Alone Dedicated Control Channel) and the TCH (Traffic Channels) congestions in Liberia GSM(s) so that the Network accessibility, service retain-ability, connection quality and network coverage will be almost at a maximum level for the satisfaction of Liberia GSM's subscribers, and the generating of more revenues for the operators.

1.5 Structure of Work

The standpoint of this thesis is as follows: The first chapter provides an introductory summary, research motivation, problem statement, objectives and structure of the work. Chapter two presents an overview of the GSM Network, discusses the various channels in a GSM network, optimization of GSM networks, types of optimization and summarizes related works similarly done in this area of study. In Chapter three, Methodologies employed in this research are introduced. Chapter four examines the expected findings and result(s) of the study. In chapter five, conclusion and recommendation(s) that will be of great help to GSM operators and subscribers are provided. This could also lead to further research in the area of study.

CHAPTER 2:

REVIEW OF RELATED LITERATURE

2.0 Introduction

This Chapter summarizes the GSM Network Architecture based on the reviews of related works done in this study, and strives to make readers understand the basic GSM Network setup, the main interfaces within a GSM Network and finally Four KPI Parameters with emphasis on TCH and SDCCH.

2.1 Overview of GSM Network

GSM networks are the section of the market for wireless devices and mobiles which are evolving more quickly. To attain the best performances in GSM networks, service providers have to continuously monitor and optimize their networks[7].

A GSM system is basically designed as a combination of three major subsystems: the mobile station (MS), the base station Subsystem (BSS), and the operation support subsystem (OSS)/ (SS) Switching System[8].

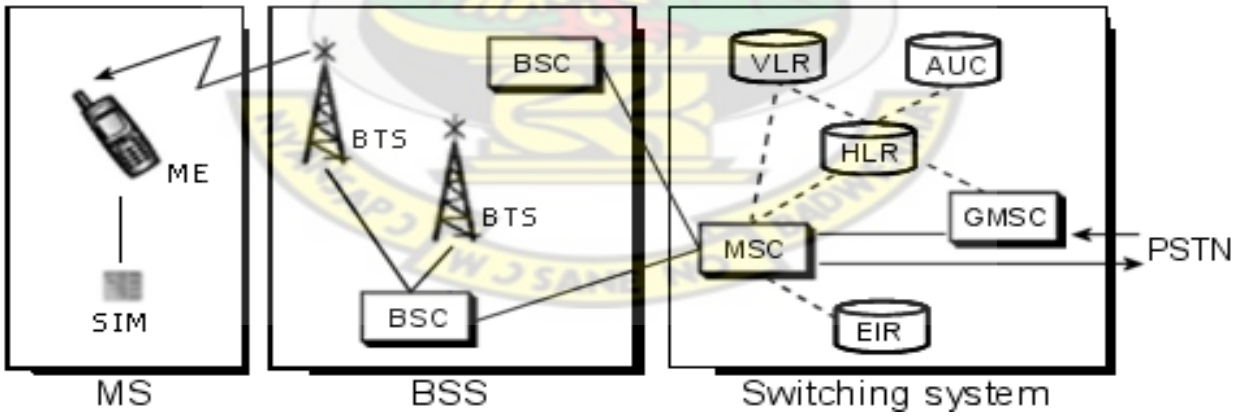


Figure 2.1 Overview of the GSM Network[9]

2.1.1 Mobile Station (MS)

The Mobile Station (MS) is the subscriber's module ME and SIM (Cell Phone+SIM) most people are familiar with. Based on F. v. d. Broek work, for a Mobile Station (MS) in a GSM network to function, there should be a cell phone and a SIM(MS = ME + SIM)[10]. In some of the newer applications (data communications in particular), an MS can also be a terminal that acts as a GSM interface, e.g. for a laptop computer. In this new application the MS does not look like a normal GSM telephone[11].

2.1.2 Mobile Equipment (ME)

The Mobile Equipment (ME) is the GSM phones people use to make and receive calls in a cellular Network. It is basically a transmitter-receiver unit that is different from, or is added by network providers [10].Every ME contains an International Mobile Equipment Identity (IMEI) number consisting of, 15 or 17 digits, which includes information of the device (ME). An IMEI can be known by typing *♯06♯ on a mobile phone (ME)[12, 13].

2.1.3 Subscriber Identity Module

The Subscriber Identity Module (SIM) is a smart card given to a subscriber. Its user identity is contain in a GSM network in which it is dependent[10, 14]. SIMs are uniquely identified by their International Mobile Subscriber Identity (IMSI) numbers, and contains the following information:

- A 2 or 3 digit Mobile Network Code (MNC) European and North American Standards, a 3 digit Mobile Country Code (MCC), and up to 10 digits Mobile Subscriber Identification Number (MSIN)[10].
- The Temporary Mobile Subscriber Identity (TMSI): is handed on to the MS by the network to hide the IMSI.
- The secret key *Ki*
- The current encryption key, also called session key; *Kc*

- The Ciphering Key Sequence Number (CKSN): a 3 bit number send by the network, acting as an identifier of the current session key
- The encoding algorithms A3 and A8[15].

2.2 Base Station Subsystem (BSS)

The Base Station Subsystem (BSS) is made of two parts, the Base Transceiver Station (BTS) and the Base Station Controller (BSC)[4, 16]. They communicate as stated in chapter one across the standardized Abis Interface allowing operations between components made by different suppliers.

2.2.1 Base Transceiver Station (BTS)

A Base Transceiver Station (BTS) is another name for a cell tower, or more accurately a name referred to the transceivers on a cell tower, that handles the mobile station and the radio-Link protocols. A single cell defines one BTS. In general, it is just a relay station that broadcasts to the MS packages it gets from its BSC and vice versa. All the channel encoding/decoding, Slow Frequency Hopping (SFH), Ciphering, Gaussian Minimum Shift Keying (GMSK) and burst formatting are all BTS responsibilities because, it is the link between the air and land interfaces[10]. Although, most BTSs are connected via a land line, some use a microwave directional radio link for this connection. Whether through a land line or through a directional radio link, the signal uses the same Abis interface.

2.2.2 Base Station Controller (BSC)

The Base Station Controller (BSC) is the center of intelligence in the Base Station Subsystem (BSS). It manages the handovers and radio channel setup from a MS, between BTSs that are connected to the BSC[4, 16][1]. It also watches the status of the BSS hardware and handles the

[1] A single BSC controls one or more BTSs and typically serves a population of around 100, 000 to 250, 000 people[10] F. v. d. Broek, "Catching and Understanding GSM-Signals," Master's of Science Master's Thesis Computer Science, Radboud University Nijmegen, 2010. (March 2009. http://openbts.blogspot.com/)

conversation of the 13kb/s voice channel over the radio link to the 64kb/s standard used in the PSTN[2].

2.3 Mobile Switching Center/ Operating Support System

The operation and maintenance sub-system offers an ability to manage the GSM network remotely. Mobile Switching Center is one of the most expansive and important section in a GSM network. It is found at the core of every network[17]. This area of the GSM network is not currently tightly specified by the SMG (Group Special Mobile) specifications. The network operators decide what capabilities they want the operation and maintenance subsystem to have. Operation and maintenance system comprises of two parts[16]:

1. Network Management Center
2. Operation and Maintenance Centre- OMC

2.3.1 Network Management Center (NMC)

The network management Centres offers the power to provide hierarchical regionalized network management of complete GSM system and singles logical facility at the top of the network management hierarchy. The NMC has a high level view of the network as compact of network nodes and interconnecting Communication facilities[18, 19]. On the other hand, it is used to filter information from the network equipment for forwarding to the NMC thus allowing it to focus on issues requiring national coordination. NMC can also coordinate issues concerning interlinking to other networks.

[2] PSTN: The **public switched telephone network** (**PSTN**) is the aggregate of the world's circuit-switched telephone networks that are operated by national, regional, or local telephone operators, providing infrastructure and services for public telecommunication. The PSTN consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and undersea telephone cables, all interconnected by switching centers, thus allowing any telephone in the world to communicate with any other.

Functionality of the NMC

- Monitors trunk routes between nodes on the network
- Monitors high level Alarms
- Passes on knowledge from one OMC region to another to improve problem solving strategies.
- Monitors OMC regions and provides assistance to OMC staffs
- Enables long term planning for the entire network

2.3.2 Operations and Maintenance Center (OMC)

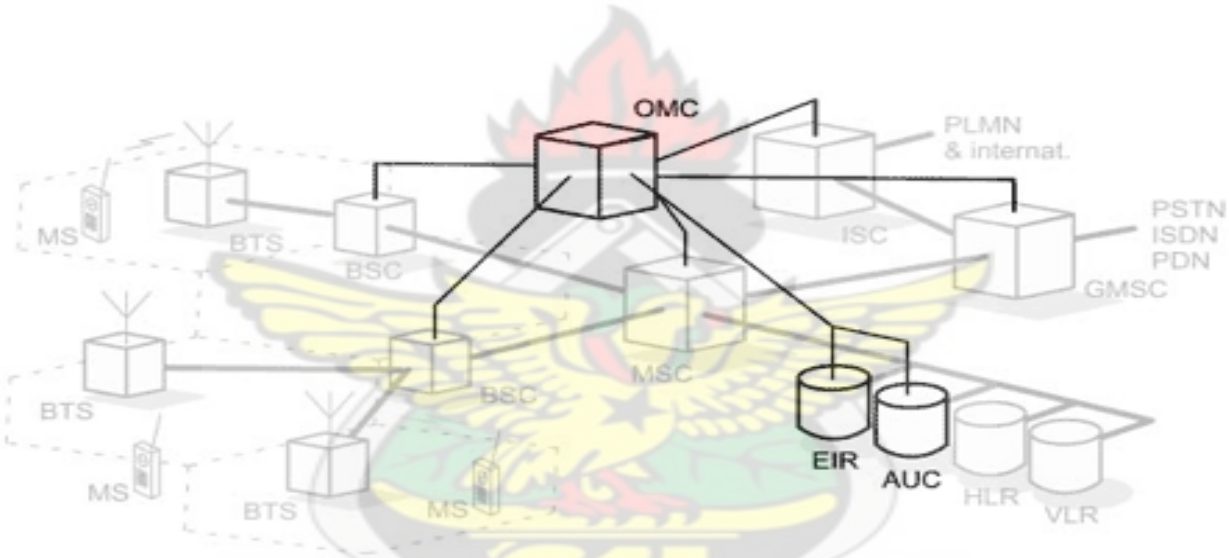


Figure 2.2 Operation And Maintenance Center (OMC)

The operations and maintenance center (OMC) is connected to all equipment's in the switching system and to the BSC[20]. The implementation of OMC is called the operation and support system (OSS)[3]. Based on Ajay R Mishra ADVANCED CELLULAR NETWORK PLANNING AND OPTIMISATION 2G/2.5G/3G EVOLUTION TO 4G (4.14.4 KPI Monitoring), monitoring is usually one of the main requirements for an OSS, and most of them will provide enough monitoring capabilities to be utilized in the packet core network

[3] The OSS is the functional entity from which the network operator monitors and controls the system. The purpose of OSS is to offer the customer cost-effective support for centralized, regional, and local operational and maintenance activities that are required for a GSM network. An important function of OSS is to provide a network overview and support the maintenance activities of different operation and maintenance organizations.

environment. Normally, the optimization engineer will be a user of those monitoring tools. The aim is to target any kind of irregular situation having a bad impact on the network performance.

The OMC is a central point from which controlling, and monitoring other network entities (i.e. base stations, switches, database, etc.), as well as monitoring the quality of service being provided by the network as a whole, are carry out.(Figure 2.2)

At present, equipment manufacturers have their own OMCs which are not compatible in every aspect with those of other manufacturers.

Function of OMC

The OMC should support the following functions[21].

- Event/ Alarm Management
- Fault Management
- Performance Management
- Configuration Management
- Security Management

2.4 Interfaces

Within the GSM network, there are several interfaces. But for this work, we will deal with the basic interfaces as related to TCH & SDCCH. The interfaces to be dealt with are as follows:

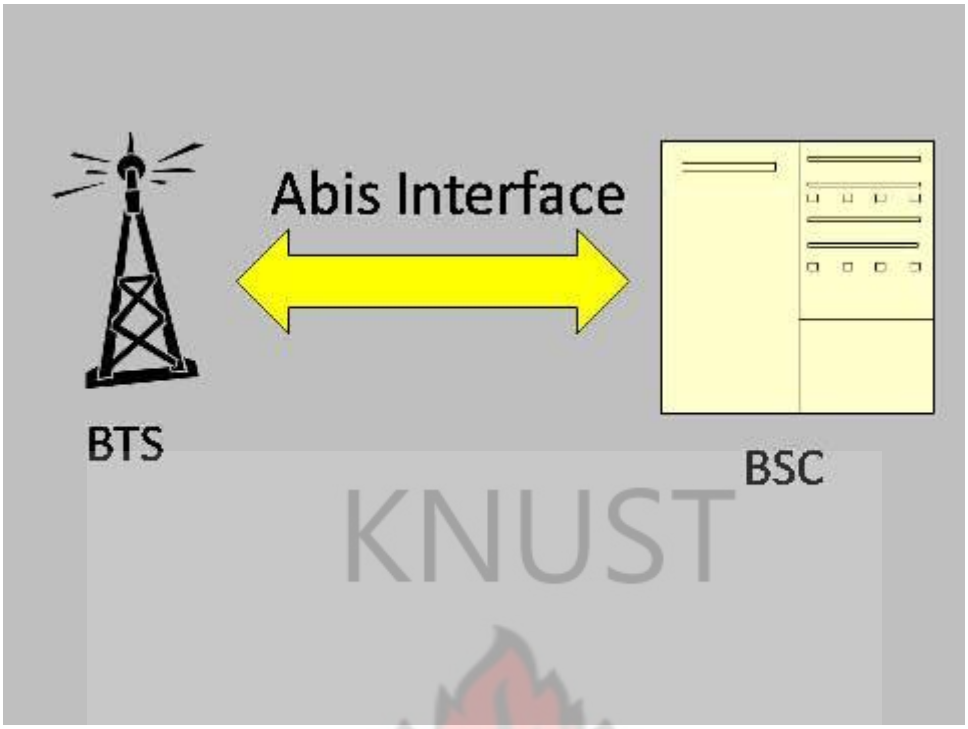


Figure 2.3 Abis Interface

Abis interface: This is a BSS internal interface linking the BSC and a BTS[22]. The Abis interface allows control of the radio equipment, and radio frequency allocation in the BTS. The primary functions carried over this interface are traffic channel transmission, terrestrial channel management, and radio channel management. This interface supports two types of communications links: traffic channels at 64 kbps carrying speech or user data for a full- or half-rate radio traffic channel, and signaling channels at 16 kbps carrying information for BSC-BTS and BSC-MSC signaling[23]. The BSC handles the LAPD[4] channel signaling for every BTS carrier. There are two types of messages handled by the traffic management procedure part of the signaling interface; **transparent** and **nontransparent**.

Transparent messages do not require analysis by the BTS but are between the MS and BSC-MSC. Nontransparent messages do require BTS analysis.

[4] **Link Access Protocol, D channel** is part of the network's communications protocol which ensures that messages are error free and executed in the right sequence. LAPD is the second layer protocol on the ISDN protocol stack in the D channel (the ISDN channel in which the control and signaling information is carried).

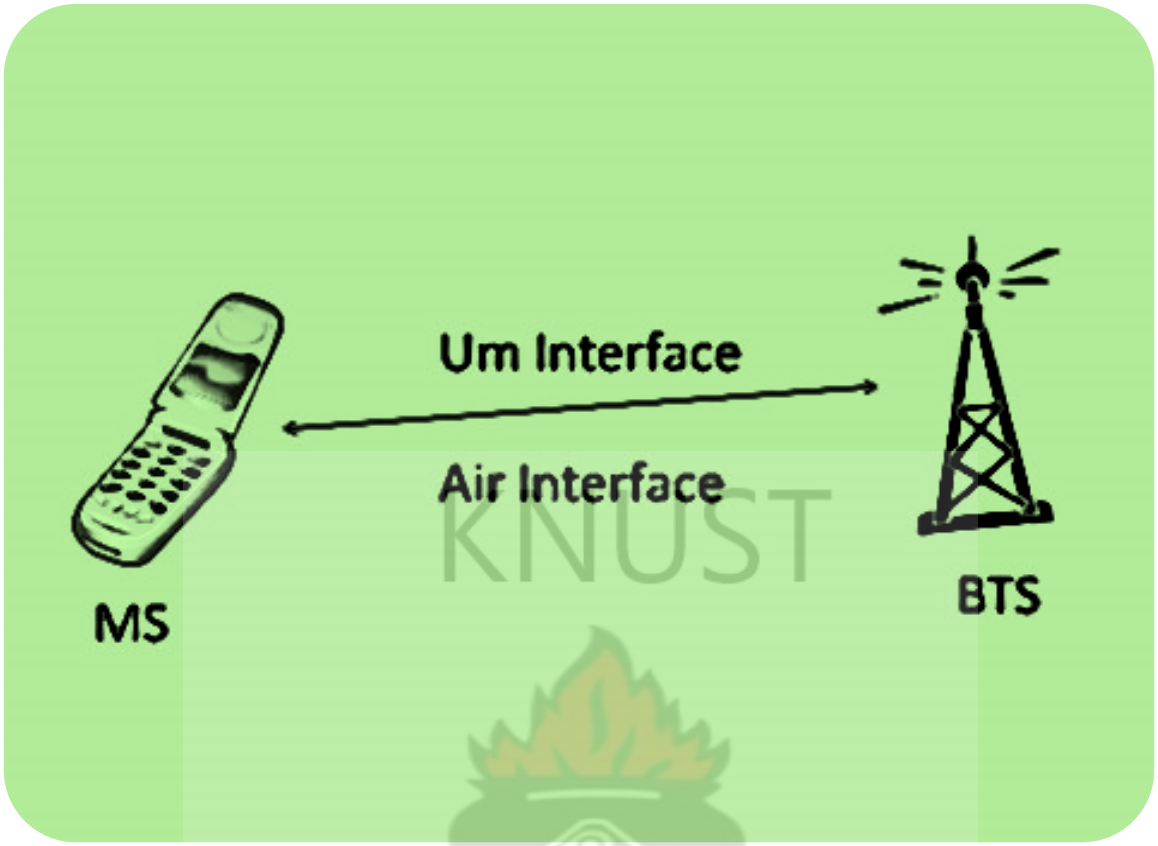


Figure 2.4 Air/ Um Interface

Um interface: The "air" or radio interface standard that is used for exchanges between a mobile (ME) and a base station (BTS / BSC). The Um radio interface (between MS and base transceiver stations [BTS] is the most important in any mobile radio system, in that; it addresses the demanding characteristics of the radio environment. The physical layer links to the data link layer, radio resource management sub layer in the MS and BS, and to other functional units in the MS and network subsystem (which includes the BSS and MSC) for supporting traffic channels. The physical interface comprises a set of physical channels accessible through FDMA and TDMA.

Each physical channel supports a number of logical channels used for user traffic and signaling. The physical layer (or layer 1) supports the functions required for the transmission of bit streams on the air interface. Layer 1 also provides access capabilities to upper layers. The physical layer is described in the GSM Recommendation 05 series (part of the ETSI documentation for GSM). At the physical level, most signaling messages carried on the radio

path are in 23-octet blocks. The data link layer functions are multiplexing, error detection and correction, flow control, and segmentation that allows long messages on the upper layers. The radio interface uses the Link Access Protocol on Dm channel (LAPD). This protocol is based on the principles of the ISDN Link Access Protocol on the D channel (LAPD) protocol. The following logical channel[5] types are supported:

+ Speech traffic channels (TCH)

8 Full-rate TCH (TCH/F)

8 Half-rate TCH (TCH/H)

+ Broadcast channels (BCCH)

8 Frequency correction channel (FCCH)

8 Synchronization channel (SCH)

8 Broadcast control channel (BCCH)

+ Common control channels (CCCH)

8 Paging channel (PCH)

8 Random access channel (RACH)

8 Access grant channel (AGCH)

+ Cell broadcast channel (CBCH)

8 Cell broadcast channel (CBCH) (the CBCH uses the same physical channel as the DCCH)

+ Dedicated control channels (DCCH)

8 Slow associated control channel (SACCH)

8 Stand-alone dedicated control channel (SDCCH)

8 Fast associated control channel (FACCH)

The radio resource layer manages the dialog between the MS and BSS concerning the management of the radio connection, including connection establishment, control, release,

[5]Each logical channel is used for a specific purpose such as paging, call set-up and speech. These logical channels are mapped onto the physical channels.

and changes (e.g., during handover). The mobility management layer deals with supporting functions of location update, authentication, and encryption management in a mobile environment. In the connection management layer, the call control entity controls end-to end call establishment and management, while the supplementary service entity supports the management of supplementary services. Both protocols are similar to those used in the fixed wire line network. The SMS protocol of this layer supports the high-level functions, related to the transfer, and management of short message services.

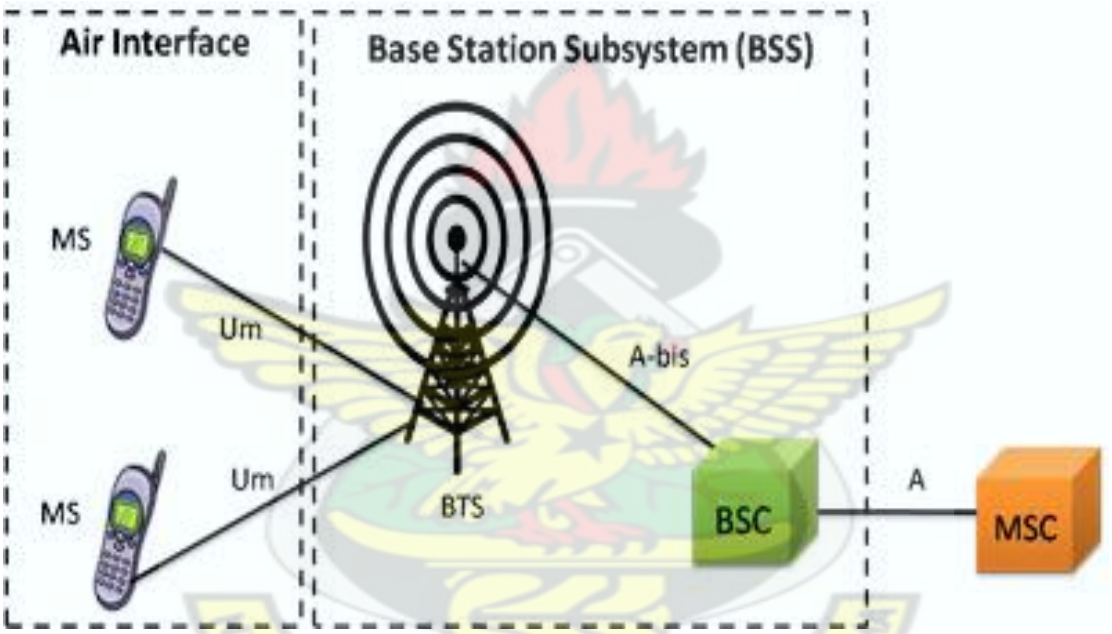


Figure 2.5- A Interface

"A" interface (BSC to MSC): The A interface is used to provide communication between the BSS and the MSC. The interface carries information to enable the channels timeslots, and the like, to be allocated to the mobile equipment being serviced by the BSSs."A" interface allows interconnection and provides two distinct types of information; signaling and traffic, between the BSS radio base subsystem and the MSC. The physical layer of the A interface is a 2-Mbps standard Consultative Committee on Telephone and Telegraph (CCITT) digital connection.

2.5 Locating and identifying congestion in GSM Networks

Congestions in GSM network are located mainly in the logical channels. Logical channel is divided into Common Control Channels (CCCH) and Traffic channels. **Common Control Channels (CCCH):** Common Control Channel is a group of control channels that support the establishment and maintenance of communication links between the mobile Stations and Base station (Harte, et al 1999). It consists of Random Access Channel (RACH), Paging Channels (PCH), and Access Grant Channel (AGCH)[24].When any of these three control channels is congested, there can't be any call establishment between the sender and receiver. This failure is called a "Call Establishment Failure" (BoulMalf and Akhtar, 2003). **Logical channels** can also be divided into two types: traffic channels (TCH) and control channel (CCH).There are again two types of traffic channels: half rate (HR) and full-rate (FR). The FR channel is a 13 kbps coded speech or data channel with a raw data rate of 9.6, 4.8 or 2.4 kbps, while the HR supports 6.5 kbps coded speech or data rate of 4.8 or 2.4 kbps. (Madhusmita PandaAnd Saraju)[7].

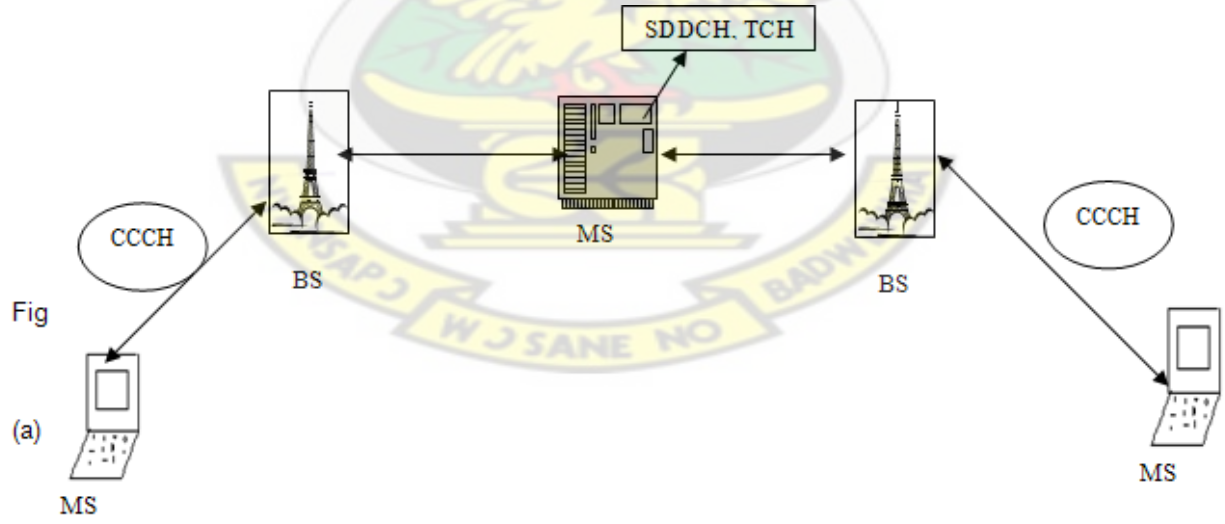


Figure 2.6 MS-MS Communication Network[5]

RACH is used to make request for Network assignment, PCH is used to alert the mobile station of incoming calls, and AGCH is used to assign Mobile Station to a specific DCCH or SDCCH for onward communication. On these Common Control Channels, congestion occurs

under three conditions*:* **Random Access Channel Congestion (RACHC) -** occurs when there is no free Random Access Channel to use to either make a call or respond to a cal1. In this case, there is total blocking to either in-coming or outgoing calls.

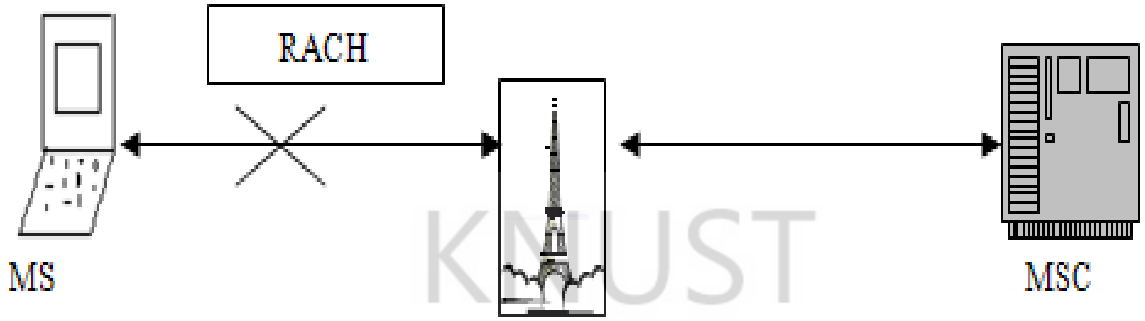


Figure 2.7 Congestion on Random Access Channel[5].

Paging Channel Congestion (PCHC) - occurs when there is no free PCH to use in alerting the mobile station of an incoming message.

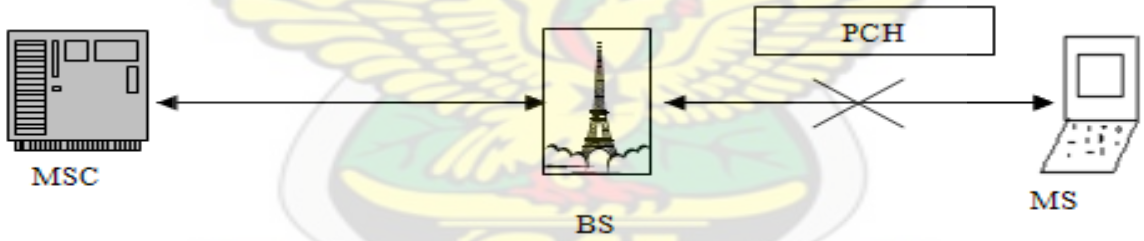


Figure 2.8 Congestion on Paging Channel[5].

Access Grant Channel Congestion (AGCHC) - occurs when there is no free Access grant channel to authenticate the responding Mobile station. It is used to assign mobile device to a channel where it can begin to communicate with the system

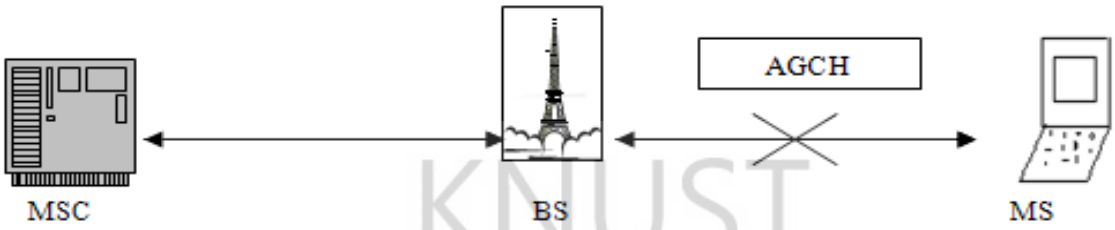


Figure 2.9 Congestion on Access Grant Channel

Dedicated Control Channel Congestion (DCCHC): is the failure to allocate Stand-alone Dedicated Control Channel (SDCCH) to provide authentication to mobile station, location updating and assignments to TCHs during idle periods. The messages on SDCCH channel includes short message service. When making a call or responding to paging message for the allocation of an SDCCH for authentication, if there is no vacant SDCCH to use at that time, then the call will be terminated.

Standalone Dedicated Control Channels

These channels are referred to as signaling channels.

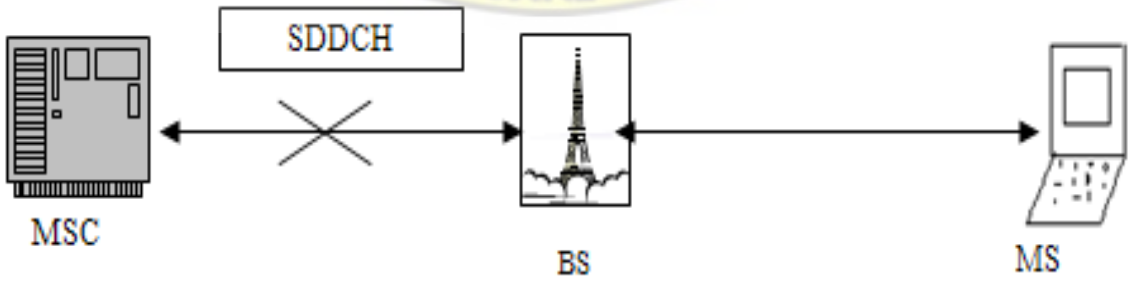


Figure 2.10 Congestion on Stand Alone Dedicated Control Channel[5]

Traffic channels congestion (TCHC): This failure occurs when an Access Grant Channel cannot get any free traffic channel (TCH) to allocate, to the request of the mobile terminal, through the random access channel. TCH is used to transfer voice, data, and control information. When there is no vacant TCH, the voice communication on the GSM network cannot be established.

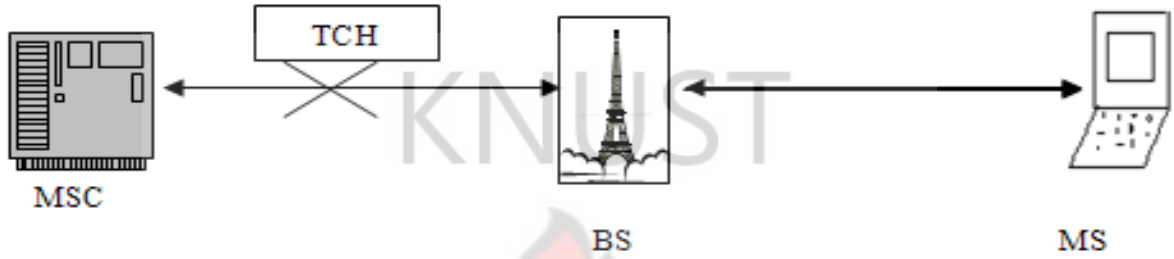


Figure 2.11 Congestion on Traffic Channel (TCH)[5]

2.6 Optimization of GSM Network

Optimization is the design and operation of a system or process to make it as good as possible in some defined sense in order to get a very efficient operation.

In order to maintain and improve every GSM network performance, service providers have to optimize their network performance continuously. Optimization is basically the only way that network providers keep track and update their networks. U S Rahman1, M. A. Matin2, & M R Rahman in A Practical Approach of Planning and Optimization for Efficient Usage of GSM, Network optimization is a tradeoff between quality, traffic/revenues and investments. Their paper dealt with a practical method of radio network planning procedure for efficiently usage of GSM network. Also, Richa Chitranshi, Jyoti Kushwaha, & Prakash Pancholy Intelligent Optimization of GSM Network, optimization increases the effectiveness of the network leading to revenue generation from the network. It allows the providers to look deep into the network statistics and analyze them, to know how effective their networks are in order to improve them[25]. Network Statistics in which the service providers look in and

analyze are referred to as "Key Performance Indicators (KPIs). There are different Key Performance Indicators (KPI) for and on different network layers. Identifying these KPIs will make it easier to optimize the network and applications. Therefore, it is useful for companies(service providers) that specialize in cellular network optimization, to have the ability to measure the performances of their networks for the purpose of optimizing the network usage and enhancing customer satisfaction[26].

2.6.1 Types of GSM Optimization

Optimization is a comparative process and requires an initial baseline of KPI's and objectives. This can be derived from operator's individual design guidelines, reports generated from OMC, service requirements, customer expectation, market benchmarks, the telecoms regulatory body, and others[27, 28]. Basically, there are two major techniques in optimization: The Physical and hardware. The physical technique of optimization deals with drive testing, observing the network reports & statistics, KPIs monitoring, OMC report reviewing, and subscriber's feedbacks. While, the hardware part of optimization deals with antenna tilting, antenna heights adjustment, installations, and others.

2.7 Used KPI Parameters Definition, Functions & Formulas

Optimization includes a combined study of the performances of neighboring KPI cells statistics with regards to assessing and enhancing the availability, accessibility, and the retain ability of an excellent network. The KPIs used in this thesis were derived from service requirements, and the customer usage & expectations from a GSM network.

Four key KPI parameters were thoroughly studied and analyzed. These are:

Traffic Channel (TCH) Congestion

Standalone Dedicated Control Channel (SDCCH) Congestion

Call Setup Success Rate (CSSR)

Call Drop Rate (CDR)

2.7.1 Traffic Channel (TCH) Congestion

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

Formula: $\boldsymbol{Call\ Setup\ TCH\ Congestion\ Rate}$ *= Number of TCH Blocks (Excluding Hand over) divided by number of TCH attempts.*

$$\frac{\boldsymbol{Number\ of\ TCH\ Drops\ (Excluding\ Handover)}}{\boldsymbol{Total\ Traffic\ Attempts}}$$

Causes:

- When there is no free traffic channel (TCH) to allocate to the request of the mobile terminal through the random access channel.
- Increasing number of subscriber/ traffic in a certain area or cell,
- Lesser capacity of sites,
- TRX hardware faults

2.7.2 Standalone Dedicated Control Channel (SDCCH) Congestion

Definition: Ratio of failed SDCCH seizures due to busy SDCCH to the total requests for the SDCCH.

Formula: $\boldsymbol{SDCCH\ Congestion\ Rate} = \textit{Failed SDCCH seizures due to busy SDCCH divided by total request for SDCCH multiply by 100\%.}$

$$\frac{\textbf{calls drop on Radio Interfaces (SDCCH)} + \textbf{calls drop on SDCCH}}{\textbf{SDCCH request for location update} + \textbf{SDCCH Request for SMS}} * \mathbf{100}\%$$

Causes/ Factors of SDCCH Congestion Rate in GSM: [3]

- Congestion Caused by Faults on Equipment or Transmission: The faults on BTS, BSC, and Abis interface, such as broken LAPD link, cause the SDCCH congestion.
- Congestion Caused by Insufficient Signaling Resources: The heavy traffic and burst traffic cause the SDCCH congestion.
- Congestion Caused by Improper Data Configuration:
- Congestion Caused by Interference

2.7.3 Call Setup Success Rate (CSSR)

Definition: Rate of calls going until TCH successful assignment.

Formula: $\boldsymbol{CSSR} =$

$$\frac{\boldsymbol{No.of\ Successful\ Seizure\ of\ SD\ channel\ or\ unblocked\ call\ attempts}}{\boldsymbol{Total\ No.of\ requests\ for\ SD\ channel\ or\ Total\ No.of\ call\ attempts}} \times \mathbf{100}\%$$

Causes: When SDCCH & TCH are assign successfully.

2.7.4 Call Drop Rate (CDR)

Definition: All calls that drop or terminated abnormally is refer to as call Drop.

Formula:

$$\boldsymbol{CDR = \frac{Dropped\ Calls}{Total\ number\ of\ attempts} \times 100\%}$$

Causes:

Failure to maintain communication over the air interface.

Failure in communication on any of the interfaces, although experience suggests air interface failure is the most usual cause.

The failure to maintain good quality of service in voice

2.8 Definition of Worst Cells

Worst Cells are those cells/areas in the network that were below fifty percent (50%) from the generated Call Setup Success Rate (CSSR). Those cells that were off during the collection of data were also included.

2.9 Fuzzy logic Optimization Algorithm

Fuzzy theory was developed from the failure to label some physical phenomena with the exact mathematical models uttered by more conventional Boolean models[29]. Conventional mathematical tools (e.g., differential equations) system modeling based is not well-suited for dealing with imprecise and uncertain systems. By contrast, a fuzzy inference system employing fuzzy if {condition} then {action} rules can model the qualitative aspects of human knowledge and reasoning processes without employing precise quantitative analyses. This fuzzy modeling or fuzzy identification, first explored systematically by Takagi and Sugeno, has found numerous practical applications in control, prediction and inference[30].

2.9.1 Fuzzy If {condition} Then {action} rules

Fuzzy if-then rules or fuzzy conditional statements are expressions of the form IF A THEN B, where A and B are labels of fuzzy sets (L. A. Zadeh. Fuzzy sets 1965) characterized by appropriate membership functions. Due to their concise form, fuzzy If-then rules are often employed to capture the vague modes of reasoning that play an essential role in the human ability to make decisions in an environment of uncertainty and imprecision. An example of a first-order Sugeno-style FIS model that manages the process of mapping from a given crisp input to a crisp output, using fuzzy set theory:

Rule 1:

If X_1 is A_1, and X_2 is A_2, ……., X_n is A_n

Then

$Y = K_0 + K_1X_1 + K_2X_2 + \ldots\ldots\ldots K_nX_n$

Where

X_1 , X_2 ,…….X_n are considered as inputs variables;

A_1 , A_2 ,…….A_n are fuzzy sets and Y is the output variable.

K_1 , K_2 ,…….K_n are considered set of consequent parameter of rules

CHAPTER 3:

METHODOLOGY

3.0 Introduction

All GSM Operators use KPIs (Key Performance Indicators) to judge their network performance and evaluate their QoS (Quality of Service) as regards to the end users perspective[31]. KPIs have different parameters that are used for and on different network layers within all networks. To optimize a network, the network provider should identify the various parameters which he wants to optimize. Identifying these will make it easier to optimize the network[26].

There are three major ways in collecting a GSM network KPI namely:

1. Data from BSC (Base Station Controller) or NOC (Network Operating Center)
2. Drive Test &
3. Questionnaires

Data collection from the BSC (Base Station Controller) or NOC (Network Operating Center) is one of the most reliable data to work with when optimizing a network. This is because the NOC connects directly to the BSC and Mobile Switching Centre (MSC) which are the most sensitive equipment within the GSM infrastructures [32].

Drive Testing provides huge perspective to the service provider about what's happening from the subscriber point of view in the network. However, after completing the drive test, data collected are not analyzed or evaluated. The Engineer(s) later analyze, evaluate, explain, and give recommendations to correct them[33]. Drive tests takes a whole lot of time.

Questionnaires on the other hand, involve the designing of questions to customers pertaining to the network. Questionnaires can be structured in different parts depending on how you want to evaluate a network. It is the simplest way to evaluate a GSM network but; it is not reliable as the Data collected from the BSC or the Drive Test.

GSM KPIs are secretive and sensitive information and are not easily released by Operators. KPIs are like the brain of all networks. They show how efficient a network operates. They are used by organizations/operators in order to evaluate its success and measure progress towards their organizational goals.

This research sought to determine the causes of SDCCH and TCH congestions in GSM networks as well as offer likely solution(s) that will reduce the problems associated with SDCCH and TCH congestions in Liberia GSMs. This chapter outlines the methods used in the study.

3.1 Research Optimization Flow Chart

The below chart (**Figure 3.1)** ***shows*** the steps in which the research was done, and the expected outcome after the research.

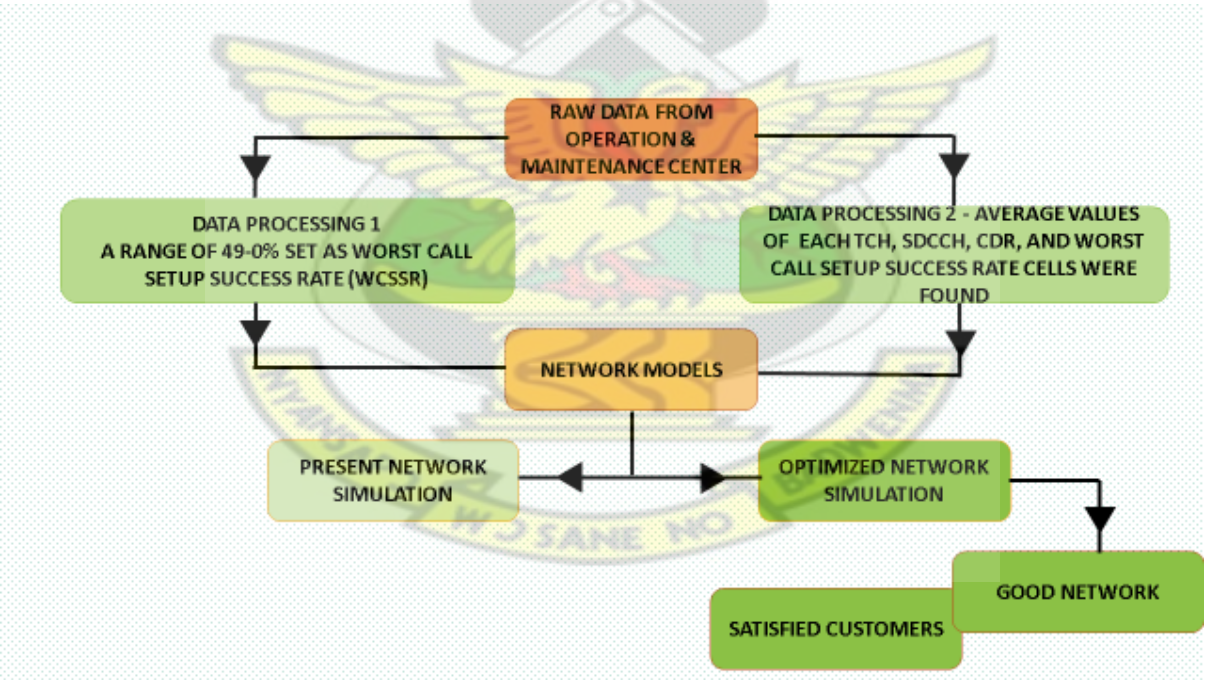


Figure 3.1 Research Optimization Flowchart

3.1.1Research framework

This research was conducted through a mixed method approach.

In order to assess the current state of TCH and SDCCH congestion in Liberia GSMs, a key performance indicator (KPI) data was collected directly from a GSM company's BSC (Huawei BSC 6900) in Liberia describing; TCH and SDCCH Congestions, and other relevant parameters like Call Setup Success Rate (CSSR), Call Drop Rate (CDR), etc. The data represent prominent status of the network, resource utilization, Hardware load etc. For confidential purposes, the name of the company will not be stated throughout the research but will be called Company ABC.

3.2 Sample size and data processing

These KPIs parameters data for the entire country, were generated from the M2000 in the BSC and saved in Excel format on hourly basis for a period of one month (February 12, 2014 – March 12, 2014). The KPI data which represent prominent status of the network can be seen in Appendix B. Some of the Parameters (CSSR & CDR) used were calculated by the BSC during the recording of the data.

To optimize a network, you start by checking for those areas that are bad in performance and make them better, and probably those areas that are better, you make them best. In order to optimize SDCCH & TCH in Liberia's GSM, we identified those bad areas/cells known as Worst Call Setup Success Rate (WCSSR). These Worst areas/cells were sampled and processed. During the sampling and processing of the data during the investigation, firstly, a range of 49-0% was chosen to be the worst call setup success rate (WCSSR). That is, for the entire work, all WCSSR used, were those below 50% from the KPI data. They (WCSSR) were separated according to their cells/areas names using normal excel formulations. From separating the data, there were seven (7) cells/areas that was below 50% during the data collection but; were either said to be OFF, OFF & ON etc. Those cells that were OFF are represented by dash (-) in the data collected and were denoted as the number one (1) during the graph plotting to clearly show the points on the graphs. Those Cells/Areas that were either

ON or OFF are also represented (OFF= 0, ON = values greater than 1). SDCCH and TCH congestions within these seven (7) areas/cells were found by using their various formulas shown in chapter two 2.7.1 & 2.7.2. The remaining KPI parameters (CDR & CSSR) used, were calculated within the BSC during the recording of data. This calculated data from the BSC was summed and averaged over the amount of WCSSR days to find their final worst cases results in the seven (7) areas/locations. (See Table 4.1). Secondly, these location results were later plotted into bar graphs, and points using OriginPro software. These bars graphs, and points clearly shows the levels of worst call setup success Rate, TCH & SDCCH congestion, and points out those days in which the cells were off.

Finally, a Sugeno-Takagi KPI Optimization simulation setup was developed using Adaptive Network Fuzzy Inference System (ANFIS) model in MATLAB. ANFIS is the major training routine for Sugeno-type fuzzy inference systems. It uses a hybrid learning algorithm to identify parameters of Sugeno-type fuzzy inference systems. By using a hybrid learning procedure, the proposed ANFIS can construct an input-output mapping based on both human knowledge(in the form of fuzzy if-then rules) and stipulated input-output data pairs[30, 34]. This optimization tool performs input-output KPI dataset by computing the membership functions parameters and setting rules which allows Fuzzy Inference System (FIS) to track the given input/output data. The rule base basic function represents the control policy of an experienced operator in an organized way by means of if <network state>, then <control output> rules[35]. This rule set was built defining the membership functions and analyzes the behavior of the fuzzy inference system by fine tuning the parameters in the rule viewer of the fuzzy logic toolbox. The simulations demonstrates and compares the current and expected optimized networks by showing their various performance levels after been tuned. The result shows that optimization is possible in real cellular network[36].

3.3 Used Softwares

There were two softwares use in this thesis. They are as follow:

1. MATLAB® is a high-level language and interactive environment for numerical computation, visualization, and programming. It can be used in analyzing data, developing algorithms and creating models and applications. The language, tools, and built-in math functions allow multiple approaches in order to arrive at a solution faster as opposed to spreadsheets or traditional programming languages[37].

2. OriginPro is a proprietary computer program for scientific interactive graphing and data analysis. It support 2D/3D plot types graphing. Statistics, signal processing, curve fitting and peak analysis are all forms of data analysis in origin. Files are imported in origin in various formats such as ASCII text, Excel, NI TDM, DIADem, NetCDF, SPC and it also exports graph to various image file formats such as JPEG, GIF, EPS, TIFF, etc.[38].

3.4 Research Fuzzy Optimization system

To understand the model represented in Fig 3.4.1 , MATLAB fuzzy neural inference engine was employed by constructing the four KPI parameters in a Sugeno-Takagi FIS while generating the required membership variables as shown in figure 3.4.1. The KPI and Sugeno-Takagi engine are set while calling the MATLAB ANFIS function so as to load data, train and generate the FIS. Dataset is loaded for training in the workspace by adjusting the membership function parameters that best model the data. A single output is generated which is used to give initial condition ANFIS data training.

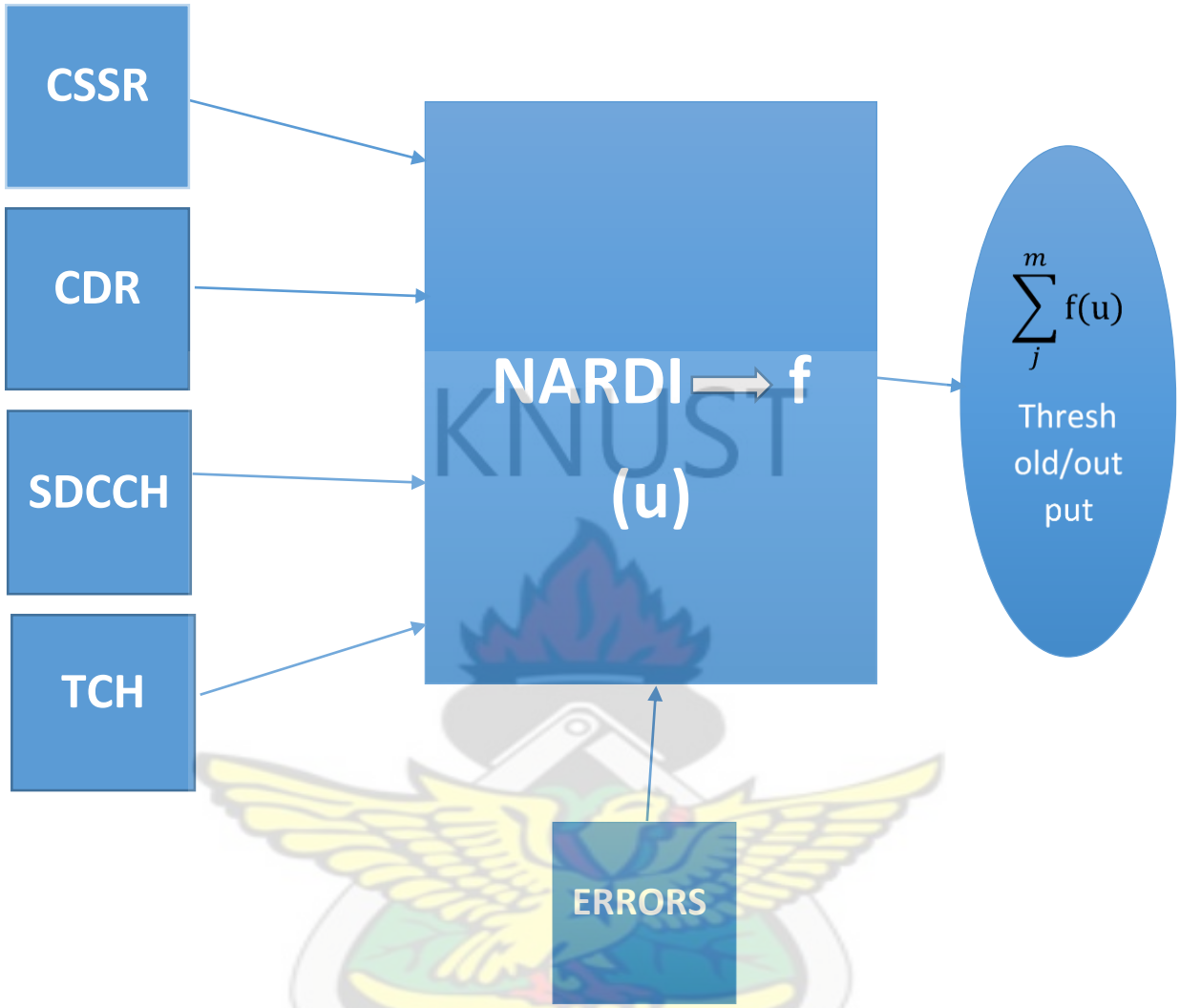


Figure 3.4.1 FUZZY OPTIMIZATION SYSTEM

3.5 TRAINING MODELS

Comparing observed data and the estimated data through developed ANFIS models, it has been proved that the developed ANFIS models predicted better results the traditional models, like MLR.

Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data

without a decision making logic system. The goal of multiple linear regression (MLR) is to model the relationship between the explanatory and response variables

The model for MLR, given n observations, is:

yi = B0 + B1xi1 + B2xi2 + ... + Bpxip + Ei where i = 1,2, ..., n

ANFIS (Adaptive Neuro Fuzzy Inference System) is the combination of the concepts of Fuzzy Logic and Artificial Neural Network.

In digital System we can get an output of either 0 or 1. Practically we can say either ON condition or OFF condition is only possible with digital Logic. In fuzzy logic we can get all the range of outputs between 0 and 1.

Fuzzy Logic System is a decision making logic system. It helps you to find the output for given set of inputs.

ANN is similar to the biological Neural Network. It has learning capability. So given a set of input and output we can train a network which acts in same manner as the set of input and output.

Now we can combine both the concepts to get the ANFIS. ANFIS is a nonlinear methodology putting together the learning capability of the Neural Network with decision ability of the Fuzzy Inference System. Each layer of the ANFIS structure depicts each step of Fuzzy Logic. The network is trained by the concept of Neural Network.

The model for ANFIS, given n observations, is

Rule 1:

If X_1 is A_1, and X_2 is A_2, ……., X_n is A_n

Then

$Y = K_0 + K_1X_1 + K_2X_2 + \ldots\ldots\ldots K_nX_n$

Where

X_1 , X_2 ,…….X_n are considered as inputs variables;

A_1 , A_2 ,…….A_n are fuzzy sets and Y is the output variable.

K_1 , K_2 ,…….K_n are considered set of consequent parameter of rules

ANFIS can be trained to learn from given data. In order to configure an ANFIS model for a specific problem, we need to specify the fuzzy rules and the activation functions (i.e. Membership functions) of fuzzification neurons. For the fuzzy rules, we can specify the antecedent fuzzy sets once we know the specific problem domain; while for the consequents of the fuzzy rules, the parameters are designed and adjusted by certain learning algorithm in the training process. On the other hand, the shapes of activation functions can also be formed and adjusted in the training process .For ANFIS models, the most commonly used activation function is the so-called bell-shaped function, described as:

$$Y = 1 + \frac{1}{1+[\left(X-\frac{S}{r}\right)2]T}$$

Where r, s and t are parameters that respectively control the slope, center and width of the bell -shaped function. And in the training process, these parameters can be specified and adjusted by the learning algorithm.

CHAPTER 4:

DISCUSSION AND RESULTS

4.0 Introduction

This chapter covers research findings from literatures reviewed and a case study of a GSM Company in Liberia concerning SDCCH & TCH Congestion. The chapter also discusses methods that can be used in the optimization of SDCCH & TCH Congestion in Liberia's GSM. Standalone Dedicated Control Channel (SDCCH) and Traffic Channel (TCH) often referred to as "signaling channels" are those logical channels that are mainly used in voice traffic within today's cellular networks. These two (especially SDCCH) are the most important resources any GSM system may depend on to accommodate subscribers needs. Without the availability of SDCCH, a new call cannot be initiated. SDCCH and TCH channels are the most vulnerable and directly affects the quality of service offered to subscribers therefore, it provides understanding of when and where congestion appears in the network[26, 33].

4.1 Worst Cells /Areas

From the analysis of the KPI data, it was recognized that seven (7) different cells were worst and were recorded. Using Microsoft Excel Quick Analysis Tools, these cells daily WCSSR, SDCCH, TCH, and CDR results were summed, and divided by their total number of worst days to find the averages of each worst cell and congestions. (See Appendix D) The average values of those worst cells SDCCH congestion, TCH congestion, CSSR and CDR during the various days were found and tabled. (See Table 4.1 below)

AVERAGE WORST CELLS/AREA IN THE NETWORK	CSSR	CDR	TCH CONGESTION	SDCCH CONGESTION
KEY PERFORMANCE INDICATORS (KPIs) VALUES (%) DASH (-) REPRESENTS CELLS OFF & RED NUMBERS WORST/BAD				
Harbel_1	**39.5**	**4.18**	**6.2**	**2.38**
Gweins_Town_1	-	-	0	**0**
Yekepa_1	**21.7**	**0.48**	**0.35**	**0.032**
Yekepa_2	**41.6**	0	0	**0**
Buchanan Road_2	**48.611**	0	0	**0**
Clay_3	**48.275**	0	0	**0**
Pleebo_3	**27.8**	0	0	**0**

Table 4.1 Worst Cells location/areas Performance Summary Data

4.2 Graphical Results Presentation

As stated in Chapter two, Worst Cells are those cells/areas in the network that were below fifty percent (50%) from the data. Those cells that were off during the collection of data were also included. Figures 4.2.1 to 4.2.7 are graphical results showing the worse call setup success rate during the one month period.

From the data collected, Cell/area Harbel 1 fell in the worst call setup success rate group (See Appendix B). Harbel 1 was below 50%. The points on the graph (***Figure 4.2.1***) shows the

various days and the percentage level of WCSSR. It was found that Feb 12 was 49.6% which is the highest, Feb 26. 28.6%which is the lowest and other days before these two. (See Appendix B). The result here shows that calls setup during the various days at harbel was very bad leading to congestions in the network. The high percentage of SDCCH & TCH congestion in the network led to the low percentage of calls that were successfully made.

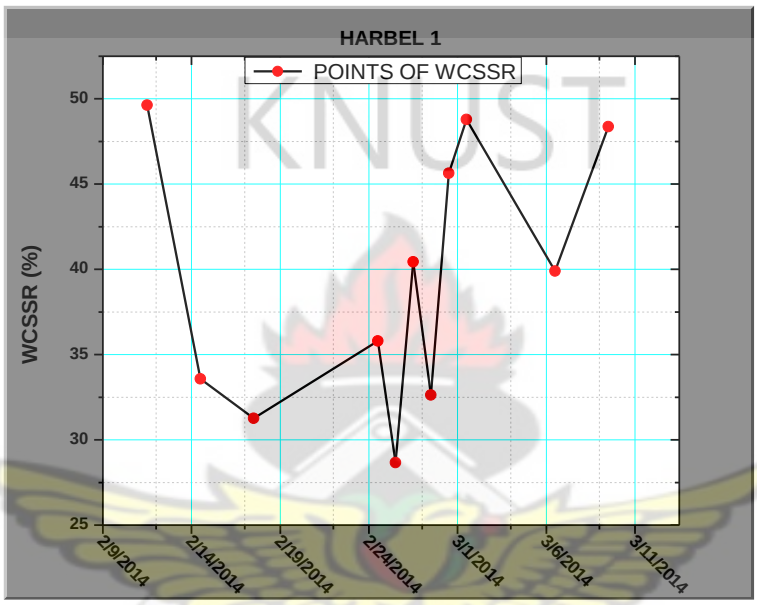


Figure 4.2.1 Location Harbel 1 WCSSR

Gweins Town 1 was off during the various days marked with the points. (See Appendix B) The graph below indicates that this area/cell (Gweins Town) was off when the data was recorded.

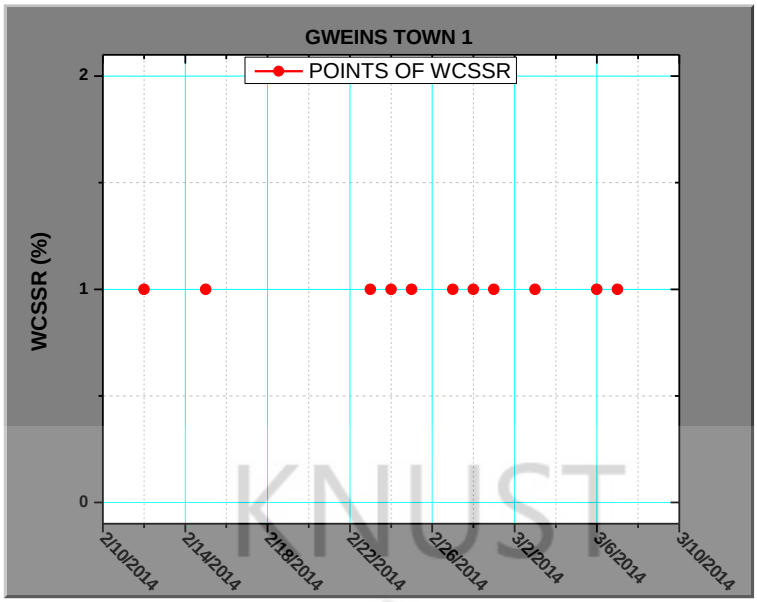


Figure 4.2.2 Location GWEINS TOWN 1 WCSSR

Yekepa 1 was off from Feb 12 to Feb 18. During the remaining days, calls setup were unsuccessful. (See Appendix B)

In this cell, SDCCH & TCH congestion were very minimal. Channels were available to calls on time but; unfortunately in the final end, the percentage of call setup success was low due to the low Connection Retain ability of the network in this area.

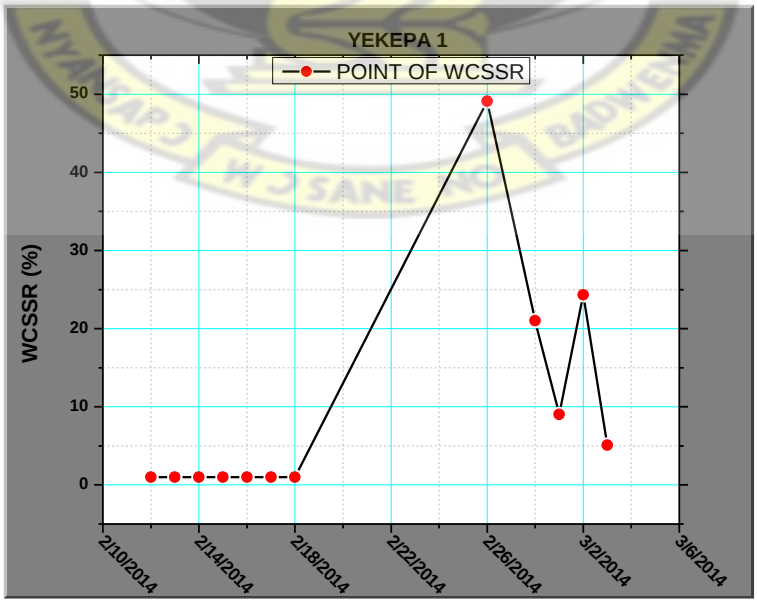


Figure 4.2.3 Location YEKEPA 1 WCSSR

Yekepa 2 was on for a day (19th Feb) at 41.6% and off for the rest of the days. (See Appendix B) In this cell, there were no congestion on SDCCH & TCH but the retain ability wasn't kept so; the Call Setup Success level was very bad. (***Figure 4.2.4***)

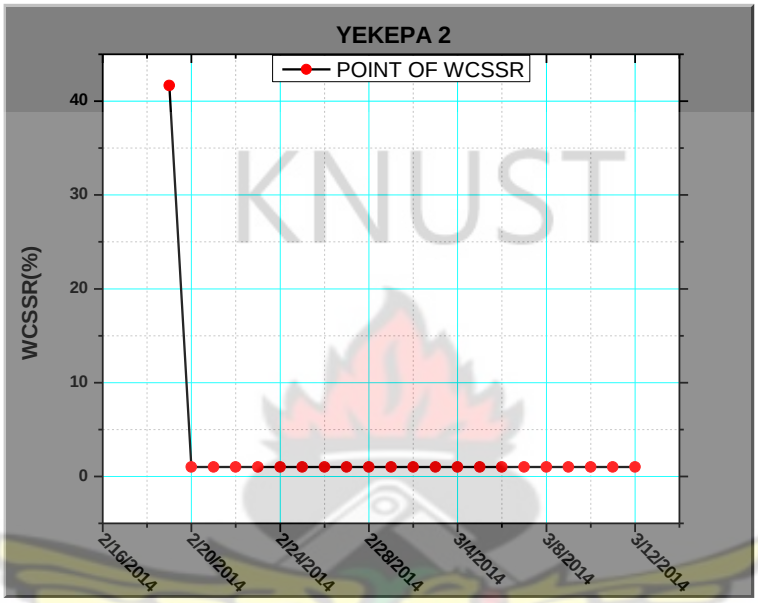


Figure 4.2.4 Location YEKEPA 2 WCSSR

Buchanan Road 2 was off, came on the 23rd Feb at 48.6%, and later went off 6th March. (See Appendix B) In Buchanan Road 2, there were no congestion on SDCCH & TCH but the retain ability wasn't kept so; the Call Setup Success level was very bad.

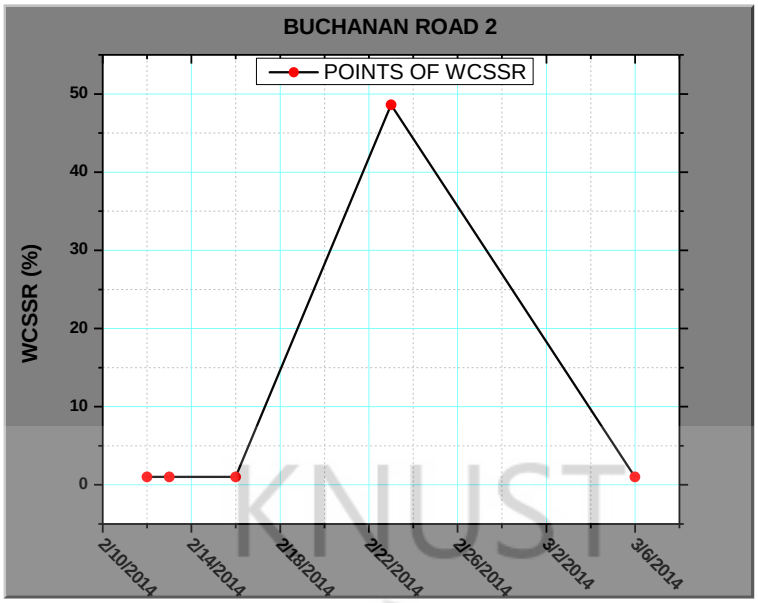


Figure 4.2.5 Location BUCHANAN ROAD 2 WCSSR

Clay was on at 48.2% on the 16th Feb and off on the 2nd March. (See Appendix B) There was no congestion on SDCCH & TCH but the retain ability wasn't kept so; the Call Setup Success level was very bad.

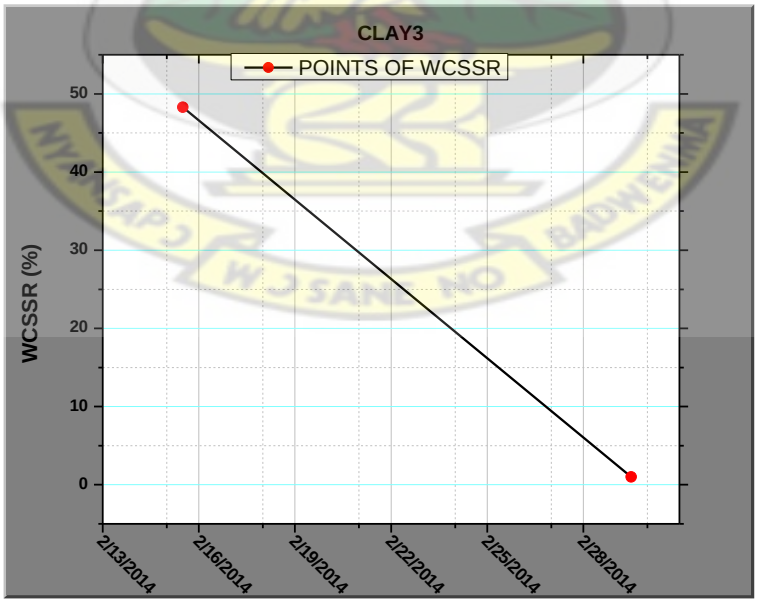


Figure 4.2.6 Location CLAY 3 WCSSR

Pleebo 3 was worst the 13th of Feb. at 30.7% and dropped to 25% on the 21st Feb. (See Appendix B) There were no congestion on SDCCH & TCH but the retain ability wasn't kept so; the Call Setup Success level was very bad.

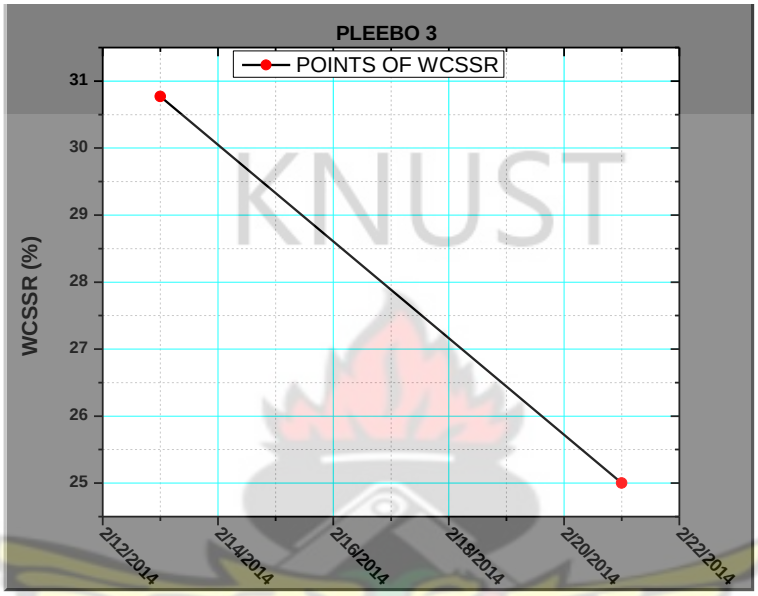


Figure 4.2.7 Location PLEEBO 3 WCSSR

4.3 Graphical representation of TCH & SDCCH Congestions

The Traffic Channel & Standalone dedicated control channel are two very important channel in all GSM networks. The graphs of Figures 4.3.1 to 4.3.7 show the levels of TCH & SDCCH congestion in those locations that were worst, those that were off, and finally those that had no SDCCH & TCH congestion. (See Appendix C)

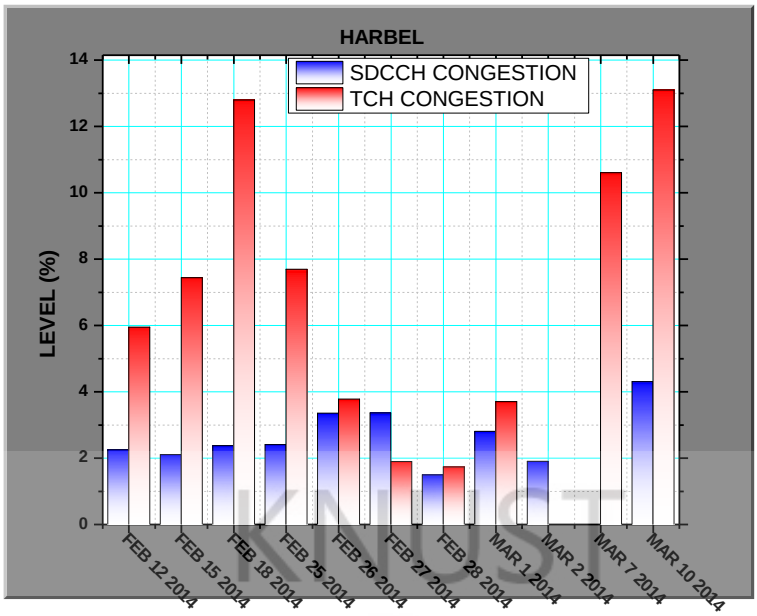


Figure 4.3.1 Harbel SDCCH & TCH Congestion

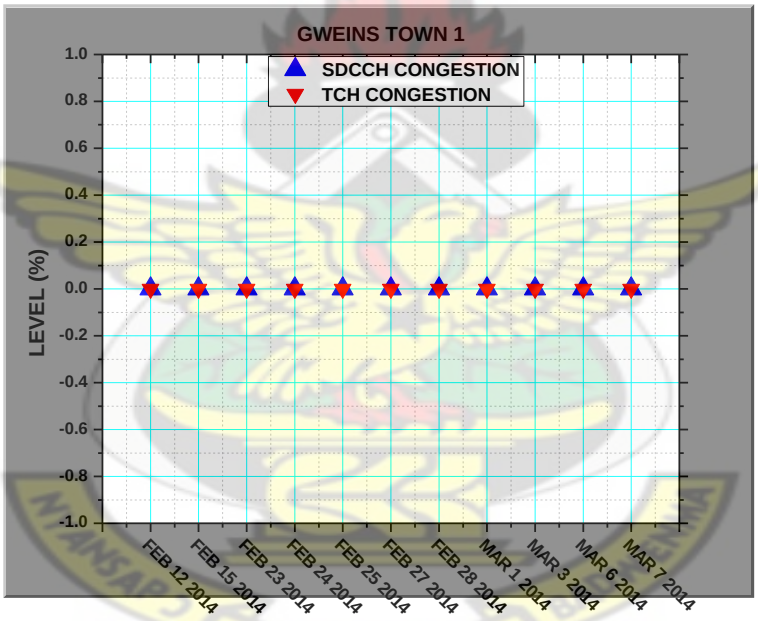


Figure 4.3.2 Gweins Town 1 SDCCH & TCH Congestion

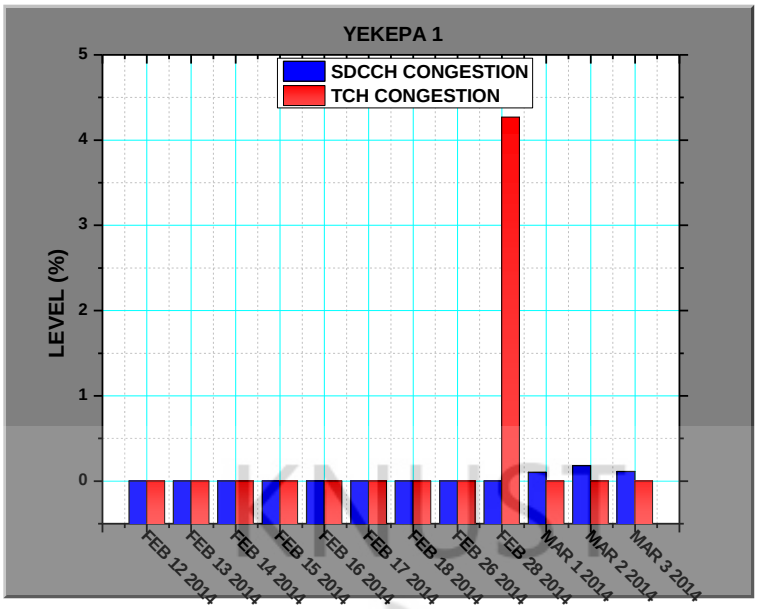


Figure 4.3.3 Yekepa 1 SDCCH & TCH Congestion

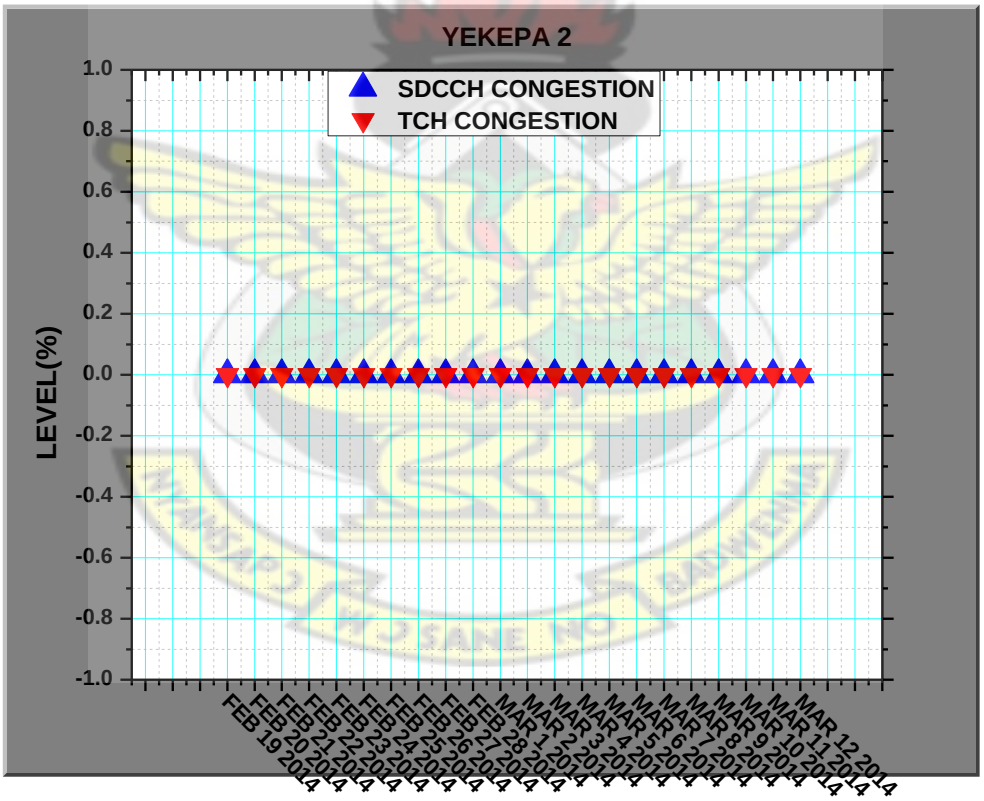


Figure 4.3.4 Yekepa 2 SDCCH & TCH Congestion

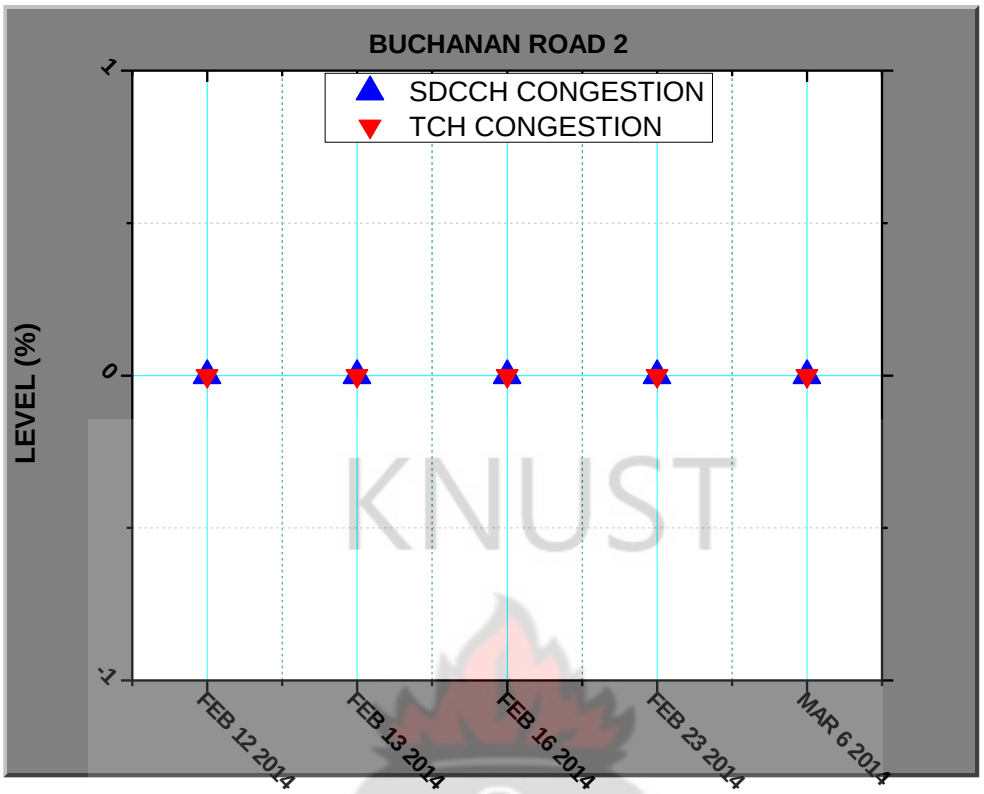


Figure 4.3.5 Buchanan Road SDCCH & TCH Congestion

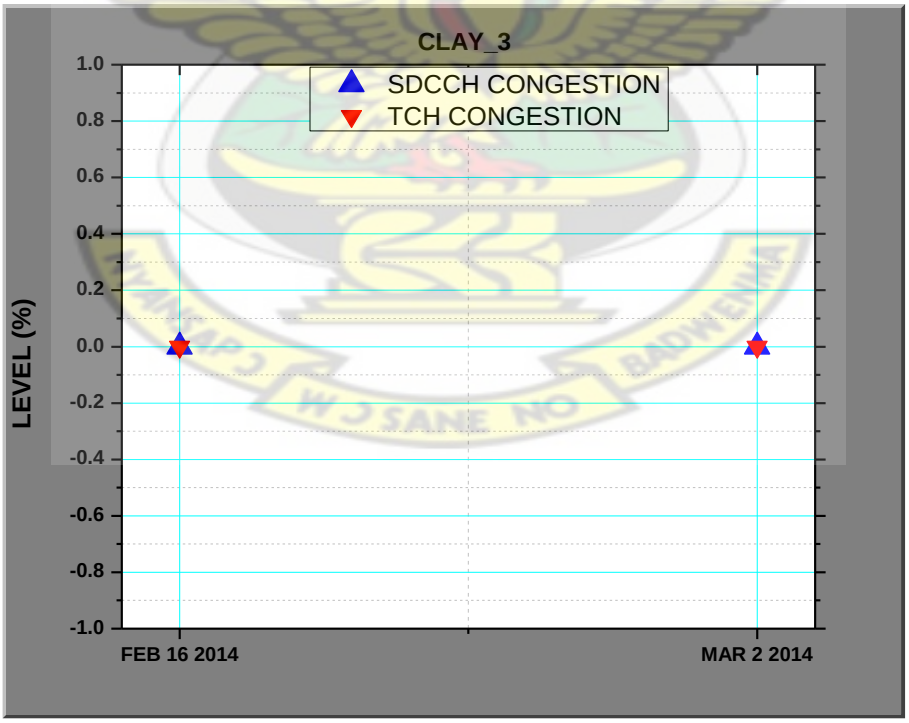


Figure 4.3.6 Clay 3 SDCCH & TCH Congestion

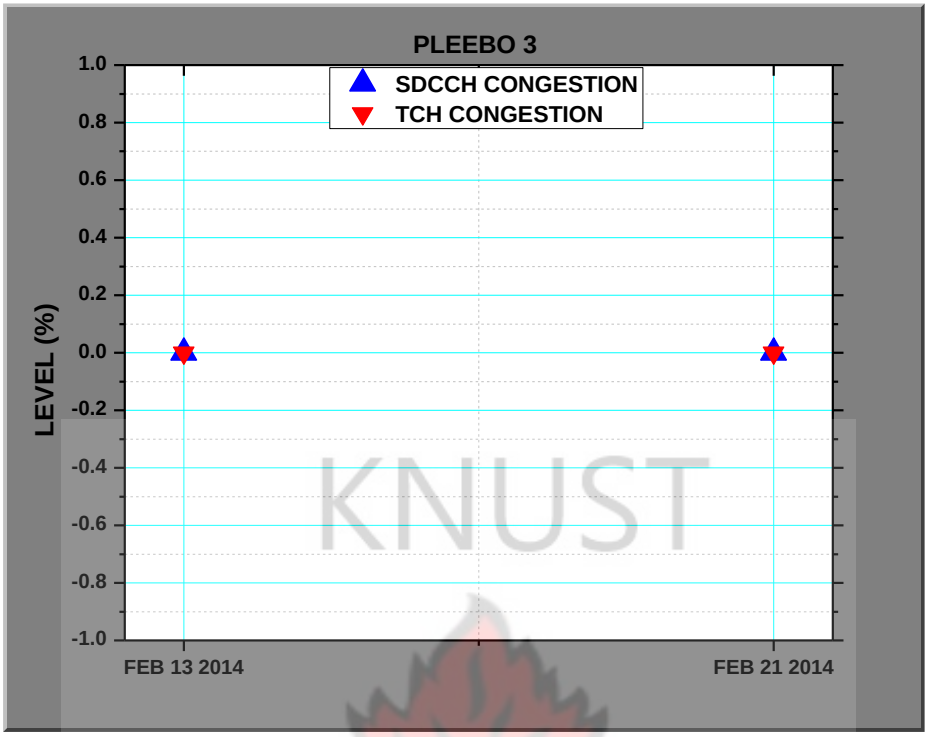


Figure 4.3.7 Pleebo 3 SDCCH & TCH Congestion

4.4 Network Model & Simulations

As stated in chapter 3, a Sugeno-Takagi KPI Optimization simulation setup was developed using Adaptive Network Fuzzy Inference System (ANFIS) model in MATLAB. The simulations compares and demonstrates the current and expected optimized suggested network with the four KPI parameters used in this work. From the comparism of these two networks, we know that optimization can be done at a peak in a live network.

These KPI parameters data were created as inputs and an Output variable, stored, and loaded for training in MATLAB. The setup was then imported from the file in the Fuzzy inference system (FIS) editor. The range of each imported variable was set. After the KPI training and generation of FIS, an offset rule viewer for the KPI is realized as shown in Figure 4.4.2. (See Appendix A for source codes)

In order for a GSM network to have a good QoS and to be almost SDCCH & TCH congestion free, we designed this optimized network and stipulated that the KPI-OPT (threshold) in the rule viewer should be either one (1) or very close to one.

Using the rule base simplification shows the congestion level in the KPI-OPT. The function output is added to the offset value which is then added to the KPI values. The algorithm developed checks and matches KPI values during stabilization. When the optimized KPI value exceeds the recommended thresholds, truncation is done. The algorithm also adjusts for the KPI values when they are in exact ranges.

4.4.1 Present Network Simulation

From the current KPI data used for this work, in those seven (7) cells/ areas in Liberia, it was observed and found that the average Worst Call Setup Success Rate was 35.1%, Call Drop Rate 1.93%, Standalone Dedicated Control Channel 0.36% and Traffic channel 1.12%. The combination adjustments of the present four KPI parameter values calculated and averaged

from company ABC, using the rule base simplification, shows the congestion level in the KPI-OPT (Figure 4.4.2). The four KPI parameter values calculated and averaged for training data are: CSSR, CDR, SDCCH, and TCH. Separating the data in MATLAB work space saved as Nardi, this was loaded for training in the neural platform. After the KPI training and generation of FIS, an offset rule viewer for the KPI is realized as shown in ***Figure 4.4.2***.

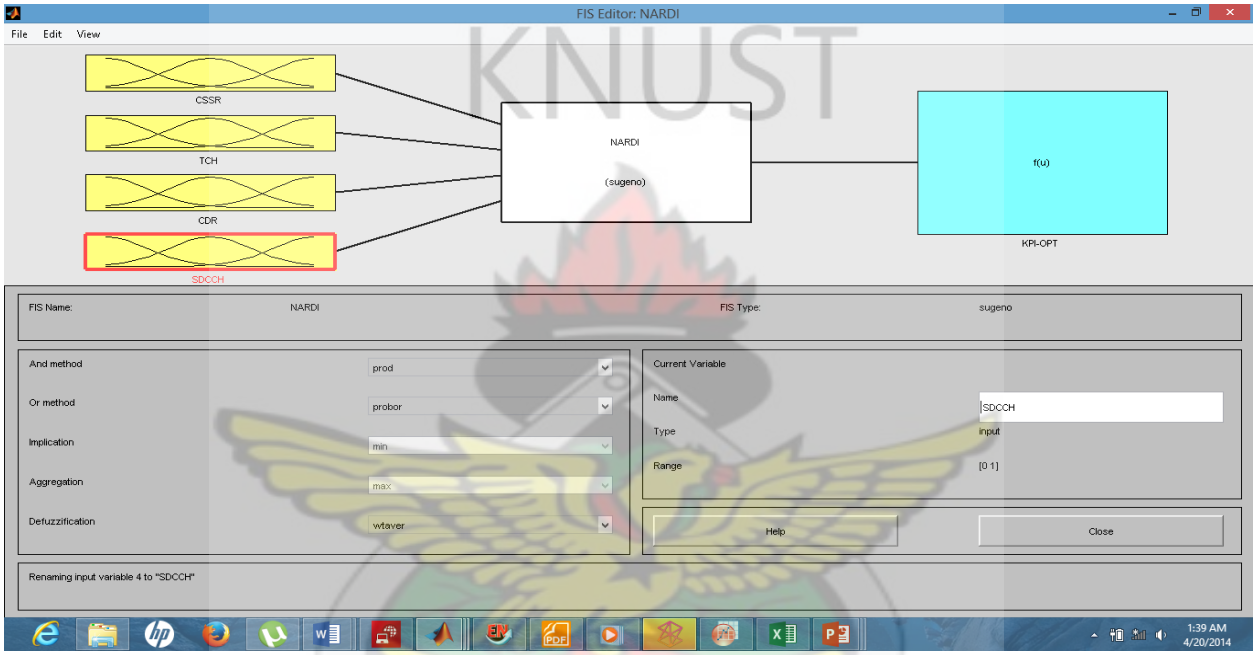


Figure 4.4.1 Sugeno-Takagi KPI Optimization Model setup

Fuzzy theory was developed from the failure to label some physical phenomena with the exact mathematical models uttered by more conventional Boolean models[29]. Conventional mathematical (e.g., differential equations) system modeling is not well-suited for dealing with imprecise and uncertain systems. By contrast, a fuzzy inference system employing fuzzy if {condition} then {action} rules can model the qualitative aspects of human knowledge and reasoning processes without employing precise quantitative analyses.

Fuzzy if-then rules or fuzzy conditional statements are expressions of the form IF A THEN B, where A and B are labels of fuzzy sets characterized by appropriate membership functions. Due to their concise form, fuzzy If-then rules are often employed to capture the vague modes

of reasoning that play an essential role in the human ability to make decisions in an environment of uncertainty and imprecision.

Present Network Model

The description of the present network state using the ANFIS model is achieve through the combination of user defined inputs and model rules. KPI user inputs for TCH, SDCCH, CDR and CSSR are 1.12, 0.36, 1.93 and 35.1 respectively. The stipulated rules defined for this model are given below:

If (CSSR is mf1) or (TCH is mf1) or (CDR is mf1) or (SDCCH is mf1) …… Then (Kpi-opt = Kpi 1)

If (CSSR is mf2) or (TCH is mf2) or (CDR is mf2) or (SDCCH is mf2)…….. Then (Kpi-opt=Kpi 2)

If (CSSR is mf3) or (TCH is mf3) or (CDR is mf3) or (SDCCH is mf3)…….. Then (Kpi-opt=Kpi 3)

If (CSSR is mf4) and (TCH is mf4) and (CDR is mf4) and (SDCCH is mf4)…….. Then (Kpi-opt=Kpi 4)

Where

Mf = membership function, kpi-opt = key performance indicator output

Based on these inputs and the above defined rules, the ANFIS model trains itself to learn to behave or act in the same manner as the present network behavior currently under study.

Figure 4.4.2 illustrated the present network behavior

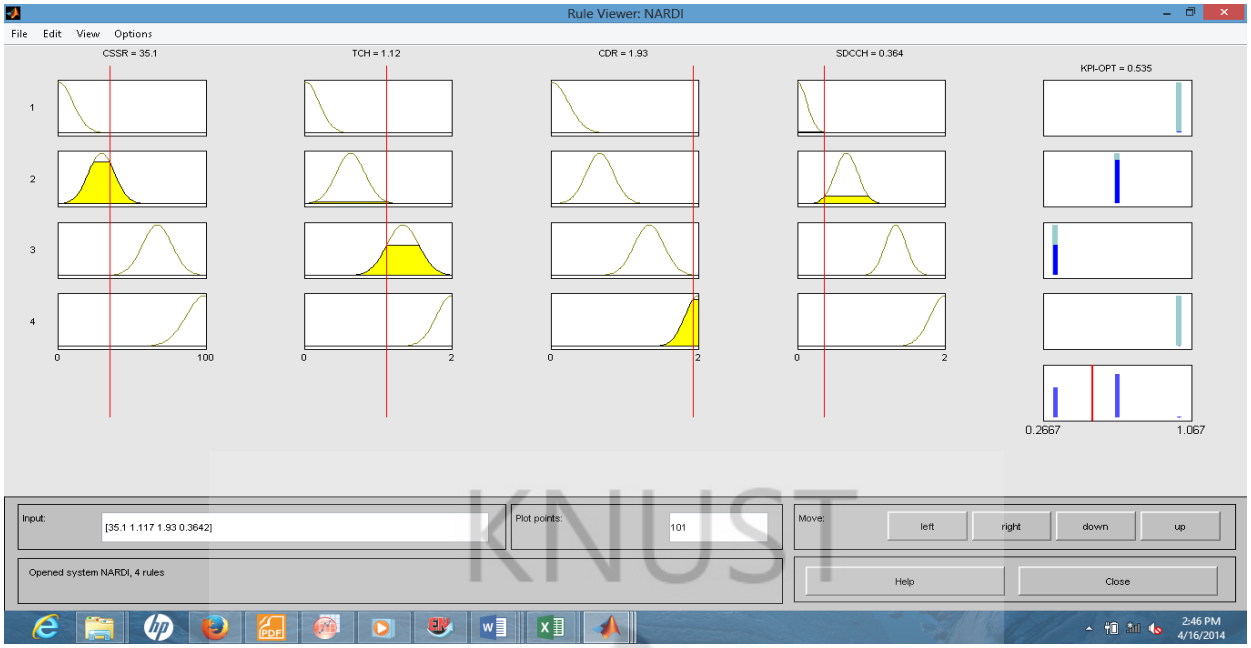


Figure 4.4.2 An Offset rule viewer for KPI algorithm

The grouping of parameter tunings and rule base simplification resulted to the Optimization and its normalization. During the optimization, the function output is added to the offset value which is then added to the KPI values. While during the normalization, the algorithm developed checks and matches the KPI values. when the optimized KPI value exceeds the recommended thresholds, truncation is done. Also, when the KPI values are in exact ranges, the algorithm adjusts for the KPI values.

4.5 Recommended Optimized Network.

From the status of the present network, an optimized GSM Model was developed which shows that optimization is very possible at a high level in live network. The input values used in the present GSM network was also used in the optimized GSM network Model. (See Appendix A). For better Accessibility in this network, SDCCH Congestion was set to zero (0% indicates no congestion) because it is a temporary channel for signaling data before TCH allocation. TCH Congestion was then set to one (1%) because it carries the voice data. One TCH is allocated to every active call therefore; to ensure this channel is allocated, the

maximum congestion targeted should be less than or equal to one percent (1%). CSSR was set to 99% showing how successful it was to access the network. Lastly, CDR was set to 1% showing how well the call connection was retained. From the inputs, the rule viewer (Fig 4.5.1) was set by fine tuning these four parameters to the various desired numbers selected in order to get an optimized network. The KPI-OPT (output/threshold) from the tuning was 0.987indicating that this network is very good and is recommended for all GSMs.

Optimization using the ANFIS tool begins with resetting the model by deleting the initial input KPIs used to illustrate the present network behavior. The model, having already knowledgeable of the present network behavior , can be tuned by varying individually the KPIs (SDCCH, TCH, CDR, CSSR) to obtain a averaged KPI output whose lines coincide after the red line.

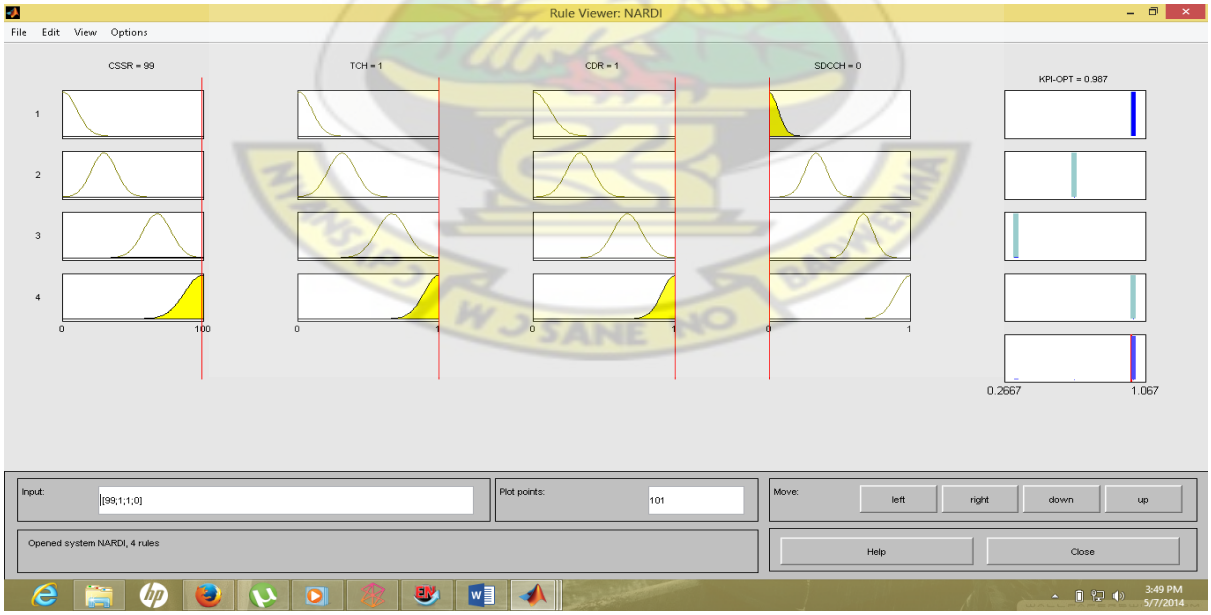


Figure 4.5.1 An Offset rule viewer for KPI optimization algorithm

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

From the study carried out to investigate the causes of SDCCH and TCH congestions in GSM networks, it was identified that TCH & SDCCH are caused by TRX Hardware faults, increasing number of subscribers/traffic in certain area, faulty equipment's, insufficient signaling resources, improper data configuration and interference.

In the assessment of the current state of Liberia's GSM networks in relation to SDCCH and TCH congestions, it was found from the seven locations considered that SDCCH & TCH congestions were at accepted levels but need improvements.

From the comparism of the simulations carried out, the optimized network model is highly recommended and should stand as benchmark for all GSM in Liberia. The methods of fuzzy logic have been employed to include the heuristic rules of an experience operator. Therefore, in order to get this optimized network with minimal SDCCH & TCH congestion, very good network accessibility, service retain ability and connection quality in Liberia's GSM networks, the following methods & strategies should be employed: There should firstly be an initial baseline for network KPI's and operator objectives, selected sites should be visited, information of the network present status should be collected, and determining functional network structure (that is; antenna direction, antenna tilting) etc. Operator should ensure that customer quality expectations be met. Hence, service availability everywhere at anytime, call setup within limits, and very good speech quality during calls should all be achieved.

In those worse affected areas (WCSSR/ Worst Cells), it is recommended that Network providers should add some extra TRXs, portable BTS in case of foreseeable special events and optimize cell boundaries (i.e. Antenna optimization). Also, they should frequently check

and make sure their configuration settings are properly set to avoid interference and improper settings.

For those areas in which their cells were off for upgrades, maintenance, repairs or other purposes, operators should strengthen neighboring cells power levels so that their coverage area will increase thereby reducing congestion and drop calls in those areas that are off.

In this thesis it has been proved that Liberia GSM networks can be improve by using fine parameter tunings method to offer high degree QoS to the end users.

5.1 Recommended Improvements

We start by saying Optimization is a process that never ends[33]. In order to improve and know the QoS of a GSM network, optimization should be done frequently.

Service providers should frequently optimize SDCCH, TCH, CDR and CSSR in order to get the best signaling for their networks.

In ensuring better quality of services as regards to optimizing TCH and SDCCH congestion in Liberia GSMs, it is firstly highly recommended that all GSM operators must ensure the threshold of the optimized fuzzy logic model be met in all locations in order to satisfy customer complaints regarding service quality. That is, operators should set their benchmarks so that management teams can easily compare network performances and apply both physical and hardware optimization strategies to optimize them as shown in this work.

Finally, the LTA on a yearly basis should make sure GSM operators abide by all rules(QoS), and should send a team of optimization Engineers to check the network performance data generated over the year in all GSM companies.

REFERENCES

[1] T. Adegbola, "Congestion Control Mechanisms and Patterns of Call Distribution in GSM Telecommunication Networks: The Case of MTN Nigeria," 2012.

[2] K. B. Moses, "Optimization models for minimizing congestion in Global System for Mobile Communications (GSM) in Nigeria," *Journal Media and Communication Studies Vol,* vol. 2, pp. 122-126, 2010.

[3] B. Haider, M. Zafrullah, and M. Islam, "Radio frequency optimization & QoS evaluation in operational GSM network," in *World Congress on Engineering and Computer Science*, 2009, pp. 20-22.

[4] "Globl System for Mobile Communication (GSM)," *web proforum tutorials,* p. 19.

[5] B. Kuboye, B. Alese, and O. Fajuyigbe, "Congestion Analysis on the Nigerian Global System for Mobile Communications (GSM) Network," *The Pacific Journal of Science and Technology,* vol. 10, pp. 262-271, 2009.

[6] J. Popoola, I. Megbowon, and V. Adeloye, "Performance evaluation and improvement on quality of service of global system for mobile communications in Nigeria," *Journal of Information Technology Impact,* vol. 9, pp. 91-106, 2009.

[7] M. P. a. S. P. Padhy2, "Traffic Analysis and Optimization of GSM Network," *IJCSI International Journal of Computer Science Issues, Special Issue, ICVCI-2011, Vol. 1, Issue 1, November 2011,* vol. Vol. 1,, p. 4, November 2011.

[8] P. Lehtimäki, "Data analysis methods for cellular network performance optimization," Doctor of Science in Technology, Faculty of Information and Natural Sciences, Helsinki University of Technology, 2008.

[9] O. Mattsson, "Positioning of a cellular phone using the SIM," *Onuitgegeven afstudeerscriptie, Royal Institute of Technology, Stockholm,* 2001.

[10] F. v. d. Broek, "Catching and Understanding GSM-Signals," Master's of Science Master's Thesis Computer Science, Radboud University Nijmegen, 2010.

[11] W. a. Goltermann, "GSM," in *GSM Pocket Guide*. vol. 2, ed, p. 54.

[12] BBC. (2002, August 25, 2011). *Phone firms defend security record*. Available: en.m.wikipedia.org/wiki/international_Mobile_Station_Equipment_Identity

[13] (2003-06). *GSME proposals regaring mobile theft and IMEI security*.

[14] J. Scourias, "Overview of the global system for mobile communications," *University of Waterloo,* vol. 4, 1995.

[15] "GSM Dm-Channels," ed, p. 84.

[16] S. Saha, "IMPLEMENTATION OF DUAL-HOMED 2G CELLULAR NETWORKS," JADAVPUR UNIVERSITY, 2010.

[17] P. R. P. Alexei Barbosa de Aguiar and R. P. P. C. Álvaro de Menezes S. Neto, Rebecca F. Pinheiro "A Novel Model for Optimized GSM Network Design " *(IJCSIS) International Journal of Computer Science and Information Security* vol. Vol. 4, No. 1 & 2, p. 6, 2009 2009.

[18] A. Leung, S. Fong, and E. Lai, "Mining Operational Data for Improving GSM Network Performance," in *FSKD*, 2002, pp. 285-289.

[19] A. Athanasopulos, "Network management for the pan-European GSM cellular system," in *Telecommunications, 1989. Second IEE National Conference on*, 1989, pp. 226-231.

[20] A. D. Kora, 1, I. C. , 1, and J.-P. C. , "Global approach of mean service satisfaction assessment," *The Journal of Engineering,* p. 6, 29th November 2013 2013.

[21] M. Laitinen and J. Rantala, "Integration of Intelligent Network services into future GSM networks," *Communications Magazine, IEEE,* vol. 33, pp. 76-86, 1995.

[22] S. Musabekov and R. Ibraimov, "NS-2 network performance evaluation of abis interface over DVB-S2 in the GSM over satellite network," in *Internet, 2009. AH-ICI 2009. First Asian Himalayas International Conference on*, 2009, pp. 1-5.

[23] H. Olofsson and A. Furuskar, "Aspects of introducing EDGE in existing GSM networks," in *Universal Personal Communications, 1998. ICUPC'98. IEEE 1998 International Conference on*, 1998, pp. 421-426.

[24] N. A. L. C.-W. a. V. a. Apte, "CAP ACITY ANAL YSIS OF THE GSM SHORT MESSAGE SERVICE," *Indian Institute of T echnology Bombay Powai, Mumbai 400 076, India,* p. 5.

[25] S. GOKSEL and January 26. (2003, January 26, 2003). *Optimization and Log File Analysis in GSM*.

[26] P. B. H. Aninyie, "PERFORMANCE EVALUATION OF A GSM/GPRS CELLULAR NETWORK USING CSSR WITH DIRECT TCH ASSIGNMENT FEATURE.," Msc TELECOMMUNICATION ENGINEERING, KNUST, 2012.

[27] U. S. Rahman1, M. A. M. , and M. R. R. , "A Practical Approach of Planning and Optimization for Efficient Usage of GSM Network," *International Journal of Communications (IJC),* vol. 1, p. 6, December 2012 2012.

[28] A. K. B. Giriraj Sharma, "A Practical Approach to Improve GSM Network Quality by RF Optimization," *International Journal of Engineering and Advanced Technology (IJEAT)*vol. 3, p. 5, April 2014 2014.

[29] A. Homaifar and E. McCormick, "Simultaneous design of membership functions and rule sets for fuzzy controllers using genetic algorithms," *Fuzzy Systems, IEEE Transactions on,* vol. 3, pp. 129-139, 1995.

[30] J.-S. R. Jang, "ANFIS: Adaptive-Network-Based Fuzzy Inference System," University of California, Berkeley, CA 94720 May 1993 1993.

[31] V. S. P. KUMAR, 1, D. B. A. , 2, and a. V. NARESH, "IMPROVEMENT OF KEY PERFORMANCE INDICATORS AND QoS EVALUATION IN OPERATIONAL GSM NETWORK," *V.S.Pavan Kumar, Dr.B.Anuradha, Vivek, Naresh/ International Journal of Engineering Research and Applications (IJERA),* vol. Vol. 1, Issue 3, pp.411-417, pp. 411-417.

[32] O. Shoewu and F. Edeko, "Outgoing call quality evaluation of GSM network services in Epe, Lagos State," *American Journal of Scientific and Industrial research. p,* vol. 416, 2011.

[33] S. GOKSEL, "Title," unpublished|.

[34] I. S. S. A. Khairuddin, "Implementation of Artificial Intelligence Techniques for Steady State Security Assessment in Pool Market " *International Journal of Engineering (IJE),* vol. 3, p. 89, January / February2009 2008.

[35] V. W. Salvador Pedraza*, Matías Toril**, Ricardo Ferrer*, Juan J. Escobar*, "Dimensioning of Signaling Capacityon a Cell Basis in GSM/GPRS," I. M. N. Nokia Networks, NSR-Málaga SCT, P.T.A, Málaga (Spain), Ed., ed. Nokia Networks, IP Mobility Networks, NSR-Málaga SCT, P.T.A, Málaga (Spain)**Dpto. Ingeniería de Comunicaciones, E.T.S.I. Telecomunicación, Universidad de MálagaC/Severo Ochoa s/n. Edif. De Instit.Universitarios, Pl.3Parque Tecnológico de Andalucía, 29590 Campanillas (Málaga), Spain, p. 5.

[36] A. N. Ndife, 1, A. U. O. , 2, E. O. I. , 3*, et al.*, "Evaluation and Optimization of Quality of Service (QoS) of Mobile Cellular Networks in Nigeria," *International Journal of Information and Communication Technology Research,* p. 6, 2013.

[37] *Matlab*. Available: http://www.mathworks. com/products/ matlab/

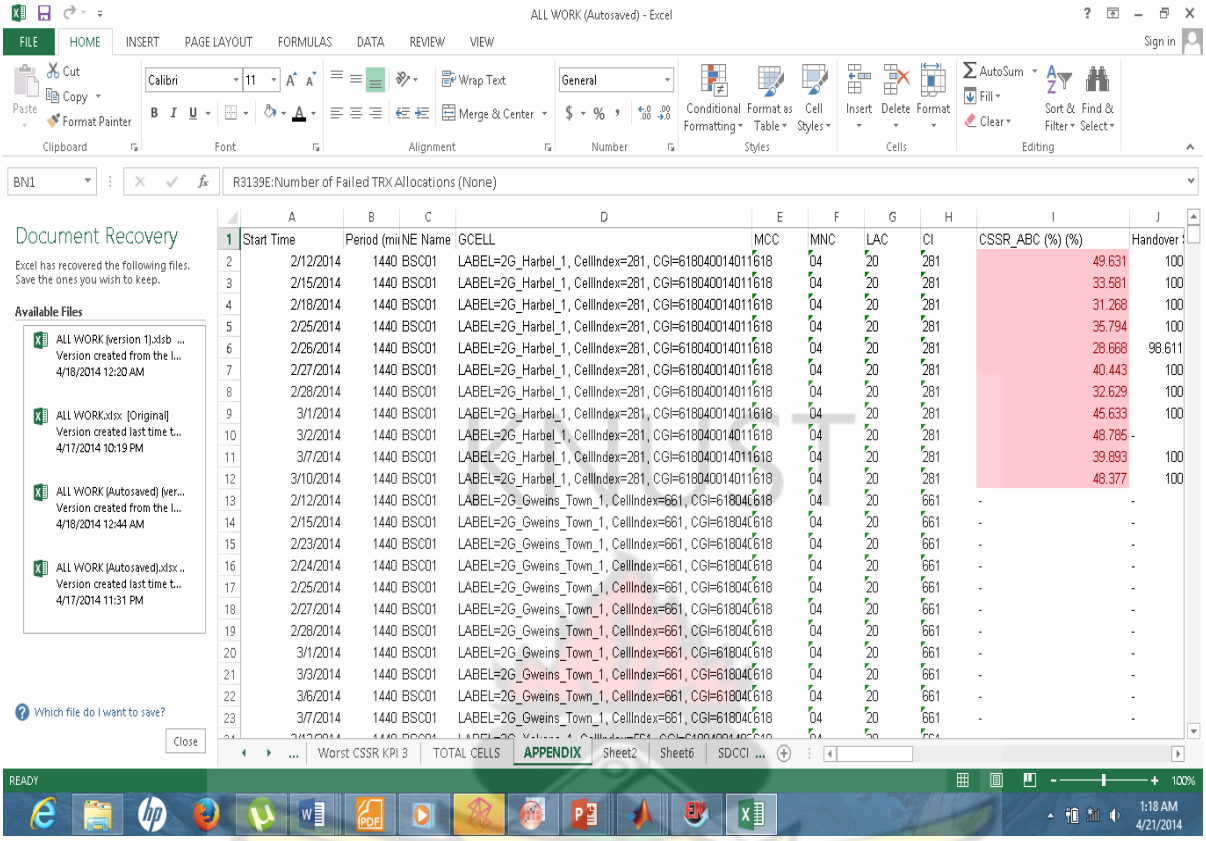
[38] *OriginPro*. Available: en.m.wikipedia.org/wiki/Origin_ (software)

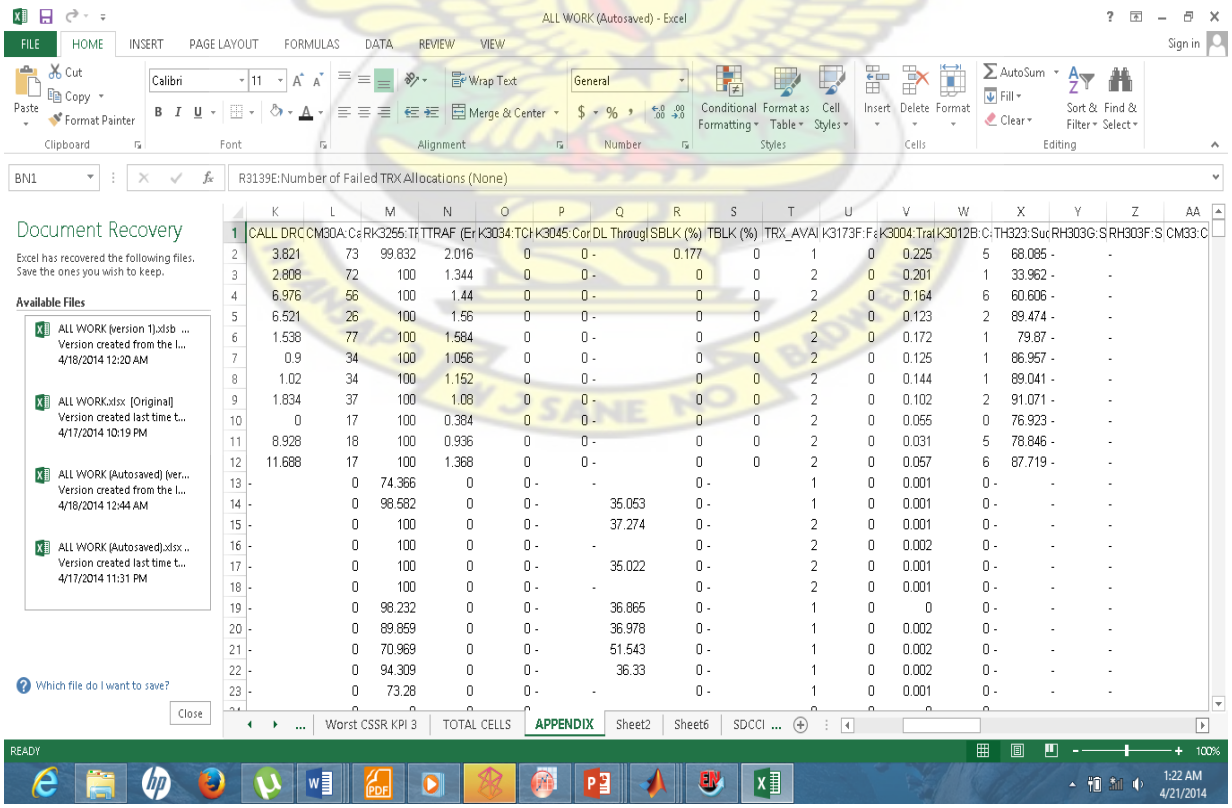
APPENDIX A: SOURCE CODE SUMMARY OF MODEL

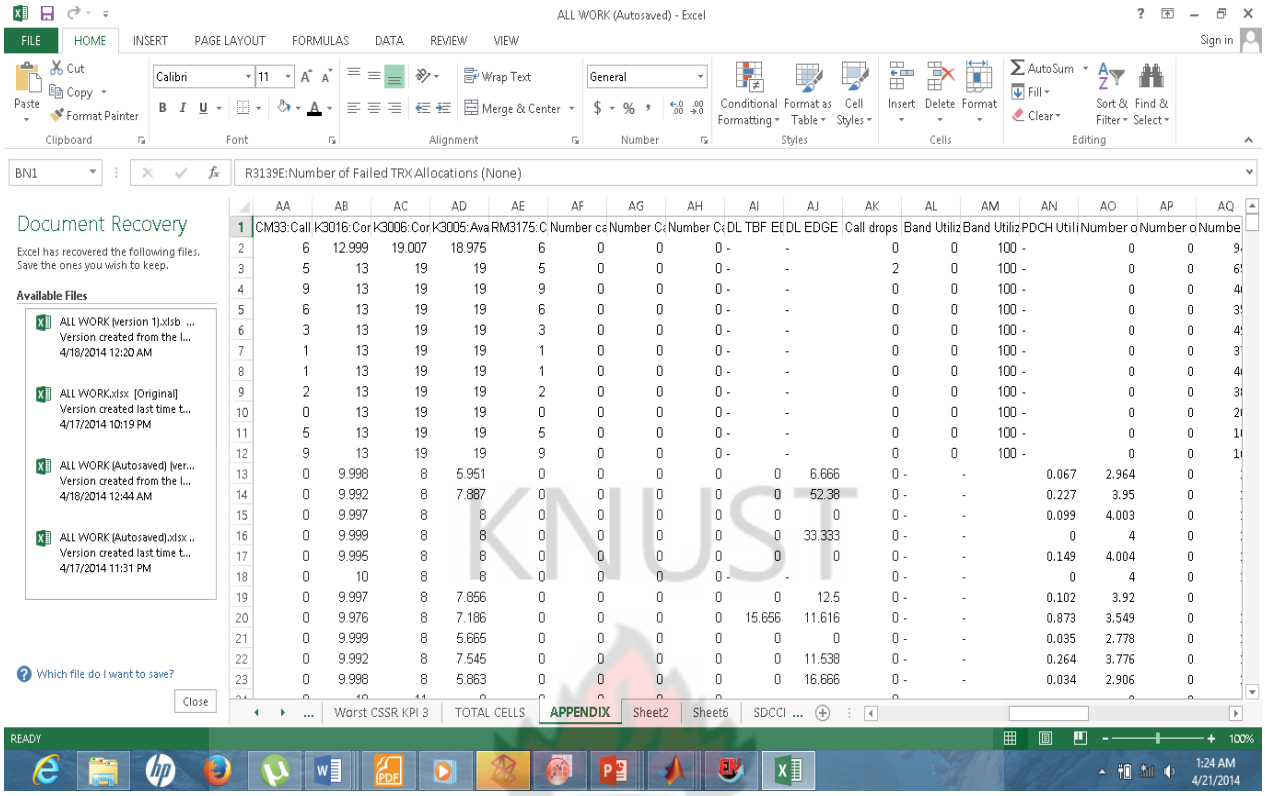
```
[System]
Name='NARDI'
Type='sugeno'
Version=2.0
NumInputs=4
NumOutputs=1
NumRules=4
AndMethod='prod'
OrMethod='probor'
ImpMethod='prod'
AggMethod='sum'
DefuzzMethod='wtaver'

[Input1]
Name='CSSR'
Range=[0 100]
NumMFs=4
MF1='mf1':'gaussmf',[0.0954895645700117 0.00794]
MF2='mf2':'gaussmf',[0.0888 0.296227513227513]
MF3='mf3':'gaussmf',[0.0996 0.672391534391534]
MF4='mf4':'gaussmf',[0.123798763365792 0.991]

[Input2]
Name='TCH'
Range=[0 1]
NumMFs=4
MF1='mf1':'gaussmf',[0.0887 0.0132275132275131]
MF2='mf2':'gaussmf',[0.0975821317103403 0.315]
MF3='mf3':'gaussmf',[0.108708696670727 0.669]
MF4='mf4':'gaussmf',[0.102233179664299 1]

[Input3]
Name='CDR'
Range=[0 1]
NumMFs=4
MF1='mf1':'gaussmf',[0.111 0.00797]
MF2='mf2':'gaussmf',[0.0929625401193558 0.333]
MF3='mf3':'gaussmf',[0.100269403861516 0.667]
MF4='mf4':'gaussmf',[0.0887518812470284 1]

[Input4]
Name='SDCCH'
Range=[0 1]
NumMFs=4
MF1='mf1':'gaussmf',[0.0640361674820331 0]
MF2='mf2':'gaussmf',[0.0772343586325407 0.333]
MF3='mf3':'gaussmf',[0.071059923957431 0.667]
MF4='mf4':'gaussmf',[0.0977394135252086 1]

[Output1]
Name='KPI-OPT'
Range=[0 1]
NumMFs=4
MF1='kpi_{4=0}s':'constant',[1]
MF2='kpi_{3=0}':'constant',[0.333333333333333]
MF3='kpi_{2=0}':'constant',[0.666666666666667]
MF4='kpi_{1=99}':'constant',[1]
```

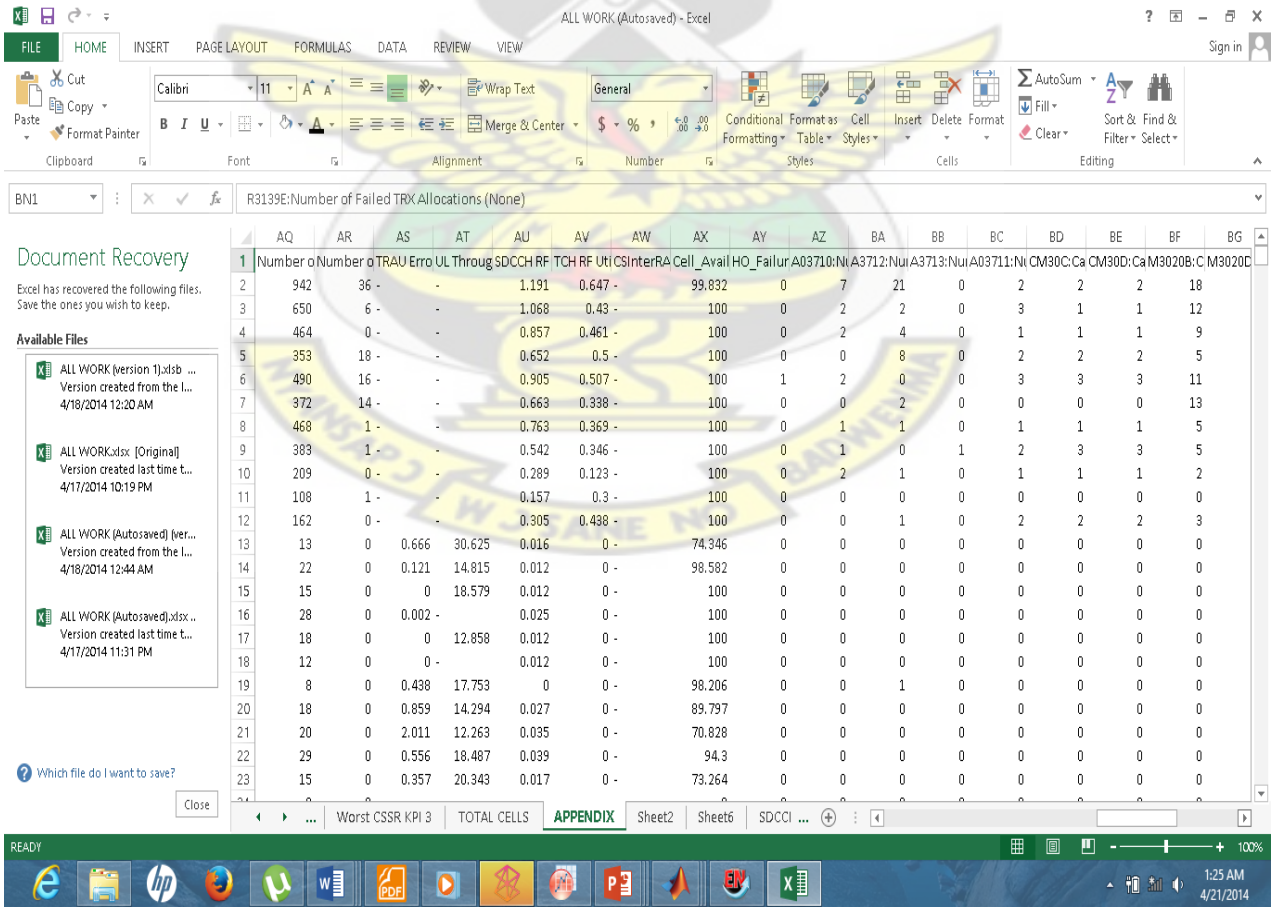
```
[Rules]
1 1 1 1, 4 (1) : 2
2 2 2 2, 3 (1) : 2
3 3 3 3, 2 (1) : 2
4 4 4 4, 1 (1) : 1
```

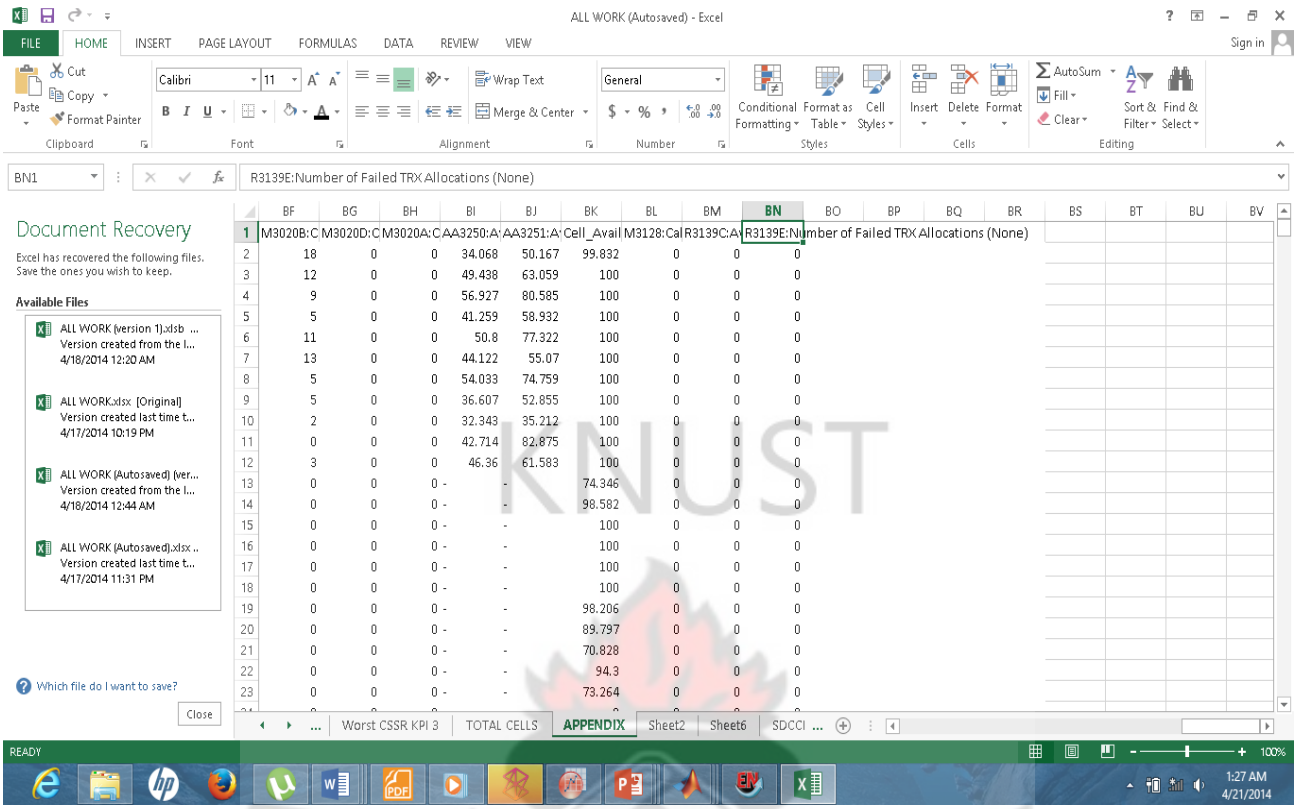
APPENDIX B: WORST CELLS KPIs DATA

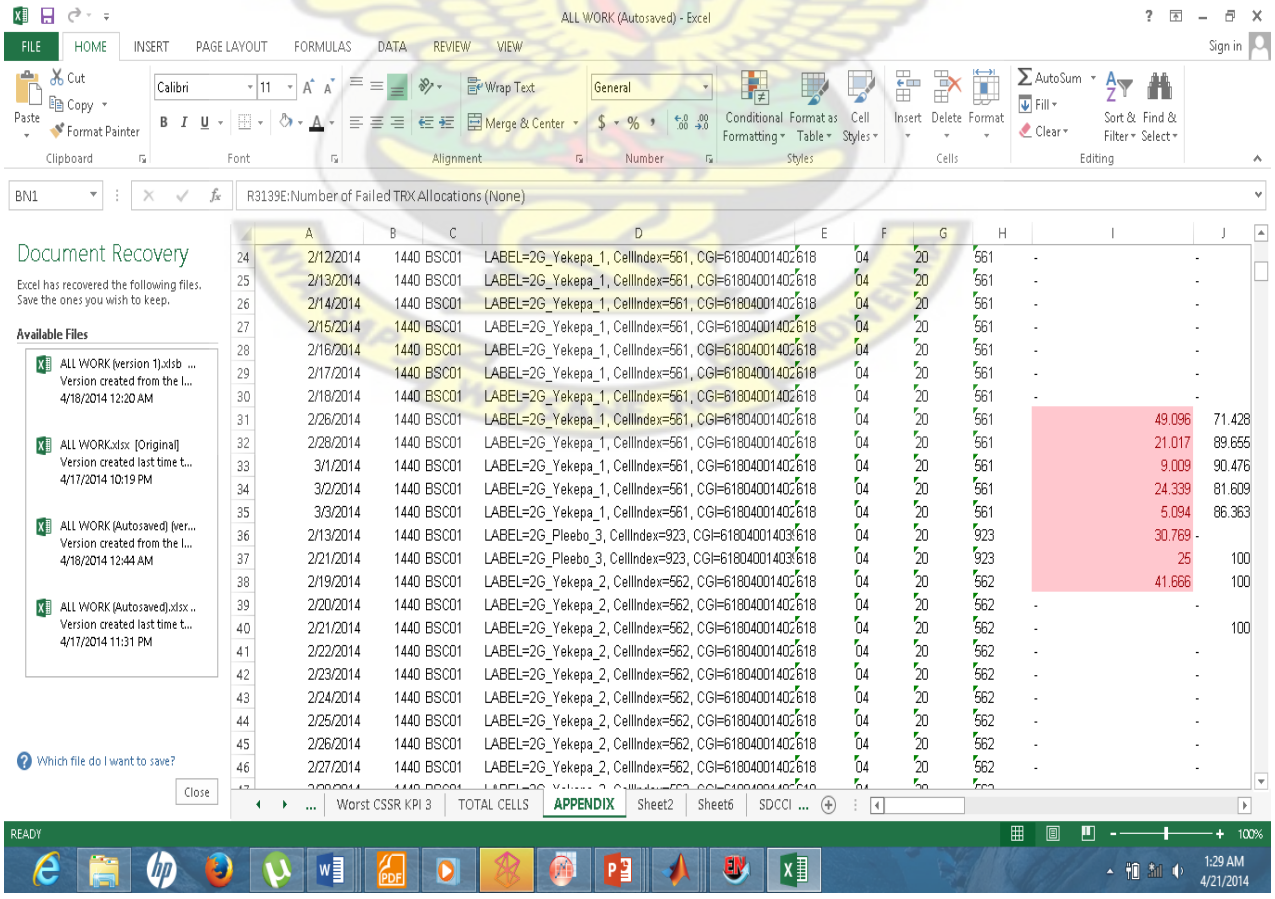


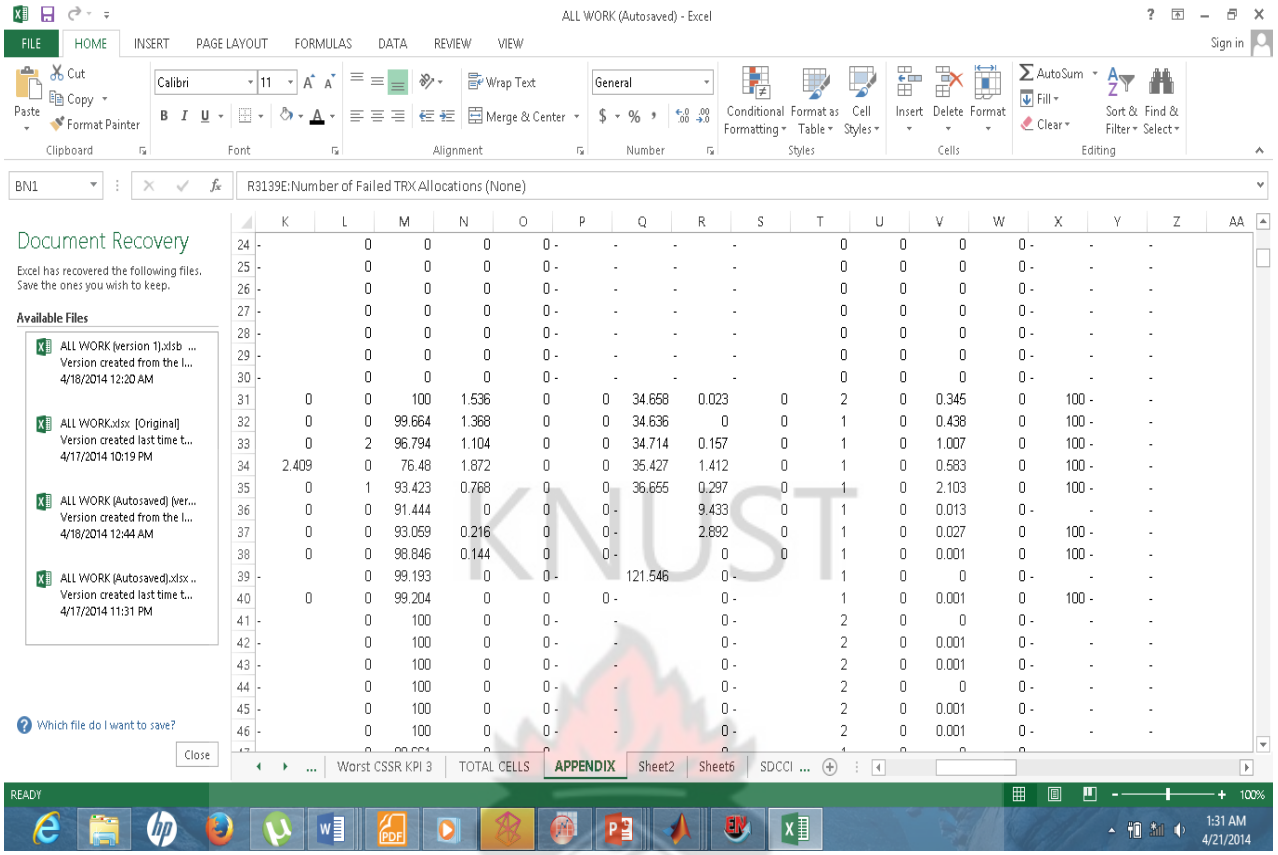


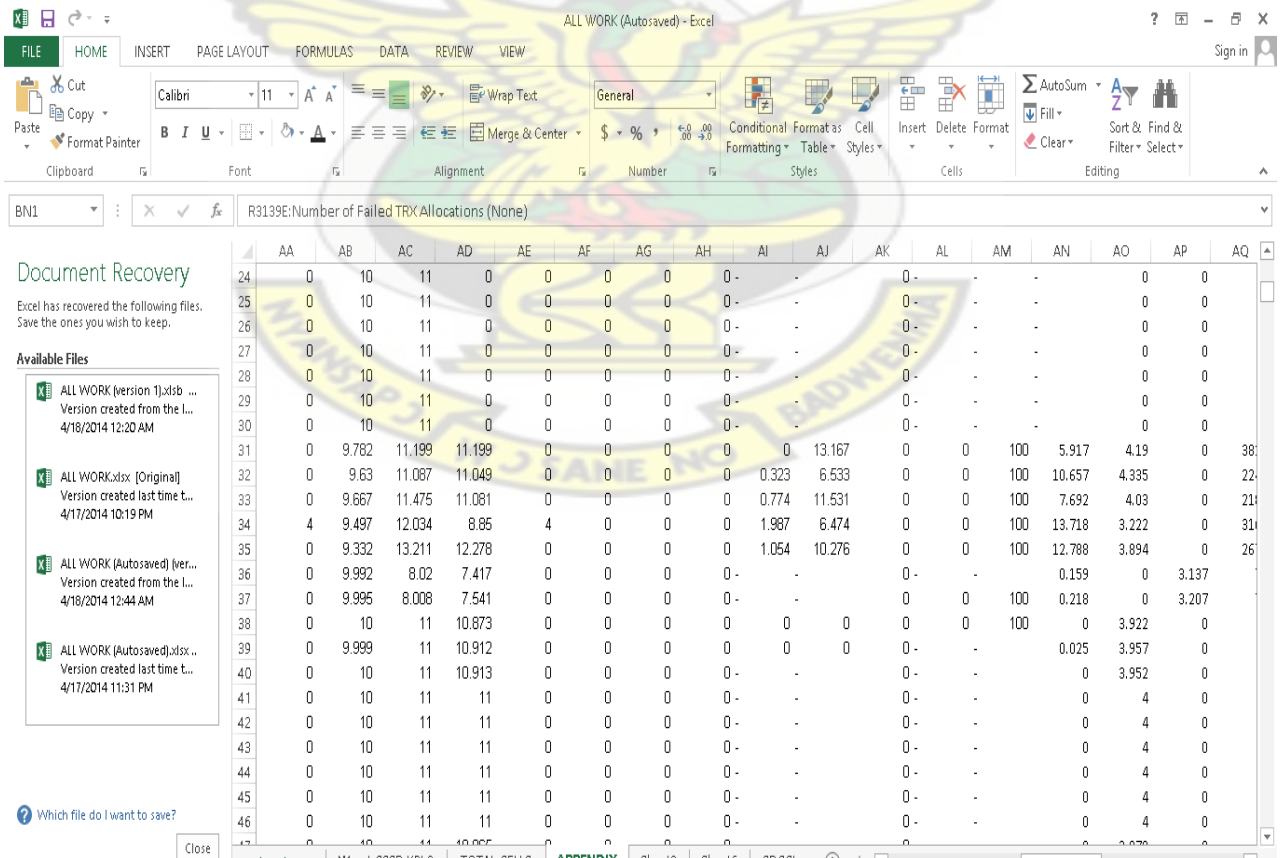

ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ... Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ
CM33:Call K3016:Cor K3006:Cor K3005:Ava RM3175:C Number ca Number C Number C DL TBF E DL EDGE Call drops Band Utiliz Band Utiliz PDCH Utili Number o Number o Numbe
6 12.999 19.007 18.975 6 0 0 0 - - 0 0 100 - 0 0 9
5 13 19 19 5 0 0 0 - - 2 0 100 - 0 0 6
9 13 19 19 9 0 0 0 - - 0 0 100 - 0 0 4
6 13 19 19 6 0 0 0 - - 0 0 100 - 0 0 3
3 13 19 19 3 0 0 0 - - 0 0 100 - 0 0 4
1 13 19 19 1 0 0 0 - - 0 0 100 - 0 0 3
1 13 19 19 1 0 0 0 - - 0 0 100 - 0 0 4
2 13 19 19 2 0 0 0 - - 0 0 100 - 0 0 3
0 13 19 19 0 0 0 0 - - 0 0 100 - 0 0 2
5 13 19 19 5 0 0 0 - - 0 0 100 - 0 0 1
9 13 19 19 9 0 0 0 - - 0 0 100 - 0 0 1
0 9.998 8 5.951 0 0 0 0 0 6.666 0 - - 0.067 2.964 0
0 9.992 8 7.887 0 0 0 0 0 52.38 0 - - 0.227 3.95 0
0 9.997 8 8 0 0 0 0 0 0 0 - - 0.099 4.003 0
0 9.999 8 8 0 0 0 0 0 33.333 0 - - 0 4 0
0 9.995 8 8 0 0 0 0 0 0 0 - - 0.149 4.004 0
0 10 8 8 0 0 0 0 - - 0 - - 0 4 0
0 9.997 8 7.856 0 0 0 0 0 12.5 0 - - 0.102 3.92 0
0 9.976 8 7.186 0 0 0 0 0 15.656 11.616 0 - - 0.873 3.549 0
0 9.999 8 5.665 0 0 0 0 0 0 0 - - 0.035 2.778 0
0 9.992 8 7.545 0 0 0 0 0 0 11.538 0 - - 0.264 3.776 0
0 9.998 8 5.863 0 0 0 0 0 16.666 0 - - 0.034 2.906 0
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:24 AM 4/21/2014

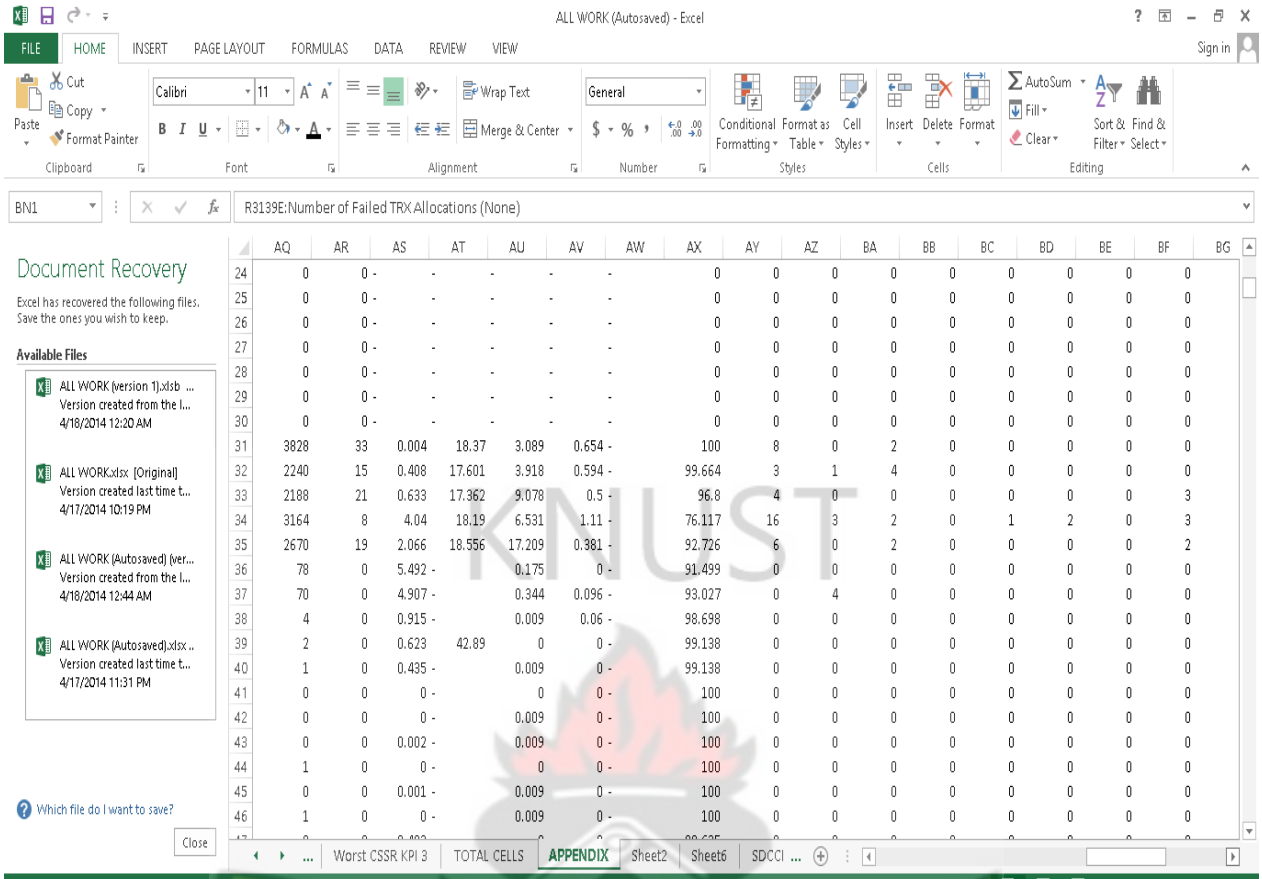

ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ... Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
AQ AR AS AT AU AV AW AX AY AZ BA BB BC BD BE BF BG
Number o Number o TRAU Erro UL Throug SDCCH RF TCH RF Uti CSInterRA Cell_Avail HO_Failur A03710:Nu A3712:Nui A3713:Nui A03711:Nu CM30C:Ca CM30D:Ca M3020B:C M3020D
942 36 - - 1.191 0.647 - 99.832 0 7 21 0 2 2 2 18
650 6 - - 1.068 0.43 - 100 0 2 2 0 3 1 1 12
464 0 - - 0.857 0.461 - 100 0 2 4 0 1 1 1 9
353 18 - - 0.652 0.5 - 100 0 0 8 0 2 2 2 5
490 16 - - 0.905 0.507 - 100 1 2 0 0 3 3 3 11
372 14 - - 0.663 0.338 - 100 0 0 2 0 0 0 0 13
468 1 - - 0.763 0.369 - 100 0 1 1 0 1 1 1 5
383 1 - - 0.542 0.346 - 100 0 1 0 1 2 3 3 5
209 0 - - 0.289 0.123 - 100 0 2 1 0 1 1 1 2
108 1 - - 0.157 0.3 - 100 0 0 0 0 0 0 0 0
162 0 - - 0.305 0.438 - 100 0 0 1 0 2 2 2 3
13 0 0.666 30.625 0.016 0 - 74.346 0 0 0 0 0 0 0 0
22 0 0.121 14.815 0.012 0 - 98.582 0 0 0 0 0 0 0 0
15 0 0 18.579 0.012 0 - 100 0 0 0 0 0 0 0 0
28 0 0.002 - 0.025 0 - 100 0 0 0 0 0 0 0 0
18 0 0 12.858 0.012 0 - 100 0 0 0 0 0 0 0 0
12 0 0 - 0.012 0 - 100 0 0 0 0 0 0 0 0
8 0 0.438 17.753 0 0 - 98.206 0 0 1 0 0 0 0 0
18 0 0.859 14.294 0.027 0 - 89.797 0 0 0 0 0 0 0 0
20 0 2.011 12.263 0.035 0 - 70.828 0 0 0 0 0 0 0 0
29 0 0.556 18.487 0.039 0 - 94.3 0 0 0 0 0 0 0 0
15 0 0.357 20.343 0.017 0 - 73.264 0 0 0 0 0 0 0 0
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:25 AM 4/21/2014

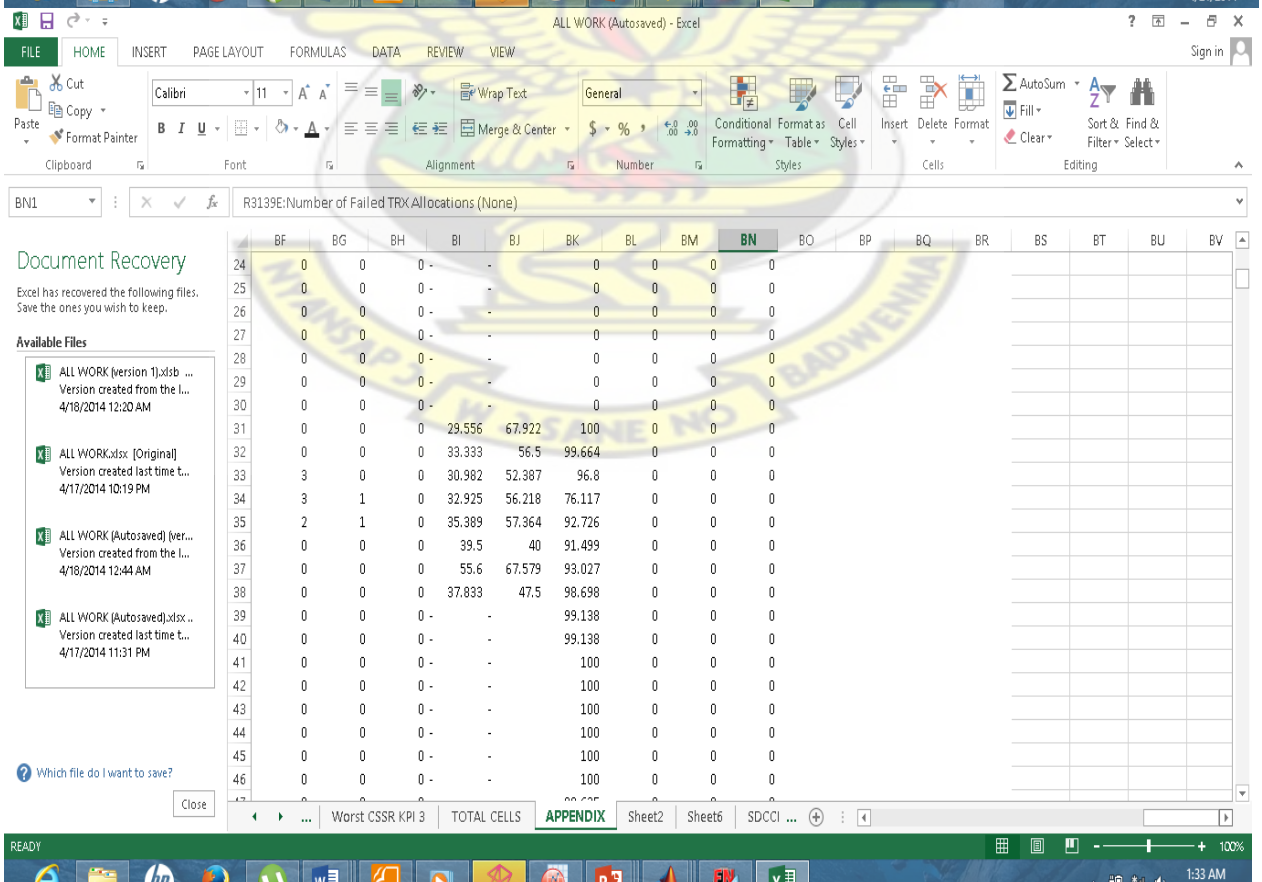

ALL WORK (Autosaved) - Excel
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx .. Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
R3139E:Number of Failed TRX Allocations (None)
Worst CSSR KPI 3
TOTAL CELLS
APPENDIX
Sheet2
Sheet6
SDCCI ...
READY
1:27 AM 4/21/2014

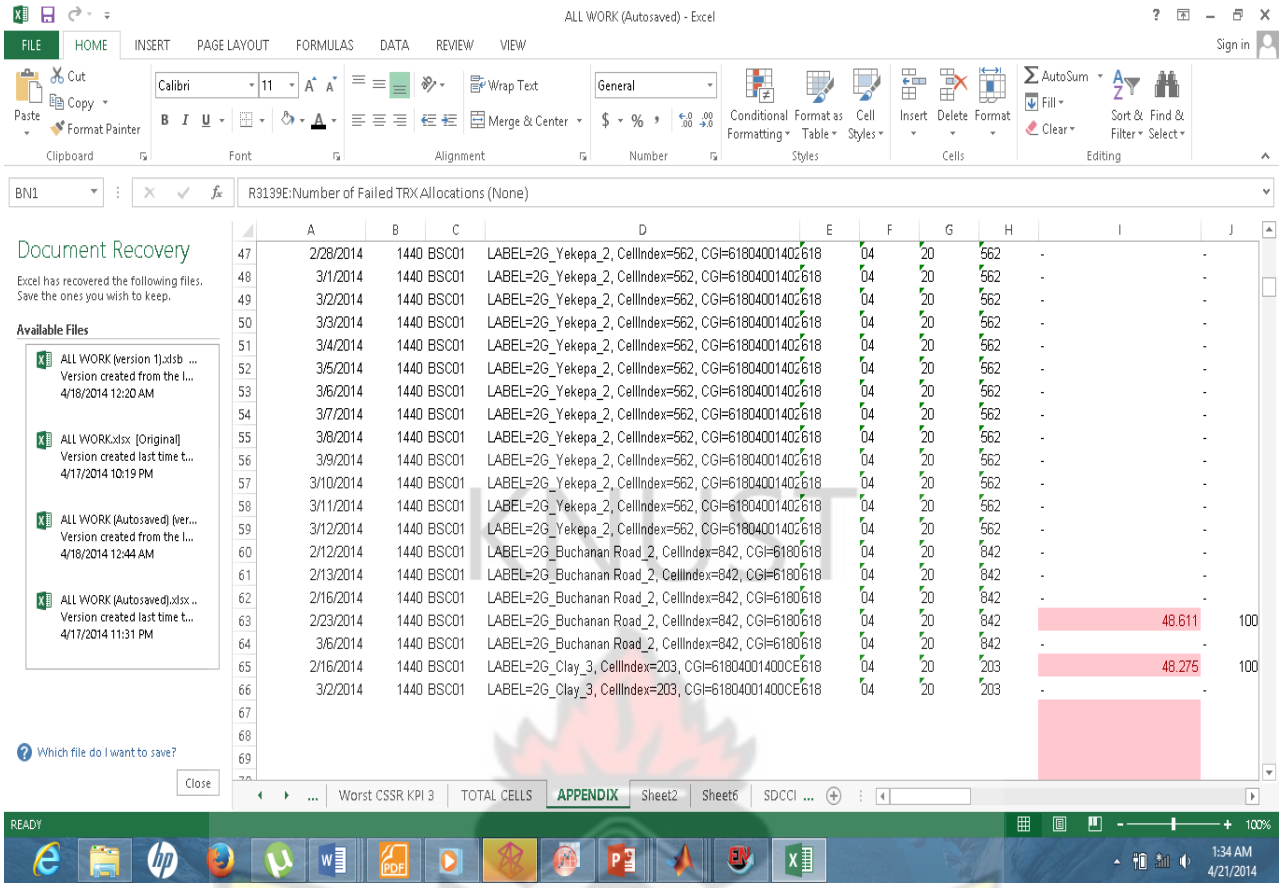

ALL WORK (Autosaved) - Excel
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx .. Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
R3139E:Number of Failed TRX Allocations (None)
Worst CSSR KPI 3
TOTAL CELLS
APPENDIX
Sheet2
Sheet6
SDCCI ...
READY
1:29 AM 4/21/2014


ALL WORK (Autosaved) - Excel
FILE
HOME
INSERT
PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
Sign in
Cut
Copy
Format Painter
Paste
Calibri
11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ...
Version created from the l...
4/18/2014 12:20 AM
ALL WORK.xlsx [Original]
Version created last time t...
4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver...
Version created from the l...
4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ...
Version created last time t...
4/17/2014 11:31 PM
Which file do I want to save?
Close
Worst CSSR KPI 3
TOTAL CELLS
APPENDIX
Sheet2
Sheet6
SDCCI ...
READY
100%
1:31 AM
4/21/2014

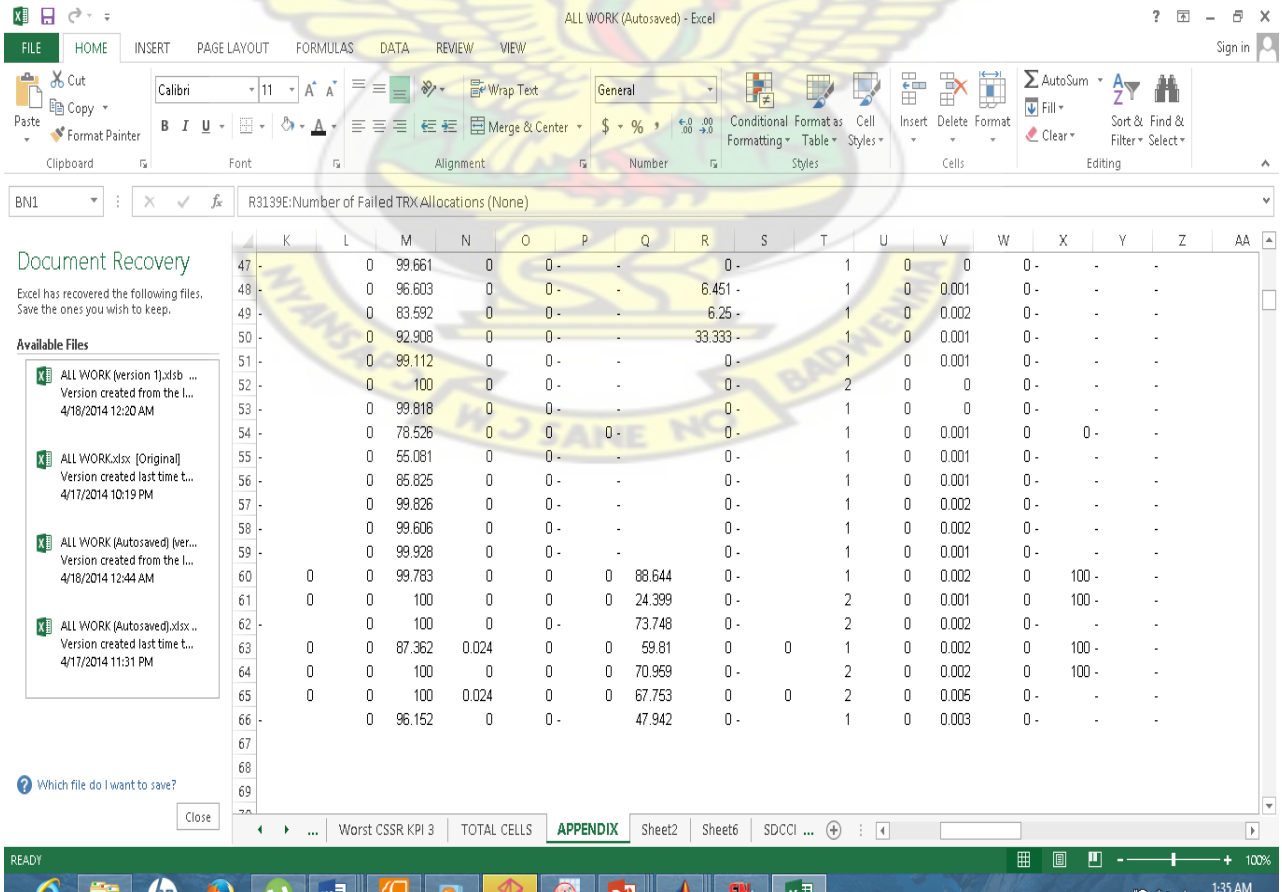

ALL WORK (Autosaved) - Excel
FILE
HOME
INSERT
PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
Sign in
Cut
Copy
Format Painter
Paste
Calibri
11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ...
Version created from the l...
4/18/2014 12:20 AM
ALL WORK.xlsx [Original]
Version created last time t...
4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver...
Version created from the l...
4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ...
Version created last time t...
4/17/2014 11:31 PM
Which file do I want to save?
Close
Worst CSSR KPI 3
TOTAL CELLS
APPENDIX
Sheet2
Sheet6
SDCCI ...
READY
100%
1:32 AM
4/21/2014


ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx .. Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
AQ AR AS AT AU AV AW AX AY AZ BA BB BC BD BE BF BG
24 0 0 - - - - - 0 0 0 0 0 0 0 0 0
25 0 0 - - - - - 0 0 0 0 0 0 0 0 0
26 0 0 - - - - - 0 0 0 0 0 0 0 0 0
27 0 0 - - - - - 0 0 0 0 0 0 0 0 0
28 0 0 - - - - - 0 0 0 0 0 0 0 0 0
29 0 0 - - - - - 0 0 0 0 0 0 0 0 0
30 0 0 - - - - - 0 0 0 0 0 0 0 0 0
31 3828 33 0.004 18.37 3.089 0.654 - 100 8 0 2 0 0 0 0 0
32 2240 15 0.408 17.601 3.918 0.594 - 99.664 3 1 4 0 0 0 0 0
33 2188 21 0.633 17.362 9.078 0.5 - 96.8 4 0 0 0 0 0 0 3
34 3164 8 4.04 18.19 6.531 1.11 - 76.117 16 3 2 0 1 2 0 3
35 2670 19 2.066 18.556 17.209 0.381 - 92.726 6 0 2 0 0 0 0 2
36 78 0 5.492 - 0.175 0 - 91.499 0 0 0 0 0 0 0 0
37 70 0 4.907 - 0.344 0.096 - 93.027 0 4 0 0 0 0 0 0
38 4 0 0.915 - 0.009 0.06 - 98.698 0 0 0 0 0 0 0 0
39 2 0 0.623 42.89 0 0 - 99.138 0 0 0 0 0 0 0 0
40 1 0 0.435 - 0.009 0 - 99.138 0 0 0 0 0 0 0 0
41 0 0 0 - 0 0 - 100 0 0 0 0 0 0 0 0
42 0 0 0 - 0.009 0 - 100 0 0 0 0 0 0 0 0
43 0 0 0.002 - 0.009 0 - 100 0 0 0 0 0 0 0 0
44 1 0 0 - 0 0 - 100 0 0 0 0 0 0 0 0
45 0 0 0.001 - 0.009 0 - 100 0 0 0 0 0 0 0 0
46 1 0 0 - 0.009 0 - 100 0 0 0 0 0 0 0 0
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:33 AM 4/21/2014

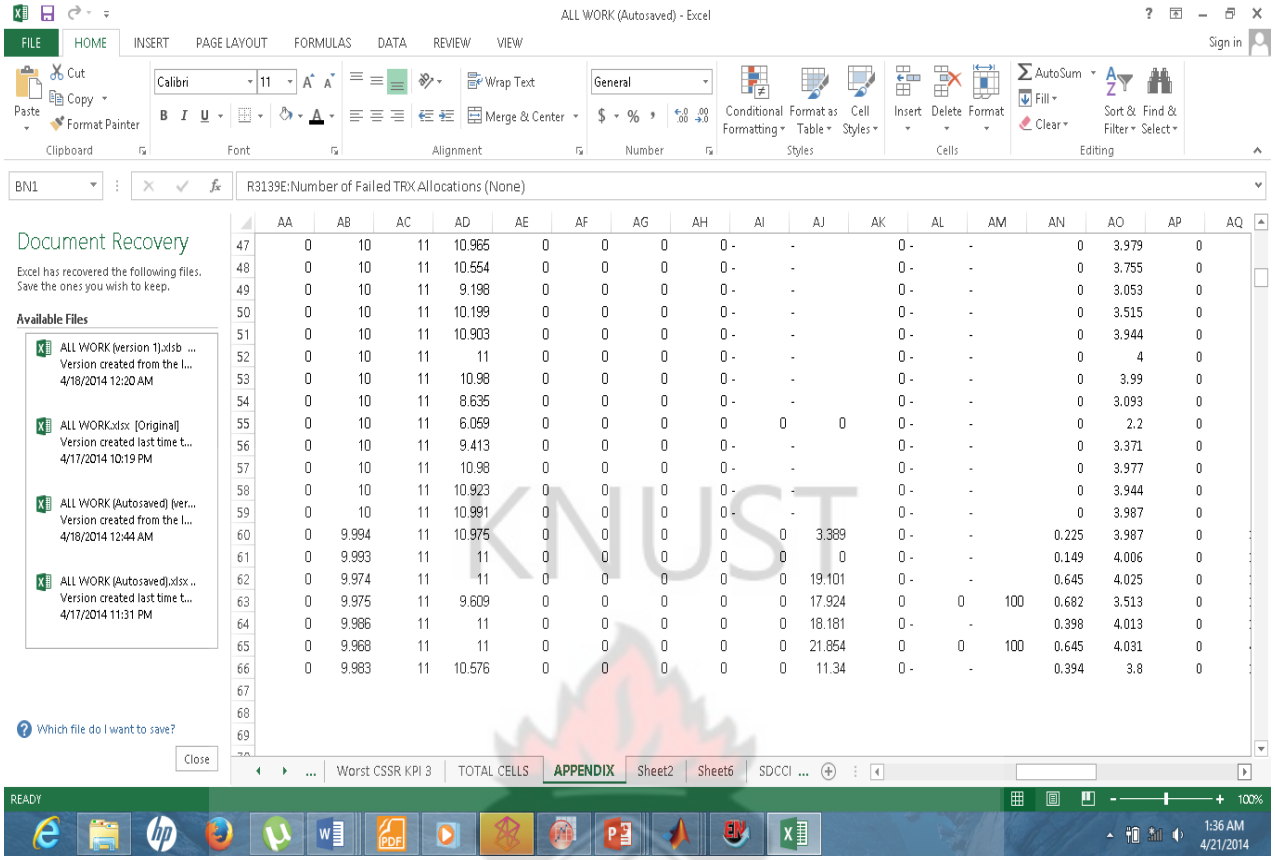

ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx .. Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
BF BG BH BI BJ BK BL BM BN BO BP BQ BR BS BT BU BV
24 0 0 0 - - 0 0 0 0
25 0 0 0 - - 0 0 0 0
26 0 0 0 - - 0 0 0 0
27 0 0 0 - - 0 0 0 0
28 0 0 0 - - 0 0 0 0
29 0 0 0 - - 0 0 0 0
30 0 0 0 - - 0 0 0 0
31 0 0 0 29.556 67.922 100 0 0 0
32 0 0 0 33.333 56.5 99.664 0 0 0
33 3 0 0 30.982 52.387 96.8 0 0 0
34 3 1 0 32.925 56.218 76.117 0 0 0
35 2 1 0 35.389 57.364 92.726 0 0 0
36 0 0 0 39.5 40 91.499 0 0 0
37 0 0 0 55.6 67.579 93.027 0 0 0
38 0 0 0 37.833 47.5 98.698 0 0 0
39 0 0 0 - - 99.138 0 0 0
40 0 0 0 - - 99.138 0 0 0
41 0 0 0 - - 100 0 0 0
42 0 0 0 - - 100 0 0 0
43 0 0 0 - - 100 0 0 0
44 0 0 0 - - 100 0 0 0
45 0 0 0 - - 100 0 0 0
46 0 0 0 - - 100 0 0 0
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:33 AM 4/21/2014

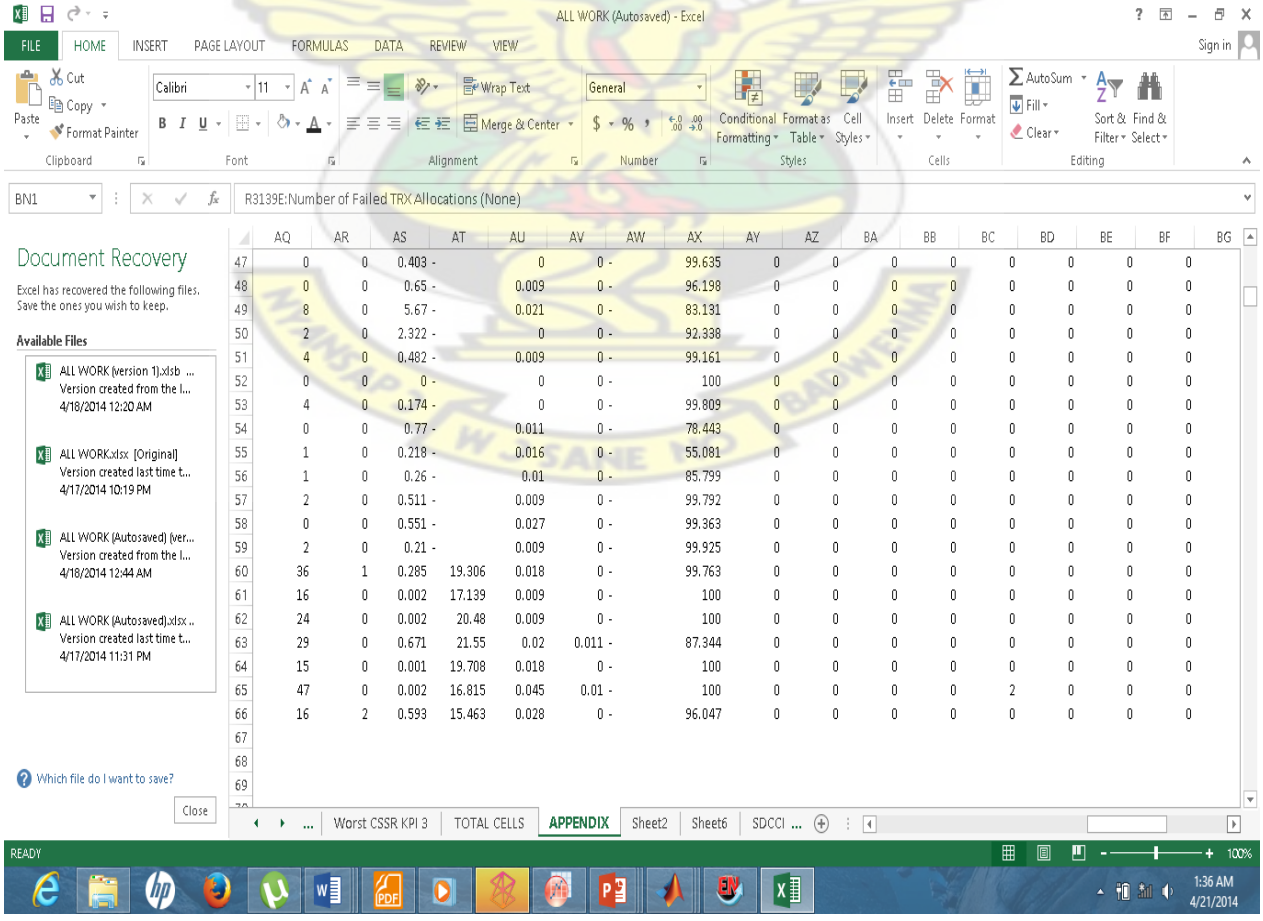


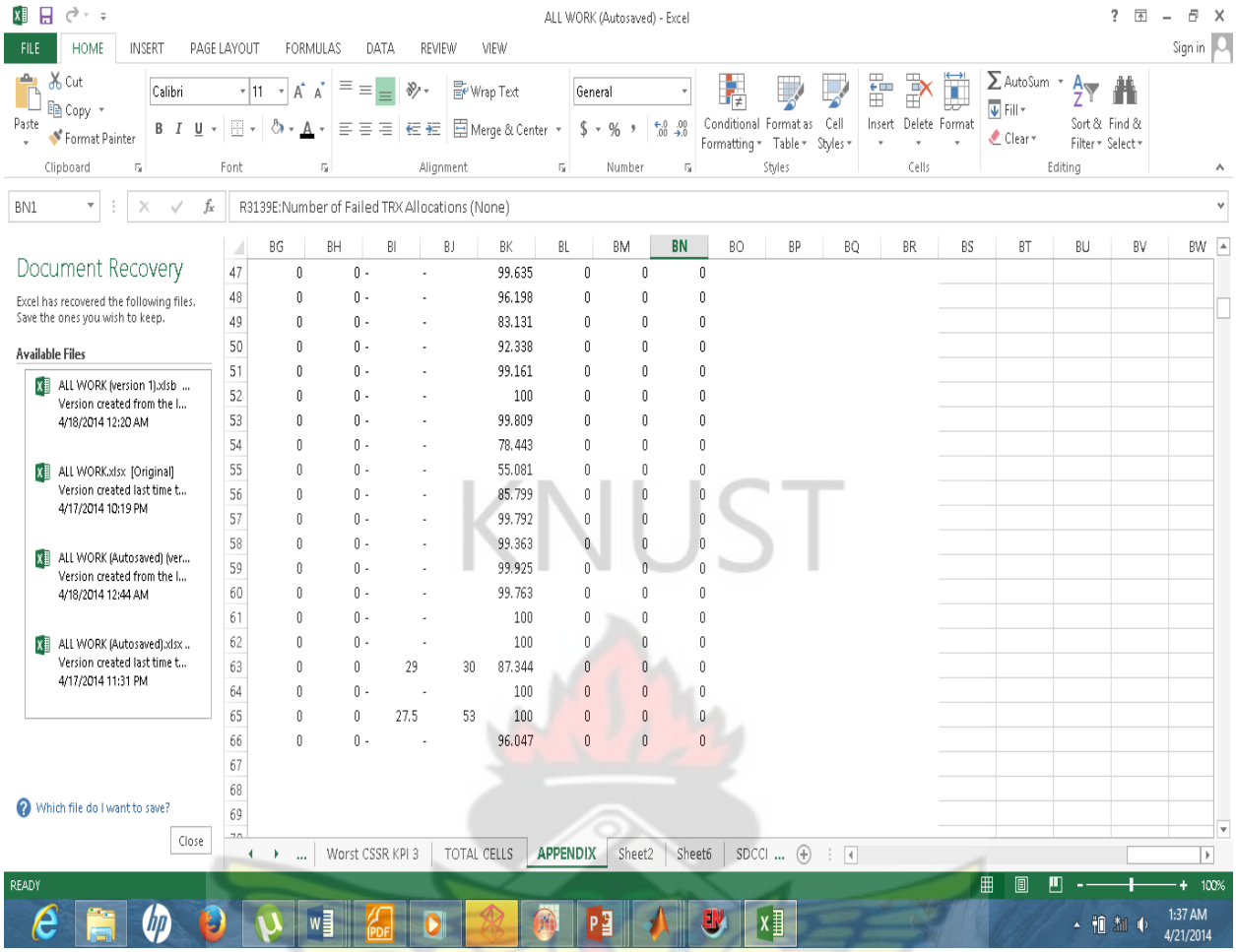
	A	B	C	D	E	F	G	H	I	J
47	2/28/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
48	3/1/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
49	3/2/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
50	3/3/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
51	3/4/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
52	3/5/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
53	3/6/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
54	3/7/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
55	3/8/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
56	3/9/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
57	3/10/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
58	3/11/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
59	3/12/2014	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=618040014026 18		04	20	562	-	-
60	2/12/2014	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618		04	20	842	-	-
61	2/13/2014	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618		04	20	842	-	-
62	2/16/2014	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618		04	20	842	-	-
63	2/23/2014	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618		04	20	842	48.611	100
64	3/6/2014	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618		04	20	842	-	-
65	2/16/2014	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=618040014006E618		04	20	203	48.275	100
66	3/2/2014	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=618040014006E618		04	20	203	-	-
67										
68										
69										



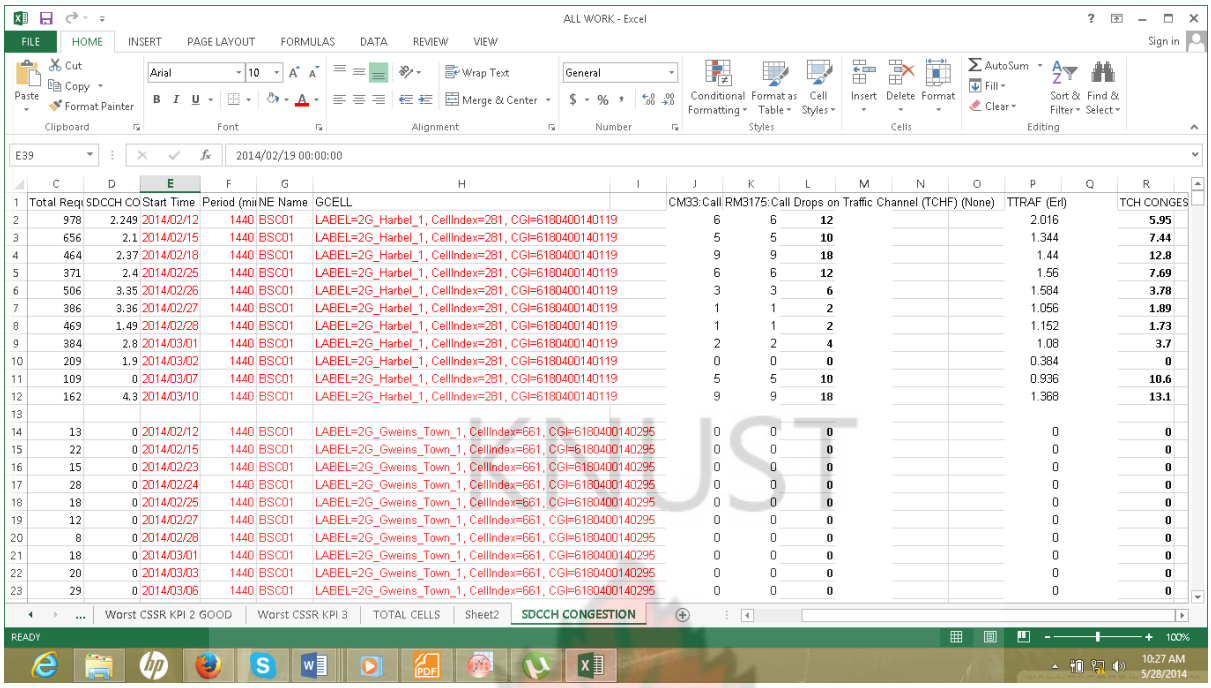
	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
47	-	0	99.661	0	0 -	-		0 -		1	0	0	0 -	-	-		
48	-	0	96.603	0	0 -	-		6.451 -		1	0	0.001	0 -	-	-		
49	-	0	83.592	0	0 -	-		6.25 -		1	0	0.002	0 -	-	-		
50	-	0	92.908	0	0 -	-		33.333 -		1	0	0.001	0 -	-	-		
51	-	0	99.112	0	0 -	-		0 -		1	0	0.001	0 -	-	-		
52	-	0	100	0	0 -	-		0 -		2	0	0	0 -	-	-		
53	-	0	99.818	0	0 -	-		0 -		1	0	0	0 -	-	-		
54	-	0	78.526	0	0	0 -		0 -		1	0	0.001	0	0 -	-		
55	-	0	55.081	0	0 -	-		0 -		1	0	0.001	0 -	-	-		
56	-	0	85.825	0	0 -	-		0 -		1	0	0.001	0 -	-	-		
57	-	0	99.826	0	0 -	-		0 -		1	0	0.002	0 -	-	-		
58	-	0	99.606	0	0 -	-		0 -		1	0	0.002	0 -	-	-		
59	-	0	99.928	0	0 -	-		0 -		1	0	0.001	0 -	-	-		
60	0	0	99.783	0	0	0	88.644	0 -		1	0	0.002	0	100 -	-		
61	0	0	100	0	0	0	24.399	0 -		2	0	0.001	0	100 -	-		
62	-	0	100	0	0 -		73.748	0 -		2	0	0.002	0 -	-	-		
63	0	0	87.362	0.024	0	0	59.81	0	0	1	0	0.002	0	100 -	-		
64	0	0	100	0	0	0	70.959	0 -		2	0	0.002	0	100 -	-		
65	0	0	100	0.024	0	0	67.753	0	0	2	0	0.005	0 -	-	-		
66	-	0	96.152	0	0 -		47.942	0 -		1	0	0.003	0 -	-	-		
67																	
68																	
69																	


ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11 Wrap Text General
Merge & Center
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ... Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ
47 0 10 11 10.965 0 0 0 0 - - 0 - - 0 3.979 0
48 0 10 11 10.554 0 0 0 0 - - 0 - - 0 3.755 0
49 0 10 11 9.198 0 0 0 0 - - 0 - - 0 3.053 0
50 0 10 11 10.199 0 0 0 0 - - 0 - - 0 3.515 0
51 0 10 11 10.903 0 0 0 0 - - 0 - - 0 3.944 0
52 0 10 11 11 0 0 0 0 - - 0 - - 0 4 0
53 0 10 11 10.98 0 0 0 0 - - 0 - - 0 3.99 0
54 0 10 11 8.635 0 0 0 0 - - 0 - - 0 3.093 0
55 0 10 11 6.059 0 0 0 0 0 0 0 - - 0 2.2 0
56 0 10 11 9.413 0 0 0 0 - - 0 - - 0 3.371 0
57 0 10 11 10.98 0 0 0 0 - - 0 - - 0 3.977 0
58 0 10 11 10.923 0 0 0 0 - - 0 - - 0 3.944 0
59 0 10 11 10.991 0 0 0 0 - - 0 - - 0 3.987 0
60 0 9.994 11 10.975 0 0 0 0 0 3.389 0 - - 0.225 3.987 0
61 0 9.993 11 11 0 0 0 0 0 0 0 - - 0.149 4.006 0
62 0 9.974 11 11 0 0 0 0 0 19.101 0 - - 0.645 4.025 0
63 0 9.975 11 9.609 0 0 0 0 0 17.924 0 0 100 0.682 3.513 0
64 0 9.986 11 11 0 0 0 0 0 18.181 0 - - 0.398 4.013 0
65 0 9.968 11 11 0 0 0 0 0 21.854 0 0 100 0.645 4.031 0
66 0 9.983 11 10.576 0 0 0 0 0 11.34 0 - - 0.394 3.8 0
67
68
69
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:36 AM
4/21/2014

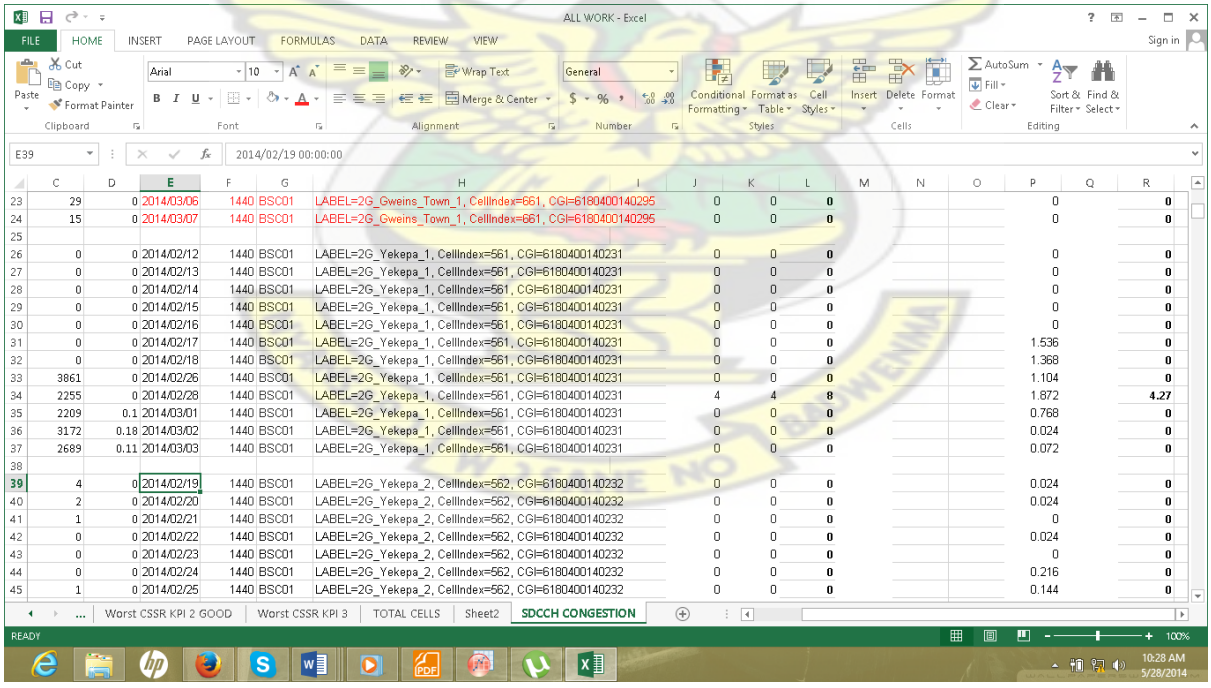

ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11 Wrap Text General
Merge & Center
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ... Version created from the l... 4/18/2014 12:20 AM
ALL WORK.xlsx [Original] Version created last time t... 4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver... Version created from the l... 4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ... Version created last time t... 4/17/2014 11:31 PM
Which file do I want to save?
Close
AQ AR AS AT AU AV AW AX AY AZ BA BB BC BD BE BF BG
47 0 0 0.403 - 0 0 - 99.635 0 0 0 0 0 0 0 0
48 0 0 0.65 - 0.009 0 - 96.198 0 0 0 0 0 0 0 0
49 8 0 5.67 - 0.021 0 - 83.131 0 0 0 0 0 0 0 0
50 2 0 2.322 - 0 0 - 92.338 0 0 0 0 0 0 0 0
51 4 0 0.482 - 0.009 0 - 99.161 0 0 0 0 0 0 0 0
52 0 0 0 - 0 0 - 100 0 0 0 0 0 0 0 0
53 4 0 0.174 - 0 0 - 99.809 0 0 0 0 0 0 0 0
54 0 0 0.77 - 0.011 0 - 78.443 0 0 0 0 0 0 0 0
55 1 0 0.218 - 0.016 0 - 55.081 0 0 0 0 0 0 0 0
56 1 0 0.26 - 0.01 0 - 85.799 0 0 0 0 0 0 0 0
57 2 0 0.511 - 0.009 0 - 99.792 0 0 0 0 0 0 0 0
58 0 0 0.551 - 0.027 0 - 99.363 0 0 0 0 0 0 0 0
59 2 0 0.21 - 0.009 0 - 99.925 0 0 0 0 0 0 0 0
60 36 1 0.285 19.306 0.018 0 - 99.763 0 0 0 0 0 0 0 0
61 16 0 0.002 17.139 0.009 0 - 100 0 0 0 0 0 0 0 0
62 24 0 0.002 20.48 0.009 0 - 100 0 0 0 0 0 0 0 0
63 29 0 0.671 21.55 0.02 0.011 - 87.344 0 0 0 0 0 0 0 0
64 15 0 0.001 19.708 0.018 0 - 100 0 0 0 0 0 0 0 0
65 47 0 0.002 16.815 0.045 0.01 - 100 0 0 0 0 2 0 0 0
66 16 2 0.593 15.463 0.028 0 - 96.047 0 0 0 0 0 0 0 0
67
68
69
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCI ...
READY
100%
1:36 AM
4/21/2014


ALL WORK (Autosaved) - Excel
FILE
HOME
INSERT
PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
Sign in
Cut
Copy
Format Painter
Paste
Calibri
11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
BN1
R3139E:Number of Failed TRX Allocations (None)
Document Recovery
Excel has recovered the following files. Save the ones you wish to keep.
Available Files
ALL WORK (version 1).xlsb ...
Version created from the l...
4/18/2014 12:20 AM
ALL WORK.xlsx [Original]
Version created last time t...
4/17/2014 10:19 PM
ALL WORK (Autosaved) (ver...
Version created from the l...
4/18/2014 12:44 AM
ALL WORK (Autosaved).xlsx ..
Version created last time t...
4/17/2014 11:31 PM
Which file do I want to save?
Close
BG BH BI BJ BK BL BM BN BO BP BQ BR BS BT BU BV BW
47 0 0 - - 99.635 0 0 0
48 0 0 - - 96.198 0 0 0
49 0 0 - - 83.131 0 0 0
50 0 0 - - 92.338 0 0 0
51 0 0 - - 99.161 0 0 0
52 0 0 - - 100 0 0 0
53 0 0 - - 99.809 0 0 0
54 0 0 - - 78.443 0 0 0
55 0 0 - - 55.081 0 0 0
56 0 0 - - 85.799 0 0 0
57 0 0 - - 99.792 0 0 0
58 0 0 - - 99.363 0 0 0
59 0 0 - - 99.925 0 0 0
60 0 0 - - 99.763 0 0 0
61 0 0 - - 100 0 0 0
62 0 0 - - 100 0 0 0
63 0 0 29 30 87.344 0 0 0
64 0 0 - - 100 0 0 0
65 0 0 27.5 53 100 0 0 0
66 0 0 - - 96.047 0 0 0
67
68
69
Worst CSSR KPI 3
TOTAL CELLS
APPENDIX
Sheet2
Sheet6
SDCCI ...
READY
100%
1:37 AM
4/21/2014

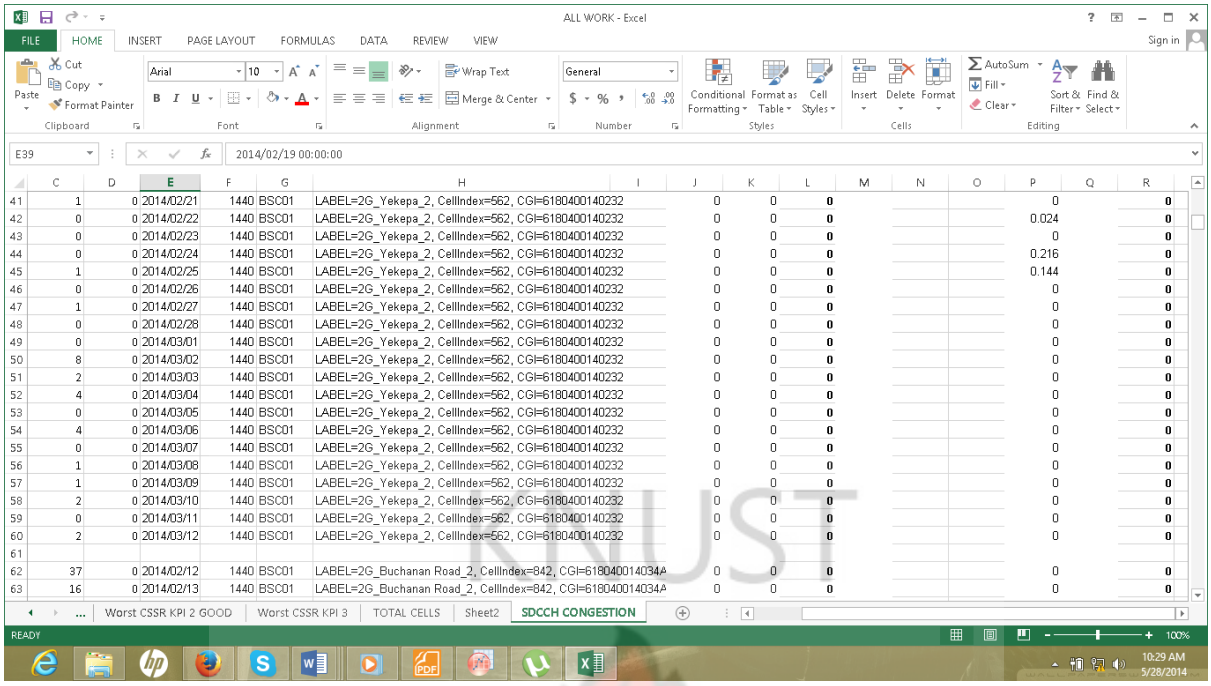
APPENDIX C: SDCCH & TCH CONGESTION DATA SUMMARY



	Total Requ	SDCCH CO	Start Time	Period (mi	NE Name	GCELL	CM33:Call	RM3175:Call Drops on Traffic Channel (TCHF) (None)		TTRAF (Erl)	TCH CONGES
2	978	2.249	2014/02/12	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	6	6	**12**	2.016	**5.95**
3	656	2.1	2014/02/15	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	5	5	**10**	1.344	**7.44**
4	464	2.37	2014/02/18	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	9	9	**18**	1.44	**12.8**
5	371	2.4	2014/02/25	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	6	6	**12**	1.56	**7.69**
6	506	3.35	2014/02/26	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	3	3	**6**	1.584	**3.78**
7	386	3.36	2014/02/27	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	1	1	**2**	1.056	**1.89**
8	469	1.49	2014/02/28	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	1	1	**2**	1.152	**1.73**
9	384	2.8	2014/03/01	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	2	2	**4**	1.08	**3.7**
10	209	1.9	2014/03/02	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	0	0	**0**	0.384	**0**
11	109	0	2014/03/07	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	5	5	**10**	0.936	**10.6**
12	162	4.3	2014/03/10	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119	9	9	**18**	1.368	**13.1**
13											
14	13	0	2014/02/12	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
15	22	0	2014/02/15	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
16	15	0	2014/02/23	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
17	28	0	2014/02/24	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
18	18	0	2014/02/25	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
19	12	0	2014/02/27	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
20	8	0	2014/02/28	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
21	18	0	2014/03/01	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
22	20	0	2014/03/03	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
23	29	0	2014/03/06	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**

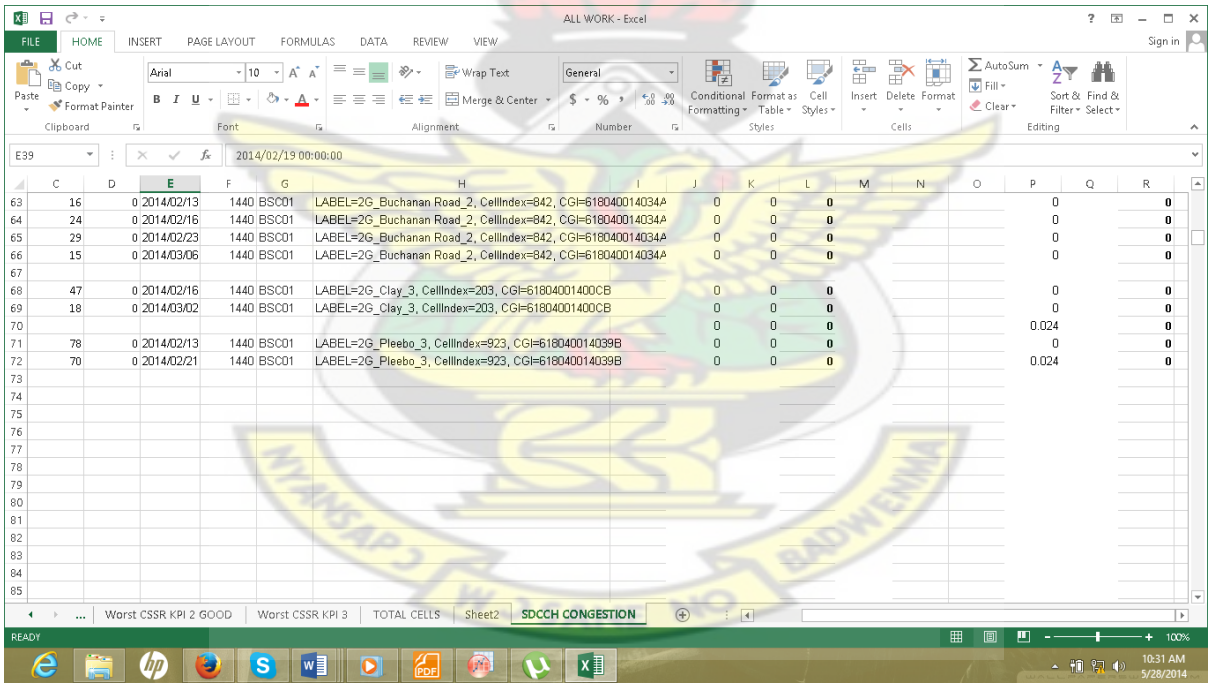


23	29	0	2014/03/06	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
24	15	0	2014/03/07	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295	0	0	**0**	0	**0**
25											
26	0	0	2014/02/12	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0	**0**
27	0	0	2014/02/13	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0	**0**
28	0	0	2014/02/14	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0	**0**
29	0	0	2014/02/15	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0	**0**
30	0	0	2014/02/16	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0	**0**
31	0	0	2014/02/17	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	1.536	**0**
32	0	0	2014/02/18	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	1.368	**0**
33	3861	0	2014/02/26	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	1.104	**0**
34	2255	0	2014/02/28	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	4	4	**8**	1.872	**4.27**
35	2209	0.1	2014/03/01	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0.768	**0**
36	3172	0.18	2014/03/02	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0.024	**0**
37	2689	0.11	2014/03/03	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231	0	0	**0**	0.072	**0**
38											
39	4	0	2014/02/19	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0.024	**0**
40	2	0	2014/02/20	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0.024	**0**
41	1	0	2014/02/21	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0	**0**
42	0	0	2014/02/22	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0.024	**0**
43	0	0	2014/02/23	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0	**0**
44	0	0	2014/02/24	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0.216	**0**
45	1	0	2014/02/25	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232	0	0	**0**	0.144	**0**



ALL WORK - Excel

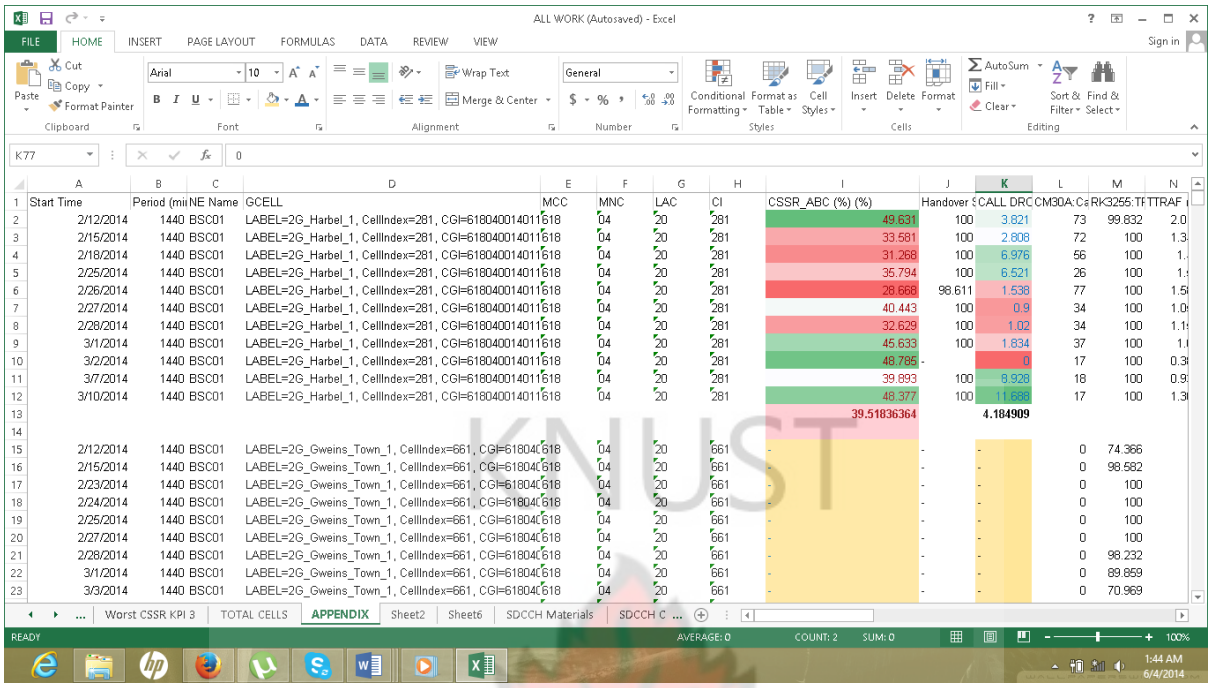
	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
41	1	0	2014/02/21	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
42	0	0	2014/02/22	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.024		0
43	0	0	2014/02/23	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
44	0	0	2014/02/24	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.216		0
45	1	0	2014/02/25	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.144		0
46	0	0	2014/02/26	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
47	1	0	2014/02/27	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
48	0	0	2014/02/28	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
49	0	0	2014/03/01	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
50	8	0	2014/03/02	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
51	2	0	2014/03/03	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
52	4	0	2014/03/04	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
53	0	0	2014/03/05	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
54	4	0	2014/03/06	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
55	0	0	2014/03/07	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
56	1	0	2014/03/08	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
57	1	0	2014/03/09	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
58	2	0	2014/03/10	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
59	0	0	2014/03/11	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
60	2	0	2014/03/12	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
61																
62	37	0	2014/02/12	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
63	16	0	2014/02/13	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0



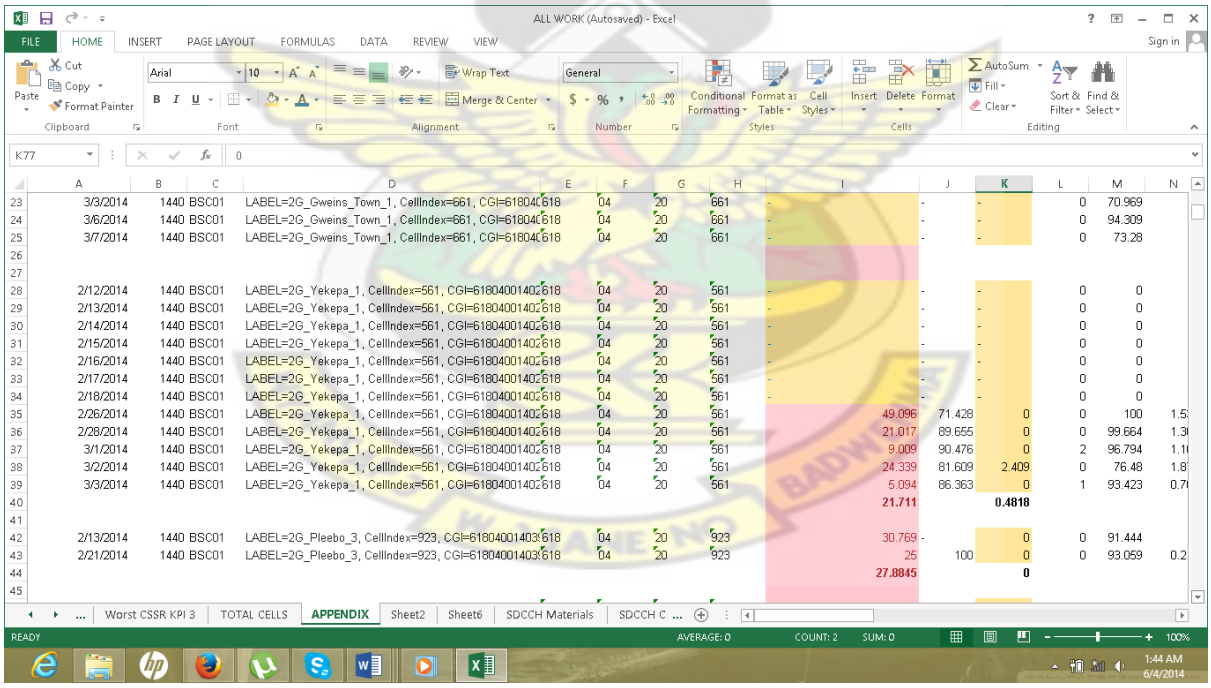
ALL WORK - Excel

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
63	16	0	2014/02/13	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
64	24	0	2014/02/16	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
65	29	0	2014/02/23	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
66	15	0	2014/03/06	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
67																
68	47	0	2014/02/16	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CB		0	0	0				0		0
69	18	0	2014/03/02	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CB		0	0	0				0		0
70								0	0	0				0.024		0
71	78	0	2014/02/13	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=6180400140398		0	0	0				0		0
72	70	0	2014/02/21	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=6180400140398		0	0	0				0.024		0
73																
74																
75																
76																
77																
78																
79																
80																
81																
82																
83																
84																
85																

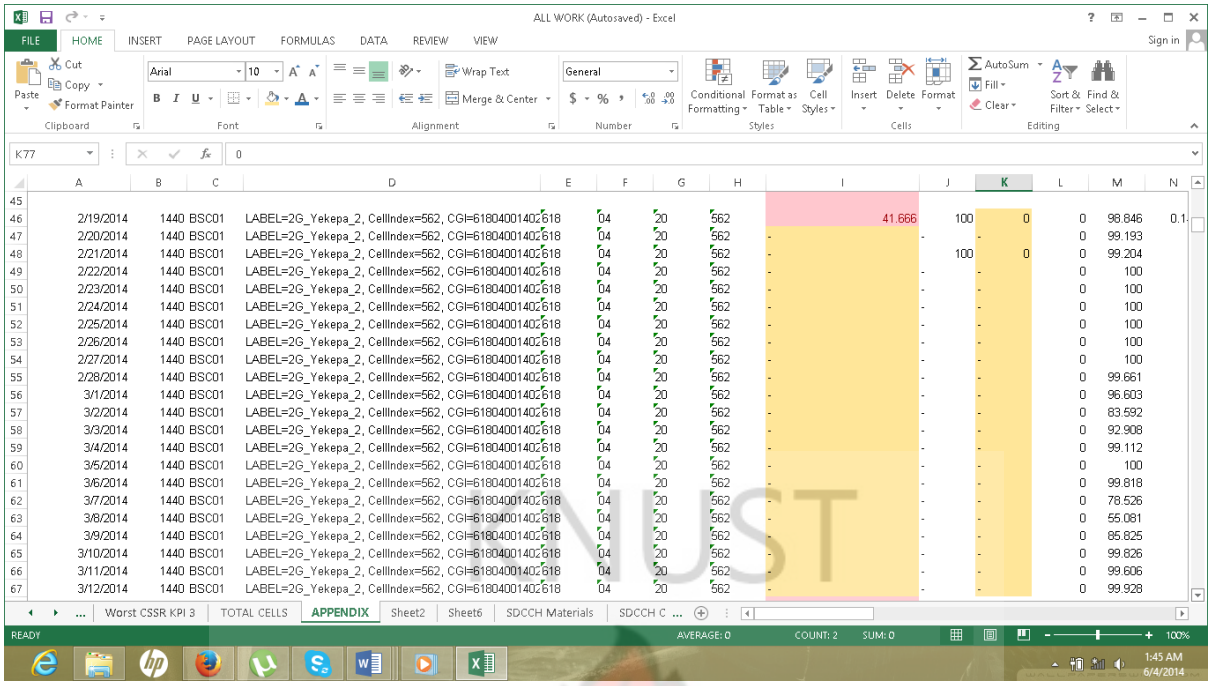
APPENDIX D: SAMPLE OF THE CALCULATED AVERAGES

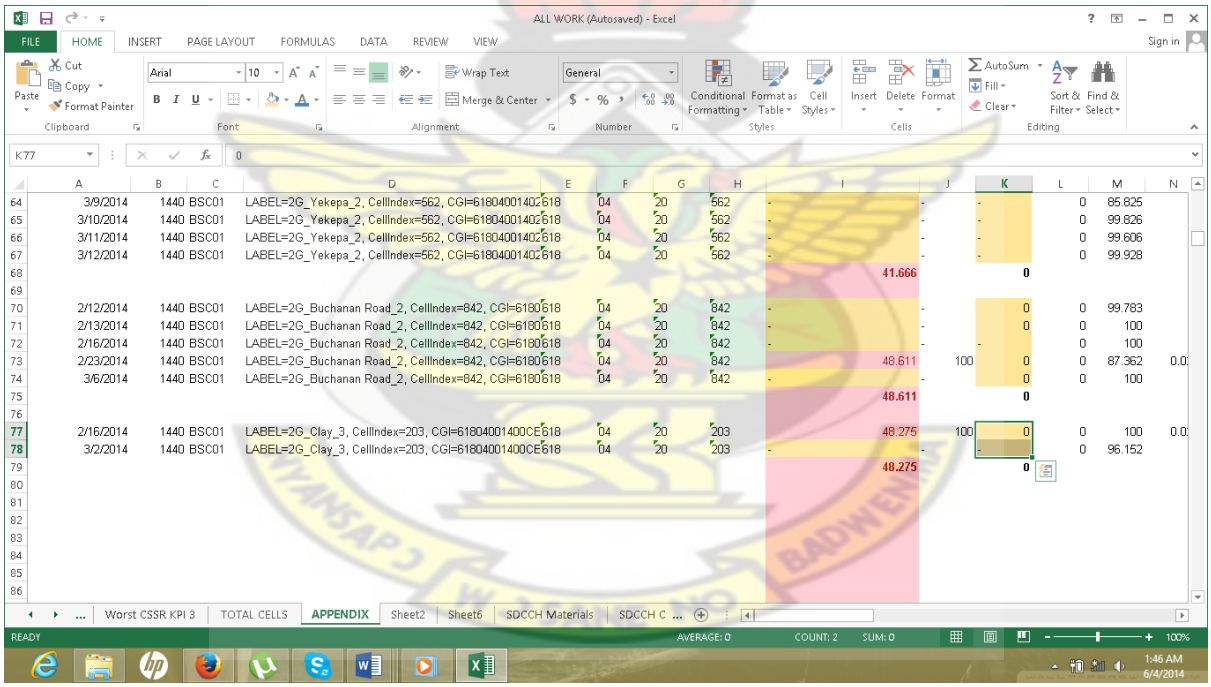


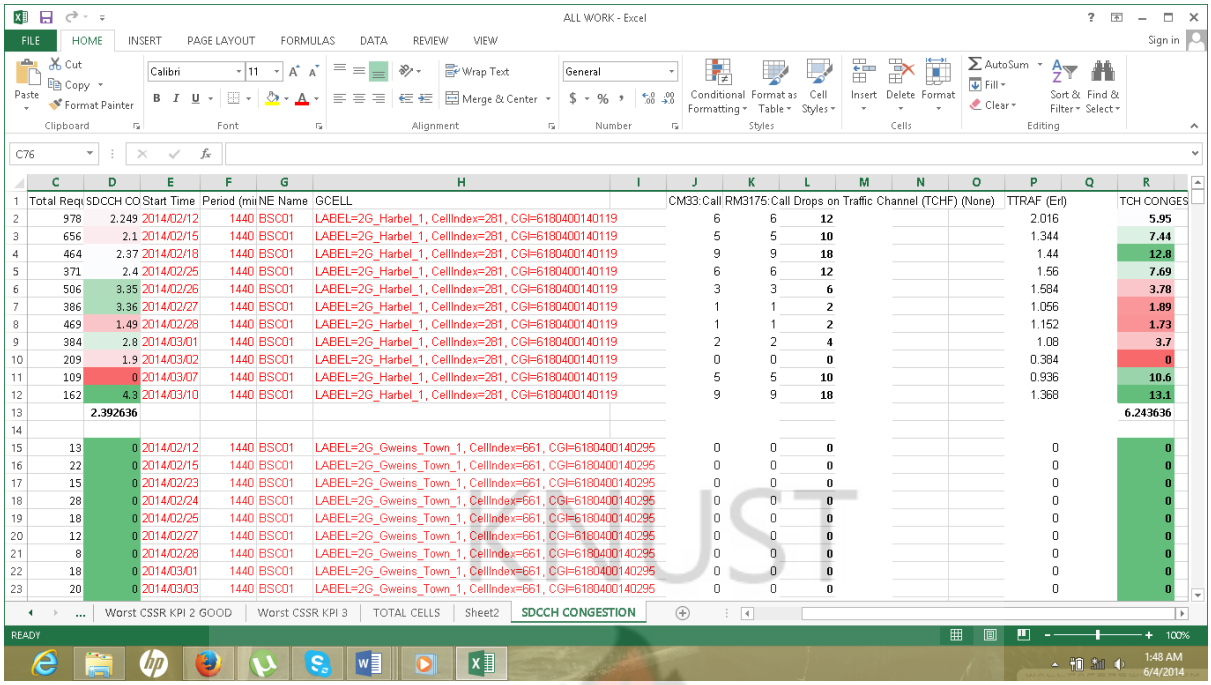
Start Time	Period (mi	NE Name	GCELL	MCC	MNC	LAC	CI	CSSR_ABC (%) (%)	Handover S	CALL DRC	M30A:Ca	RK3255:TF	TTRAF
2/12/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		49.631	100	3.821	73	99.832	2.0
2/15/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		33.581	100	2.808	72	100	1.3
2/18/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		31.268	100	6.976	56	100	1.
2/25/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		35.794	100	6.521	26	100	1.
2/26/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		28.668	98.611	1.538	77	100	1.5
2/27/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		40.443	100	0.9	34	100	1.0
2/28/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		32.629	100	1.02	34	100	1.1
3/1/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		45.633	100	1.834	37	100	1.
3/2/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		48.785	-	0	17	100	0.3
3/7/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		39.893	100	8.928	18	100	0.9
3/10/2014	1440	BSC01	LABEL=2G_Harbel_1, CellIndex=281, CGI=618040014011618	04	20	281		48.377	100	11.688	17	100	1.3
								39.51836364		4.184909			
2/12/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	74.366	
2/15/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	98.582	
2/23/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	100	
2/24/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	100	
2/25/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	100	
2/27/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	100	
2/28/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	98.232	
3/1/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	89.859	
3/3/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	70.969	

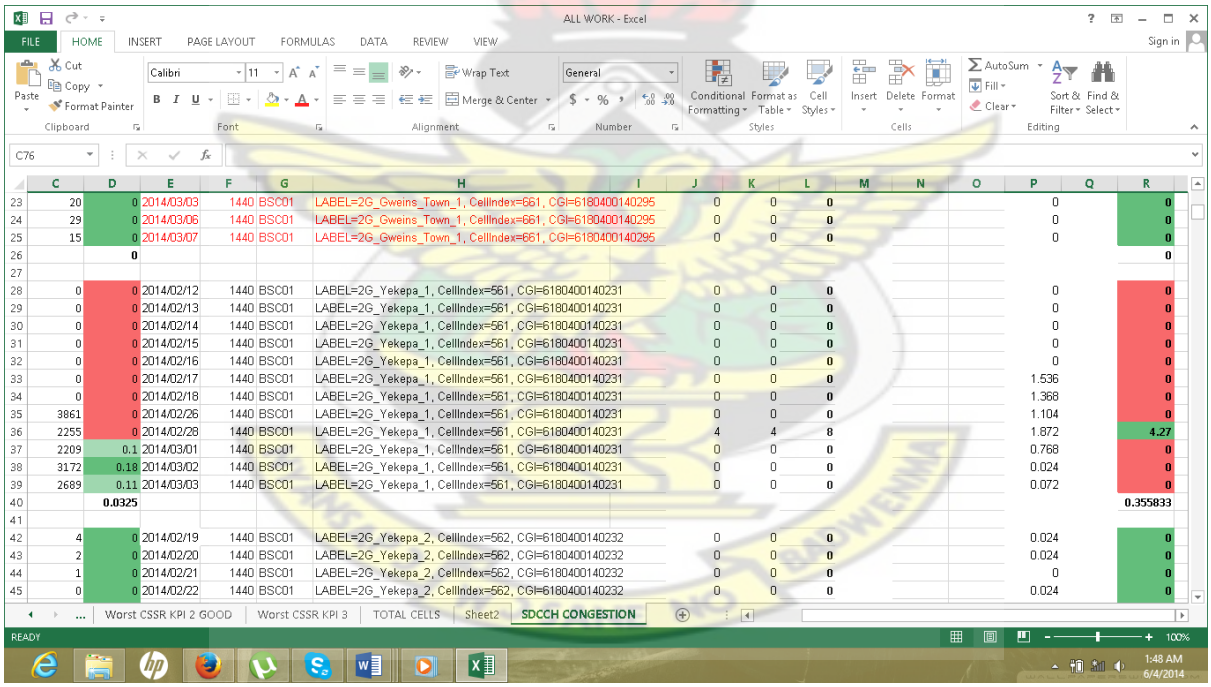


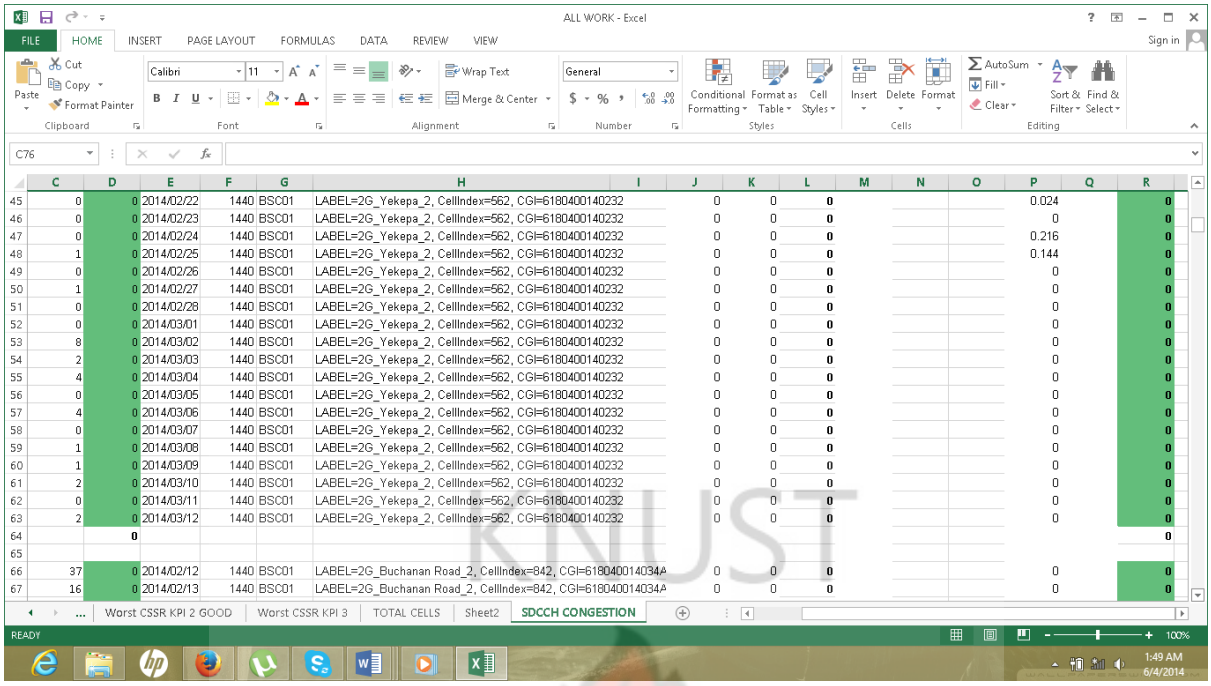
Start Time	Period (mi	NE Name	GCELL	MCC	MNC	LAC	CI	CSSR_ABC (%) (%)	Handover S	CALL DRC	M30A:Ca	RK3255:TF	TTRAF
3/3/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	70.969	
3/6/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	94.309	
3/7/2014	1440	BSC01	LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=61804(	618	04	20	661	-	-	-	0	73.28	
2/12/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/13/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/14/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/15/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/16/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/17/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/18/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	-	-	-	0	0	
2/26/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	49.096	71.428	0	0	100	1.5
2/28/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	21.017	89.655	0	0	99.664	1.3
3/1/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	9.009	90.476	0	2	96.794	1.1
3/2/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	24.339	81.609	2.409	0	76.48	1.8
3/3/2014	1440	BSC01	LABEL=2G_Yekepa_1, CellIndex=561, CGI=618040014026	618	04	20	561	5.094	86.363	0	1	93.423	0.7
								21.711		0.4818			
2/13/2014	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=618040014039	618	04	20	923	30.769	-	0	0	91.444	
2/21/2014	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=618040014039	618	04	20	923	25	100	0	0	93.059	0.2
								27.8845		0			


ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Arial 10
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
K77
0
2/19/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 41.666 100 0 0 98.846 0.1
2/20/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.193
2/21/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 100 0 0 99.204
2/22/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/23/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/24/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/25/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/26/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/27/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
2/28/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.661
3/1/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 96.603
3/2/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 83.592
3/3/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 92.908
3/4/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.112
3/5/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 100
3/6/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.818
3/7/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 78.526
3/8/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 55.081
3/9/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 85.825
3/10/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.826
3/11/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.606
3/12/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.928
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCH Materials SDCCH C ...
READY AVERAGE: 0 COUNT: 2 SUM: 0 100%
1:45 AM 6/4/2014


ALL WORK (Autosaved) - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Arial 10
Wrap Text Merge & Center
General
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
K77
0
3/9/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 85.825
3/10/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.826
3/11/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.606
3/12/2014 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=61804001402618 04 20 562 0 99.928
41.666 0
2/12/2014 1440 BSC01 LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618 04 20 842 0 0 99.783
2/13/2014 1440 BSC01 LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618 04 20 842 0 0 100
2/16/2014 1440 BSC01 LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618 04 20 842 0 100
2/23/2014 1440 BSC01 LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618 04 20 842 48.611 100 0 0 87.362 0.0
3/6/2014 1440 BSC01 LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=6180618 04 20 842 0 0 100
48.611 0
2/16/2014 1440 BSC01 LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CE618 04 20 203 48.275 100 0 0 100 0.0
3/2/2014 1440 BSC01 LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CE618 04 20 203 0 96.152
48.275 0
Worst CSSR KPI 3 TOTAL CELLS APPENDIX Sheet2 Sheet6 SDCCH Materials SDCCH C ...
READY AVERAGE: 0 COUNT: 2 SUM: 0 100%
1:46 AM 6/4/2014


ALL WORK - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11 Wrap Text General
Merge & Center
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
C76
C D E F G H I J K L M N O P Q R
1 Total Req SDCCH CO Start Time Period (mi NE Name GCELL CM33:Call RM3175:Call Drops on Traffic Channel (TCHF) (None) TTRAF (Erl) TCH CONGES
2 978 2.249 2014/02/12 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 6 6 12 2.016 5.95
3 656 2.1 2014/02/15 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 5 5 10 1.344 7.44
4 464 2.37 2014/02/18 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 9 9 18 1.44 12.8
5 371 2.4 2014/02/25 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 6 6 12 1.56 7.69
6 506 3.35 2014/02/26 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 3 3 6 1.584 3.78
7 386 3.36 2014/02/27 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 1 1 2 1.056 1.89
8 469 1.49 2014/02/28 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 1 1 2 1.152 1.73
9 384 2.8 2014/03/01 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 2 2 4 1.08 3.7
10 209 1.9 2014/03/02 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 0 0 0 0.384 0
11 109 0 2014/03/07 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 5 5 10 0.936 10.6
12 162 4.3 2014/03/10 1440 BSC01 LABEL=2G_Harbel_1, CellIndex=281, CGI=6180400140119 9 9 18 1.368 13.1
13 2.392636 6.243636
14
15 13 0 2014/02/12 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
16 22 0 2014/02/15 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
17 15 0 2014/02/23 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
18 28 0 2014/02/24 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
19 18 0 2014/02/25 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
20 12 0 2014/02/27 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
21 8 0 2014/02/28 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
22 18 0 2014/03/01 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
23 20 0 2014/03/03 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
... Worst CSSR KPI 2 GOOD Worst CSSR KPI 3 TOTAL CELLS Sheet2 SDCCH CONGESTION
READY
100%
1:48 AM
6/4/2014


ALL WORK - Excel
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW
Sign in
Cut Copy Format Painter Paste
Calibri 11 Wrap Text General
Merge & Center
Conditional Formatting Format as Table Cell Styles
Insert Delete Format
AutoSum Fill Clear Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
C76
C D E F G H I J K L M N O P Q R
23 20 0 2014/03/03 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
24 29 0 2014/03/06 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
25 15 0 2014/03/07 1440 BSC01 LABEL=2G_Gweins_Town_1, CellIndex=661, CGI=6180400140295 0 0 0 0 0
26 0 0
27
28 0 0 2014/02/12 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0 0
29 0 0 2014/02/13 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0 0
30 0 0 2014/02/14 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0 0
31 0 0 2014/02/15 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0 0
32 0 0 2014/02/16 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0 0
33 0 0 2014/02/17 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 1.536 0
34 0 0 2014/02/18 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 1.368 0
35 3861 0 2014/02/26 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 1.104 0
36 2255 0 2014/02/28 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 4 4 8 1.872 4.27
37 2209 0.1 2014/03/01 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0.768 0
38 3172 0.18 2014/03/02 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0.024 0
39 2689 0.11 2014/03/03 1440 BSC01 LABEL=2G_Yekepa_1, CellIndex=561, CGI=6180400140231 0 0 0 0.072 0
40 0.0325 0.355833
41
42 4 0 2014/02/19 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232 0 0 0 0.024 0
43 2 0 2014/02/20 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232 0 0 0 0.024 0
44 1 0 2014/02/21 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232 0 0 0 0 0
45 0 0 2014/02/22 1440 BSC01 LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232 0 0 0 0.024 0
... Worst CSSR KPI 2 GOOD Worst CSSR KPI 3 TOTAL CELLS Sheet2 SDCCH CONGESTION
READY
100%
1:48 AM
6/4/2014

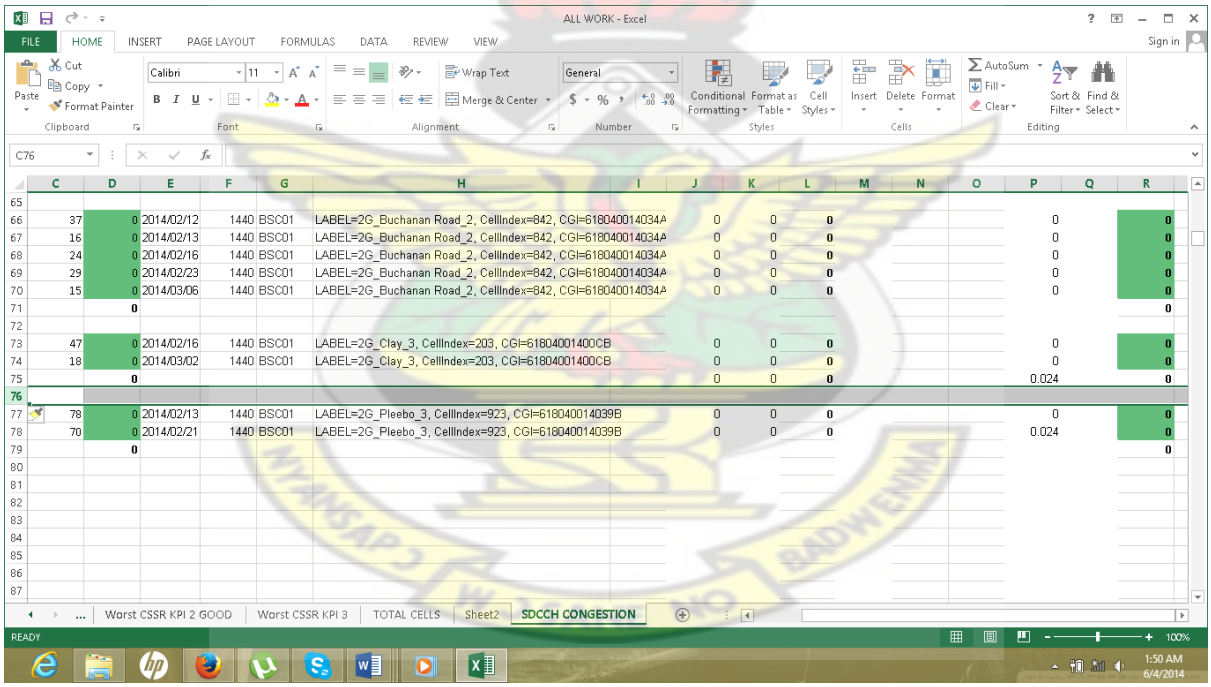


ALL WORK - Excel

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
45	0	0	2014/02/22	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.024		0
46	0	0	2014/02/23	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
47	0	0	2014/02/24	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.216		0
48	1	0	2014/02/25	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0.144		0
49	0	0	2014/02/26	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
50	1	0	2014/02/27	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
51	0	0	2014/02/28	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
52	0	0	2014/03/01	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
53	8	0	2014/03/02	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
54	2	0	2014/03/03	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
55	4	0	2014/03/04	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
56	0	0	2014/03/05	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
57	4	0	2014/03/06	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
58	0	0	2014/03/07	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
59	1	0	2014/03/08	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
60	1	0	2014/03/09	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
61	2	0	2014/03/10	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
62	0	0	2014/03/11	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
63	2	0	2014/03/12	1440	BSC01	LABEL=2G_Yekepa_2, CellIndex=562, CGI=6180400140232		0	0	0				0		0
64		0														0
65																
66	37	0	2014/02/12	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
67	16	0	2014/02/13	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0

Worst CSSR KPI 2 GOOD | Worst CSSR KPI 3 | TOTAL CELLS | Sheet2 | SDCCH CONGESTION

READY



ALL WORK - Excel

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
65																
66	37	0	2014/02/12	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
67	16	0	2014/02/13	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
68	24	0	2014/02/16	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
69	29	0	2014/02/23	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
70	15	0	2014/03/06	1440	BSC01	LABEL=2G_Buchanan Road_2, CellIndex=842, CGI=618040014034A		0	0	0				0		0
71		0														0
72																
73	47	0	2014/02/16	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CB		0	0	0				0		0
74	18	0	2014/03/02	1440	BSC01	LABEL=2G_Clay_3, CellIndex=203, CGI=61804001400CB		0	0	0				0		0
75		0						0	0	0				0.024		0
76																
77	78	0	2014/02/13	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=6180400140398		0	0	0				0		0
78	70	0	2014/02/21	1440	BSC01	LABEL=2G_Pleebo_3, CellIndex=923, CGI=6180400140398		0	0	0				0.024		0
79		0														0
80																
81																
82																
83																
84																
85																
86																
87																

Worst CSSR KPI 2 GOOD | Worst CSSR KPI 3 | TOTAL CELLS | Sheet2 | SDCCH CONGESTION

READY