EVALUATION OF QUALITY OF SERVICE KEY PERFORMANCE INDICATORS

FOR

M-TEL NETWORK OF AREA VI KADUNA

BY

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF A MASTER OF SCIENCE (M.Sc) DEGREE IN ELECTRICAL ENGINEERING

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CERTIFICATION

This thesis entitled “Evaluation of quality of service key performance indicators for M-tel network of area VI Kaduna” by Abdullahi Salisu Umar, meets the regulations governing the award of the degree of Master of Science (Electronics and Telecommunications Engineering) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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This is to certify that I carried out the work reported in this thesis under the supervision of Professor B. G. Bajoga and Dr. D. D. Dajab. All sources of information as seen in this thesis are specifically acknowledged by means of references. I declare that no part of this thesis has been submitted elsewhere by me for the award of a degree.

…… ……

Abdullahi Salisu Umar Date

DEDICATION

This work is dedicated to my parents and all those that contributed to my success in life.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Almighty Allah, Lord and Owner of the universe for giving me the opportunities while denying others in his ultimate justice. I would like to acknowledge the invaluable guidance, concern and support of my supervisors, Prof. B. G. Bajoga and Dr. D. D. Dajab during this research. Many thanks also to my head of Department, Dr. M. B. Mu'azu who helped to review this thesis. It is an obligation to recognize the unquantifiable sacrifice of my parent's time, energy and resources in caring and nurturing me from the time I put my first step on earth onwards, I pray to almighty Allah to give them the best of every good things. Also thanks to my lecturers, Dr. B. A. Adegboye, Mallam Yusuf Jibril, Dr. K. Farayola, Dr. Boyi Jimoh, Mr O. Akinsanmi and Dr. J. Y. Oricha. I thank my brothers, sisters, my friends, Umar Salisu Umar, Nura Salisu, Sadiq Salisu, Musbahu Salisu, Naja Salisu, Abdullahi Mas'ud, Ahmed Badawi, Ali Said, Aminu Yusuf, Aliyu Burga, Ahmed Mohammed, Jamal Aminu, Mohammed Ilu, Sulaiman Garba, Abdullahi Sulaiman, Sulaiman ilu, Aliyu Aboki, Farouk Yabo, Ibrahim Yusuf, kamil Abubakar, Habib Amin, Idris Abdullahi, Adamu Magaji, Imran Ahmed, Sani Ibrahim Kontagora, and Tijjani Elyakub I will not forget to also mention my colleagues at M-Tel for their support and assistance, Tony Nwavulu, Rabiu Ibrahim, Sani Rabe, Engr. Mohammad Usman Siraj, Engr. Bello Salisu, Zaid Shittu, Nasidi Yusuf, Bello Mohammed, Abdulsalam Jibril, Joshua Audu, Engr. M. B. A. Yabagi, Ahmed Rafsanjani, Silas Daji, and Mike Fatoba.

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ABSTRACT

The thesis involves the evaluation and selection of appropriate Key Performance Indicators (KPIs) to improve network performance. This thesis studies the key performance indicators of M-tel Network, (Area VI Kaduna), the Base Station Controller (BSC) is considered with particular emphasis on peak period by processing and analyzing the Network KPIs recorded. In network improvement it is exceptionally important to determine what the critical system metrics are or key factors that need to be monitored to determine what is simply the quality to meet or if possible exceed the expectations of the subscribers. The data on the network has been analyzed which revealed that, the network was found to be prone to down time as a result of over reliance on Nigerian Telecommunications (NITEL) transmission. The implication of the results show gradual decline in subscriber base, frequent call drops and handover failure as a result of frequent power outage. Appropriate suggestions necessary to improve the Network for optimal performance were discussed and recommendation made.

TABLE OF CONTENTS

TITLE PAGE…….…….

CERTIFICATION …… i

DECLARATION…… ii

DEDICATION…… iii

ACKNOWLEDGEMENT…… iv

ABSTRACT…… v

TABLE OF CONTENT…… vi

LIST OF FIGURE…….. x

LIST OF TABLE……. xi

LIST OF ABBREVATION……. xii

LIST OF APPENDICES …….. xiii

CHAPTER ONE

INTRODUCTION

1.1 Introduction…… 1

1.2 Thesis Motivation…… 2

1.3 Literature Review……...… 2

1.4 Problem definition and Methodology……..……. 5

1.5 Thesis Outline……. 5

CHAPTER TWO

M-TEL NETWORK STRUCTURE

2.1 Introduction…… 6

2.2 Transit Mobile Switch Centre (TMC/STP connection……... 7

2.3 Home Location Register (HLR)……...…… 8

2.4 Short Message Centre (SMS)……..… 8

2.5 Voice Mail Service (VMS)…… 9

2.6 Transmission Link…….. ……. 10

2.7 GSM Network Components and Functions……..… 11

2.7.1 The Network and Switching Sub system (NSS)…… 11

2.7.2 The Mobile Switching Centre (MSC)…… 11

2.7.3 The Gateway Mobile Service Centre (GMSC) …… 12

2.7.4 The Visitor Location Register (VLR)…..…… 12

2.7.5 The Authentication Centre (AuC) …… 12

2.7.6 The Equipment Identity register (EiR) …… 12

2.7.7 The GSM Interworking Unit (GIWU) …… 13

2.7.8 The Operation and Support Subsystem (OSS) …… 13

2.7.9 The Base Station Subsystem (BSS) ……. 13

2.7.10 The Base Transceiver station (BTS) ……. 13

2.7.11 The Base Station Controller (BSC) …… 14

2.7.12 The Mobile Station (MS) …… 14

2.7.13 The Terminal…… 14

2.7.14 The Sim …… 15

CHAPTER THREE

QUALITY OF SERVICE IMPROVEMENT

3.1 Introduction……. 16

3.2 Process of Network improvement ...……... 16

3.3 Tools Used in Network improvement ……. 18

3.3.1 Advance network tester……. 18

3.3.2 Geological Positioning System (GPS)…… 18

3.3.3 Signaling Analyzer …… 18

3.3.4 Traffic Statistical data…… 19

3.4 Coverage…… 19

3.4.1 Blind zone for signal …… 19

3.4.2 Traffic Congestion ……. 20

3.4.3 Traffic Balance …… 20

3.5 Interference …… 21

3.6 Operation and Maintenance Centre and Radio (OMCR) …….. 21

3.6.1 Configuration management …… 21

3.6.2 Performance management ……. 21

3.6.3 Performance management objective …….. 22

3.6.4 Fault Management …….. 23

3.6.5 Main Features of fault management …… 24

3.6.6 Security management …… 24

3.6.7 System Features ……..…… 25

CHAPTER FOUR

KEY PERFORMANCE INDICATORS (KPI)

4.1 Introduction …….. 26

4.2 Call Statistical Index …….…… 26

4.3 Call Drop …… 27

4.3.1 Factors leading to call drop …… 28

4.3.2 Call drop due to handover …… 29

4.3.3 Call drop due to Transmission Fault …….. 29

4.4 TCH Congestion rate ……. 29

4.5 SDCCH in service rate ……. 30

4.6 Handover Success rate ……. 30

4.7 Busy hour traffic …… 30

4.8 Grade of service …….. 30

4.9 Traffic …… 31

CHAPTER FIVE

DATA ANALYSIS

5.0 Introduction ……. 32

5.1 M-tel Area VI Kaduna …… 32

5.2 Frequency used …… 32

5.3.1 Traffic channel ……..….. 33

5.3.2 Control channel ……. 33

5.3.3 Common Control channel …….. 34

5.3.4 Dedicated Control channel …… 34

5.4 Channel combination …….. 34

5.4.1 Arrangement of channel in the cell …… 35

5.4.2 Data processing and reliability …… 36

5.4.3 Presentation of results …… 37

5.5.1 SDCCH in service rate (March- August 2006) ……..…… 37

5.5.2 SDCCH in congestion rate (March – August 2006) ……. 38

5.5.3 Handover Success rate (March- August 2006) …… 39

5.5.4 Call Success rate (March- August 2006) …… 40

5.5.5 Call drop rate (March – August 2006 …… 40

5.5.6 Traffic in Erlang (March – August 2006) ……. 40

5.6 Comment on the Data obtained ……..…….. 50

CHAPTER SIX

CONCLUTION

6.1 Introduction …… 52

6.2 Summary of result… ……. 52

6.3 Significance of Work……..…….. 53

6.4 Limitations...…… 53

6.5 Conclusion…… …… 54

6.6 Recommendations …… 55

REFERENCES …… 56

APPENDIX A KPIs FOR MARCH…… 59

APPENDIX B KPIS FOR APRIL …….. 60

APPENDIX C KPIs FOR MAY …… 61

APPENDIX D KPIs FOR JUNE …… 62

APPENDIX E KPIS FOR JULY ……. 63

APPENDIX F KPIS FOR AUGUST …….. 64

APPENDIX G SDCCH INSERVICE RATE DATA…… 65

APPENDIX H SDCCH CONGESTION DATA …… 66

APPENDIX I HANDOVER SUCCESS RATE DATA…….. 67

APPENDIX J DUAL BAND HANDOVER DATA ……. 68

APPENDIX K CALL SUCCESS RATE DATA …… 69

APPENDIX L RADIO SWITCH RATE DATA …… 70

APPENDIX M CALL DROP RATE DATA …….. 71

APPENDIX N TCH IN SERVICE RATE DATA …….. 72

APPENDIX O TRAFFIC IN ERLANG DATA …… 73

APPENDIX P KPIs BENCH MARKS…… 74

LIST OF FIGURES

Figure 2.1 TMSC/SCP connection 7

Figure: 2.2 HLR Connection 8

Figure 2.3 SMS connection 9

Figure 2.4 VMS connection 9

Figure 2.5 M-TEL BTS locations and Transmission link 10

Figure 2.6 Architecture of the GSM network 11

Figure 3.2 Flow chart of quality of service improvement 17

Figure 5.1 SDCCH in service rate (March- August 2006) 41

Figure 5.2 SDCCH congestion rate (March- August 2006) 42

Figure 5.3 Handover success rate (March- August 2006) 43

Figure 5.4 Dual band Handover success rate (March – August 2006) 44

Figure 5.5 Call success rate (March- August 2006) 45

Figure 5.6 TCH in service rate (March- August 2006) 46

Figure 5.7 Radio switch rate (March – August 2006) 47

Figure 5.8 Call drop rate (March- August 2006) 48

Figure 5.9 Traffic in Erlang (March – August 2006) 49

LIST TABLES AND CHARTS

4.1 LINE Chart 4.1 SDCCH in service rate…….. 41

4.2 LINE Chart 4.2 SDCCH in congestion rate……. 42

4.3 LINE Chart 4.3 Handover Success rate…….. 43

4.4 LINE Chart 4.4 Dual Handover success rate…… 44

4.5 LINE Chart 4.5 Call Success rate…….. 45

4.6 LINE Chart 4.6 TCH in service rate…… 46

4.7 LINE Chart 4.7 Radio Switch rate……. 47

4.8 LINE Chart 4.8 Call Drop rate…… 48

4.9 LINE Chart 4.9 Traffic in Erlang…… 49

LIST OF ABBREVIATION

A-GPS	Assisted GPS positioning system
AGCH	Access Grant Channel
AMPS	American Mobile Phone System
AP	Access Poi
ATM	Asynchronous Transfer Mode
AuC	Authentication Center
BA	BCCH Allocation
BGW	Billing Gateway
BEP	Bit Error Probability
BER	Bit Error Rate
BCCH	Broadcast Control Channel
BS	Base station
BSIC	Base Station Identification Code
BSS	Base Station Subsystem
BSSGP	Base Station Subsystem GPRS protocol
BSC	Base Station Controller
BTS	Base Transceiver Station
CAMEL	Customised Application for Mobile Network Enhanced Logic
CC	Call Control
CCCH	Common Control Channel
CDMA	Code Division Multiple Access
CEPT	Conference Europeenne des Postes et Telecommunications

CGW	Cell Gateway
CI	Cell Identity
CIR	Carrier/Interference
CM	Communication Management
CN	Core Network
CRS	Cell Resource Server
CS	Circuit Switched
CS	Coding Scheme
DCR	Dropped Call Rate
DCCH	Dedicated Control Channel
DL	Down Link
DPCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
DRX	Discontinuous Reception
DS-CDMA	Direct Sequence-Code Division Multiple Access
DTAP	Direct Transfer Application Process
DTM	Dual Transfer Mode
DTX	Discontinuous Transmission
ECSD	Enhanced Circuit Switched Data
EDGE	Enhanced Data Rates for Global Evolution
EFL	Effective Frequency Load
EFR	Enhanced Full Rate (speech coded)
EGPRS	Enhanced General Packet Radio System

EIR	Equipment Identity Register
Ei	Electrical Interface
ETSI	European Telecommunications Standards Institute
FACCH	Fast Associated Control Channel
FCCH	Frequency Correction Channel
FDD	Frequency Division Duplex
FDMA	Frequency division Multiple Access
FER	Frame Error Rate
FH	Frequency Hopping
FR	Full Rate
FTP	File Transfer Protocol
GERAN	GSM EDGE Radio Access Network
GGSN	Gateway GPRS Support Node
GMLC	Gateway Mobile Location Center
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HC	Handover Control
HLR	Home Location Register
HO	Handover
HPLMN	Home Public Land Mobile Network
HR	Half Rate

HSCSD	High Speed Circuit Switched Data
HSDPA	High Speed Downlink Packet Access
IMEI	International Mobile Equipment Identity
IMGI	International Mobile Group Identity
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ITU	International Telecommunication Union
ITU-T	Telecommunication standardization sector of ITU
IWMSC	Inter Working MSC
KPIs	Key Performance Indicators
LA	Link Adaptation
LAPD	Link Access Protocol for the D channel
LAPDm	Link Access Protocol for the Dm channel
MA	Mobile Allocation
MS	Mobile Station
MSC	Mobile Services Switching Centre
MTEL	Mobile Telecommunication
MP	Memory Processor
NC	Network Control
NCC	Network (PLMN) Colour Code
NCC	Nigerian Communication Commission

NITEL	Nigerian Telecommunication Limited
NCCR	Network Controlled Cell Re-selection
NMS	Network Management Subsystem
NSAPI	Network layer Service Access Point Identifier
NSS	Network and Switching Subsystem
OMC	Operations and Maintenance Center
OSI	Open System Interconnection
OSS	Operation Sub-System
PACCH	Packet Associated Control Channel
PAGCH	Packet Access Grant Channel
PBCCH	Packet Broadcast Control Channel
PC	Power Control
PCCCH	Packet Common Control Channel
PCHM	Packet Channel Manager
PCM	Pulse Code Modulation
PCU	Packet Control Unit
PCH	Paging Channel
PDCP	Packet Data Convergence Protocol
PDTCH	Packet Data Traffic Channel
PLMN	Public Land Mobile Network
PSDN	Public Switch Digital Network
PSTN	Public Switch Telephone Network
PPAS	Prepaid Administrative System

PSPDN	Packet-Switched Public Data Network
PSTN	Public-Switched Telephone Network
PTM	Point-To-Multipoint
QoS	Quality of Service
RAT	Radio Access Technology
RLC	Radio Link Control
RM	Resource Manager
RNAS	Radio Access Network Access Server
RNC	Radio Network Controller
RR	Radio Resource
RRM	Radio Resource Management
RT	Real Time
RXLEV	Received Signal Level
RXQUAL	Received Signal Quality
SACCH	Slow Associated Control Channel
SCH	Synchronization Channel
SCP	Signal Control Point
SDCCH	Stand alone Dedicated Control Channel
SDH	Synchronous Digital Hierarchy
SDP	Service Data Point
SI	System Information
SIM	GSM Subscriber Identity Module
SM-SC	Short Message Service Center

SMSCB	Short Message Service Cell Broadcast
SMS-GMSC	Short Message Service Gateway MSC
SMS-IWMSC	Short Message Service Inter Working MSC
SMS-MO/PP	Mobile Originated Short Messages
SMS-MT/PP	Mobile Terminated Short Messages
SMS-PP	Point-to-Point Short Message Service
SMG	Special Mobile Group
SMLC	Serving Mobile Location Center
SMS	Short Message Service
SMSS	Switching and Management Sub-System
SMTP	Simple Mail Transfer Protocol
STP	Signal Transfer Point
SS7	Signaling System number 7
TA	Timing Advance
TCH	Traffic Channel
TCP	Transport Control Protocol
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TMSI	Temporary Mobile Subscriber Identity
TOA	Time of Arrival
TRAU	Transcoder/Rate Adapter Unit
TRX	Transceiver
TSL	Timeslot

UL	Uplink
UMTS	Universal Mobile Telecommunication services
URL	Uniform Resource Locator
USIM	Universal Subscriber Identity Module
VLR	Visiting Location Register
VMS	Voice Mail System
VPLMN	Visited Public Land Mobile Network
WAP	Wireless Application Protocol
WCDMA	Wideband CDMA
WTP	Wireless Transport Protocol
WWW	World Wide Web
ZTE	Zhongshing Telecom China

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

When Nigeria gained her independence in 1960, there were only 18,724 functional telephone lines for an estimated population of 45 million which was a teledensity ratio of 0.04 telephones per 100 people. According to the International Telecommunication Union (ITU), by 1966, Nigeria teledensity ratio was a mere 0.36 and 0.4 by (1999). According to the Nigerian Communication Commission (NCC), Nigeria's teledensity is a far cry from the African average of 1.67. However, with the liberalization of the telecommunication industry in Nigeria the story changed dramatically with the teledensity ratio tripling within just one year of Global System for Mobile Telecommunication (GSM) operation. By May 2005 Nigeria with an estimated population of over 120 million had more than 9 million Global System for Mobile Communication (GSM) subscribers, making the country one of the fastest growing GSM market, in the World. At the moment, there are about 40 million subscribers with just four fully functional GSM operators in Nigeria; Mobile Telecommunication Network (MTN), Celtel, Glo mobile telecommunication and Mobile Telecommunication (M-tel) while others like Mubaddalah and Alheri have recently been given licenses to start operations. Four years after the start of the GSM era in Nigeria, the focus is gradually shifting from providing coverage to providing quality service. The euphoria of owning a phone set is gradually giving way to complaints of dropped calls and congestion. The operators are fast realizing that they are in a highly competitive environment, where dissatisfaction by subscribers may give rise to high rate of subscriber reduction and low revenue for the operator. The performance of the network has a direct impact on the revenue. The Nigerian Communication Commission (NCC) is bringing pressure on the operators to step up the quality of service offered to

Nigerians and had even gone a step further to award contracts to a private company to conduct comparative analysis of the quality of service of each operator. To attract, maintain and move subscribers to high- value services, while providing quality service will require monitoring and quality assurance with a view to improving the Network. The network statistics captured in the Operation and Maintenance Centre (OMC) in the M-tel (Area VI Kaduna) are monitored and analyzed. This thesis is aimed at describing how M-tel network performs taking the key performance indicators of the Base Station Controller (BSC), by analyzing the network and finding where and why the network is having low quality service, and suggests ways to help overcome the problems.

1.2 THESIS MOTIVATION

The Mobile Telecommunication (M-tel) is considered the least among the mobile operators in terms of service quality and coverage. This fact has given the challenge as a subscriber and telecommunication industry practitioner to carry out this study, The project work is aimed at dealing with the M-tel network malfunction, network data analysis and suggest appropriate corrective measures to be taken in order to improve the performance of the network.

1.3 LITERATURE REVIEW

Data communication began with Samuel Morse, who in 1844 invented and pioneered the telegraph, which uses Morse code consisting of interweaving dots and dashes as its method for delivering communication over vast distances. A very condensed time line of major milestone for communication industry is provided below even though there are numerous other milestone of equal importance for communication but this list represent shifts in thinking,

1844 - Samuel Morse invents the Telegraph

1876 - Alexander Bell invents the Telephone

1901 - Guglielmo Marconi sends Morse code using a radio

1931 - First United State (U.S.) Television Transmission takes place

1946 - AT & T offers mobile phone services

1953 - First Microwave network installed

1977 - Bell Lab transmits TV signals on optical fibers

1983 - Cellular Communication fosters another communication revolution [1].

The first generation mobile communication: Analog cellular mobile communication which features:

1) Frequency Division Multiple Access (FDMA)
2) Analog Signal
3) Narrow band

The second generation mobile communication: Digital cellular mobile communication which features:

- Time Division Multiple Access (TDMA)
- Digital Signal
- Narrow band

The third generation mobile communication: IMT 2000 (3G)

1) Code Division Multiple Access (CDMA)
2) Digital Signal
3) Broad band where 2000 means frequency is 2000MHz

Mobile communication has been the foremost fast growing technology of 21st Century; it has been only 25 years that full duplex analog mobile service was introduced while commercial launch of digital mobile service is not more than 14 years. After the success of analog cellular system, many incompatible mobile systems were developed in Europe, Japan and North America. because in the beginning of cellular systems, each country developed its own system, which was an undesirable situation for the following reasons:

- The equipment was limited to operate only within the boundaries of each country.
- The market for each mobile equipment was limited.

In order to overcome these problems, the Conference of European Posts and Telecommunications (CEPT) formed, in 1982, the Groupe Spécial Mobile (GSM) in order to develop a pan-European mobile cellular radio system (the GSM acronym became later the acronym for Global System for Mobile communications). The standardized system had to meet certain criteria [1].

- Spectrum efficiency
- International roaming
- Low mobile and base stations costs
- Good subjective voice quality
- Compatibility with other systems such as (Integrated Services Digital Network) ISDN.
- Ability to support new services, unlike the existing cellular systems, which were developed using analog technology, the GSM system was developed using digital technology [2].

In 1989 the responsibility for the GSM specifications passed from the CEPT to the European Telecommunications Standards Institute (ETSI). The aim of the GSM specifications is to describe the functionality and the interface for each component of the system, and to provide guidance on the design of the system. These specifications will then standardize the system in order to guarantee the proper interworking between the different elements of the GSM system. Network quality depends upon a number of factors such as radio resources, radio networking planning, network equipments,

transmission links, network congestion, landscape, equipment environment, and fault clearance period. Some of these factors such as radio resources and landscape are limited and natural that they can not be altered by any methods while others can be maintained by better network management. Radio performance improvement plays a vital role in GSM network quality [1].

1.4 PROBLEM DEFINITION AND METHODOLOGY

It is to examine the various key performance indices (KPIs), obtained from the operation and maintenance centre and radio and other base station subsystem, as they affect the quality and delivery of services in the MTEL network.

The following improvement procedure is involved in the study; Network data collection via Operation and Maintenance Centre for radio resources (OMCR), Network parameters evaluation, Network adjustment solution, suggestion and recommendations

1.5 THESIS OUTLINE

Chapter one is the Introduction, thesis motivation, methodology and literature review. Chapter two is the description of M-tel network structure. Chapter three is the theoretical background describing the basic concept of Quality of service improvement. Chapter four describes the Operation and maintenance Centre (OMC) in the Kaduna M-tel network. Chapter five is the analysis of the key performance indicators (KPIs) parameters; while Chapter six is the conclusion, limitation, significance of the work and recommendation.

CHAPTER TWO

MOBILE TELECOMMUNICATION (M-TEL) NETWORK STRUCTURE

2.1 INTRODUCTION

The design of the network involved the building of eleven Mobile Switching Centre (MSC)/ Base Station Controller (BSC) nodes and five hundred and seventy nine Base Transceiver Stations (BTS) nationwide with a combined capacity of 1.2 million subscribers.

Node- interconnections, according to the relevant standards, are supported by Erickson switches. The entire networks have gateway mobile switching centre (GMSC) functionality. The Intelligent Network (IN) comprising the billing gateway (BGW), prepaid administrative system (PPAS), the signal control point (SCP), the interactive voice response (IVR) nodes as well as the centralized nodes consisting of the voice mail system (VMS), short message system (SMS), and the service data point (SDP) are all supported by Erickson equipment, There will also be three home location register (HLR) nodes (one per vendor) with 512,000 subscriber licenses per HLR, while each HLR node interconnects every signal transfer point (STP) in the network for full redundancy. The required transmission and signaling links between the network nodes are also specified according to the International Telecommunication Union (ITU-T) standards as in figures 2.1 to 2.4 [3].

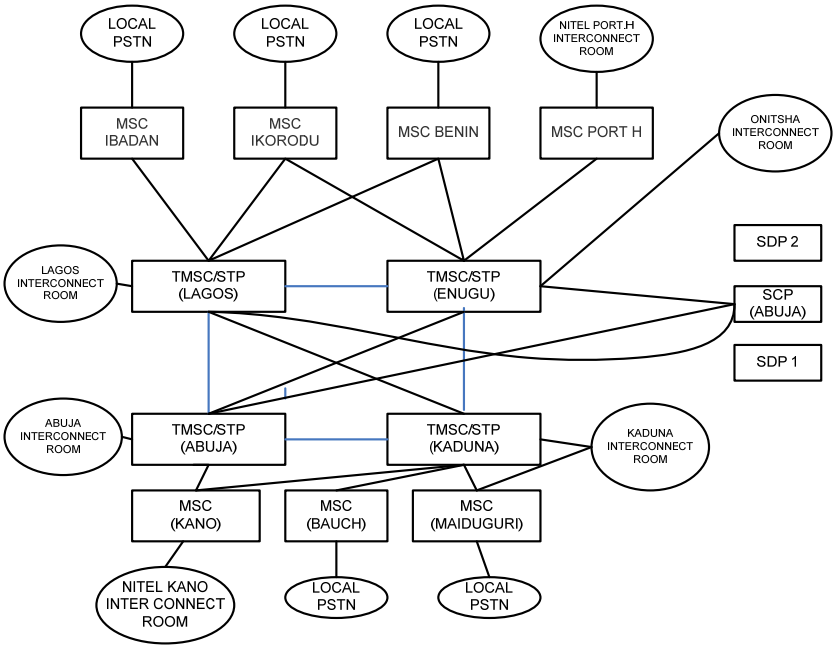


Fig: 2.1 TMSC/SCP Connections

2.2 TRANSIT MOBILE SWITCHES CENTRE (TMSC/STP CONNECTIONS)

Enugu and Lagos switches are designed as Mobile Switching Centre MSC/TSC/STP while the Abuja switch will be MSC/STP. Furthermore, the network design adopted by M-tel is such that all MSC nodes in the network are supposed to have GMSC functionality, It means that both Ericsson Telecoms and Zhongshing Telecom China (ZTE), the two M-tel equipment vendors have done dimensioning for the transit switches assuming that other Mobile Switching Centre (MSC) nodes are directly connected to the Public Switch Telephone Network (PSTN) and other Public Land Mobile Networks PLMNs for both outgoing and incoming calls. These are illustrated in figure 2.1

Intra –network traffic and signaling are handled by the transit switches, while traffic towards other network are routed directly from other MSC nodes not utilizing Lagos,

Enugu or Abuja switches. Each one of eleven MSC nodes act as a gateway for both outgoing and incoming traffic, and each one of the MSC nodes has direct routes towards

other networks (both outgoing and incoming) and no direct transit traffic towards other network will pass through the Transit Mobile Switching Centre (TMSC) nodes [3].

2.3 HOME LOCATION REGISTER (HLR) CONNECTIONS

Each HLR node is connected to every Signal Transfer Point (STP) in the network. The signaling links are dimensioned with 30% load but are capable to be loaded up to 60% for the redundancy reasons. The HLR in Abuja and the Lagos STP are interconnected through two high speed signaling links which occupy two physical E1s. For other connections only one E1 per HLR-STP connection is necessary. HLR traffic is highly important, because if the HLR node fails, there is no HLR redundancy feature. HLR redundancy can be possible if HLRs work in pairs, but for this design Ericsson HLR pair is needed. This can not be obtained in the present design with other vendor's HLR. This is shown in figure 2.2 [3].

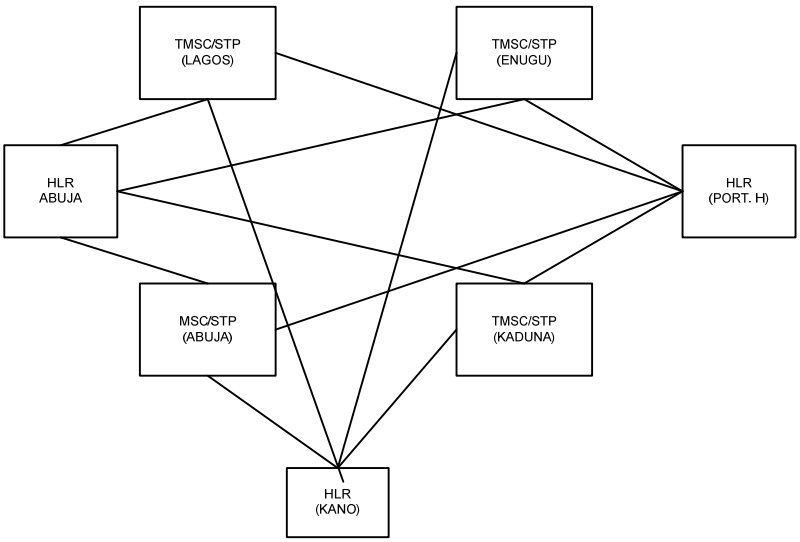


Fig 2.2 HLR Connection

2.4 SHORT MESSAGE SERVICE (SMS) TRAFFIC

Inter voice SMS platform are placed in Abuja switching room. It is dimensioned to carry 160k SMS in busy hour. Six time-slots from the SMS platform are needed for this purpose. Two time-slots are for the mobile originated SMS traffic and other four time-slots carry terminating messages as describe in figure 2.3

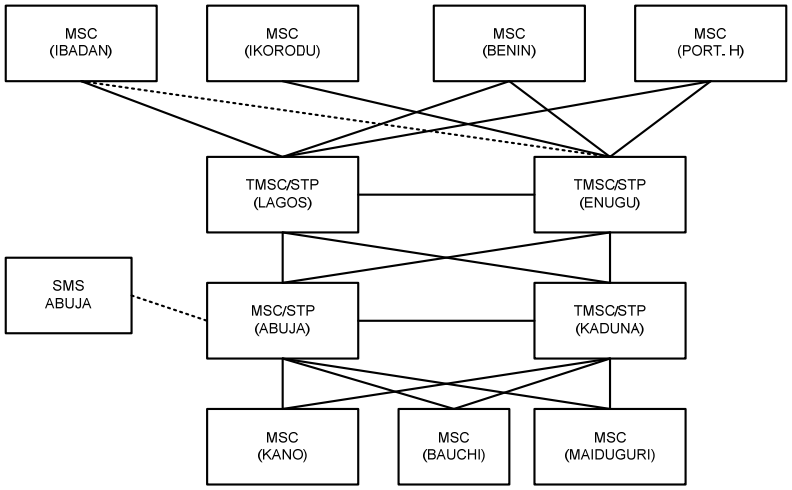


Fig 2.3 SMS connection

2.5 VOICE MAIL SERVICE (VMS) TRAFFIC

There are two voice mail services (VMS) platforms, one in Lagos and the other in Abuja. Each platform has signaling links for signaling purposes. The signaling link from each (VMS) is connected to the co-located signal transfer point (STP) node (as indicated in figure 2.4 The signaling between (VMS) platforms and other mobile switching centre (MSC) nodes are performed through the two signal transfer point (STP) nodes. There is no need to allocate separate signaling links from STP to other switches for VMS purposes due to low VMS signaling traffic [3] as indicated in figure 2.4

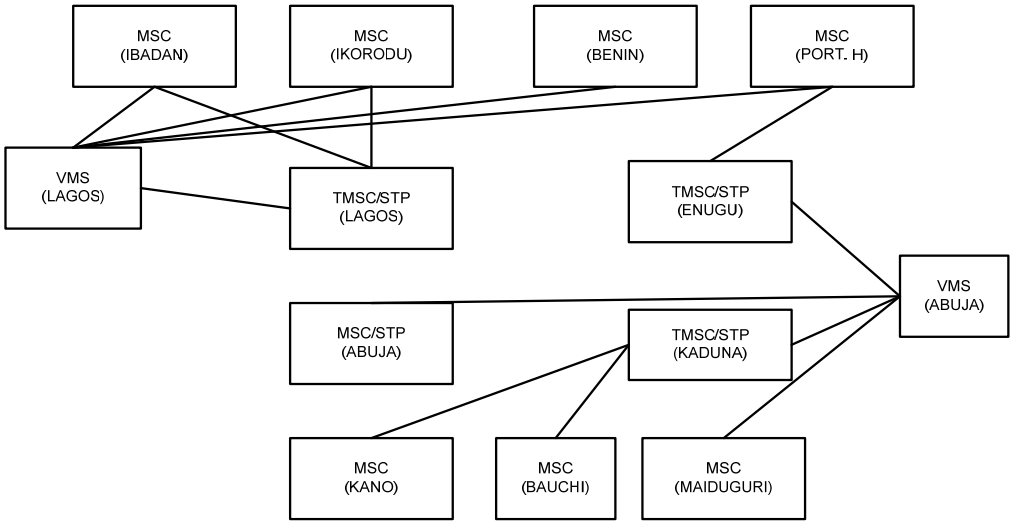


Fig. 2.4 VMS connection

2.6 TRANSMISSION LINKS

The transmission links of the M-tel network (E1 requirements) were designed to utilize the already existing Nigerian Telecommunication (NITEL) transmission network but where such digital transmission network does not exist; M-tel developed its own transmission backbone. The transmission link between the Kaduna GMSC/STP and other network nodes and some Base Transceiver Stations (BTS) locations are owned by NITEL. However for such areas where the transmission link does not exist a new transmission backbone was developed to link the Base Transceiver Stations (BTS) in those locations to the Base Station Controller (BSC) and Mobile Switching Centre (MSC) in Kaduna as shown in figure 2.5

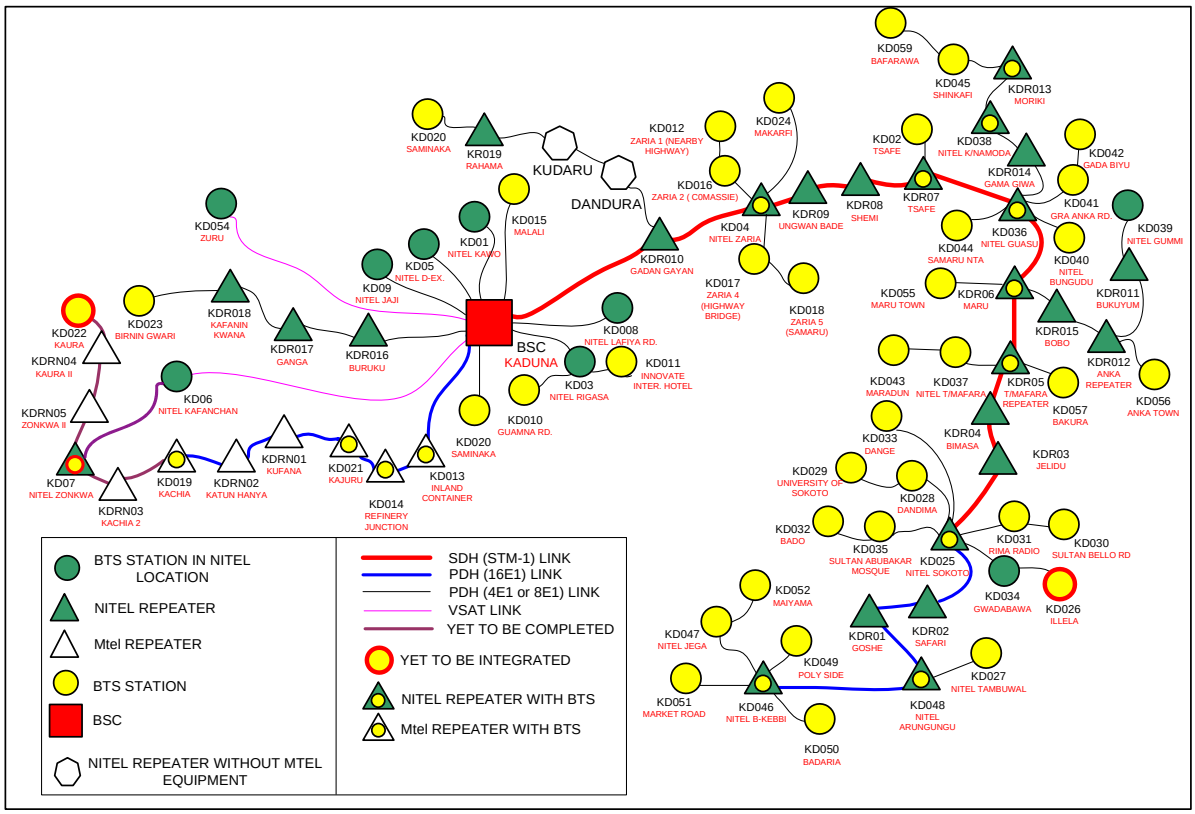


Fig 2.5 M-TEL BTS locations and Transmission link

2.7 GSM NETWORK COMPONENTS AND FUNCTIONS

The expanded M-tel GSM network so far installed can generally be divided into three sub systems, each of which is comprised of a number of functional units as shown in fig 2.6. They are;

- The Network and Switching System (SS)
- The Base Station Subsystem (BSS).
- The Operation and Support Subsystem (OSS).

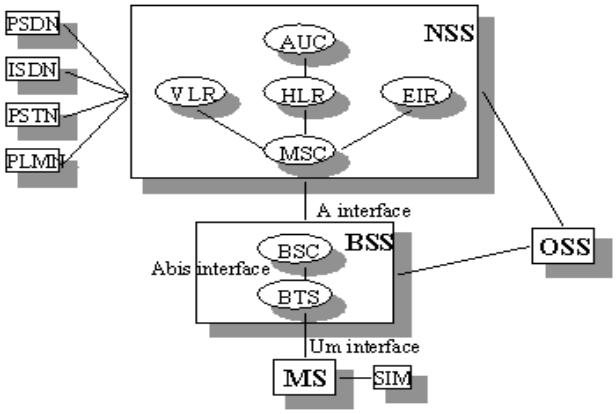


Figure 2.6 Architecture of the GSM network

2.7.1 THE NETWORK AND SWITCHING SUBSYSTEM (NSS)

The main role of the NSS is to manage the communications between the mobile users and other users, such as mobile users, integrated service digital network (ISDN) users, fixed telephony users, etc. It also includes data bases needed in order to store information about the subscribers and to manage their mobility. The different components of the NSS are described in the following sections. [4, 5]

2.7.2 THE MOBILE SWITCHING CENTER (MSC)

The MSC performs the system telephony functions. It also controls calls to and from other telephony and data systems, such as the public switched telephone network (PSTN), integrated services digital network (ISDN). Gateway functionality enables an

MSC to interrogate a network's (HLR) in order to route a call to a mobile station (MS).Such an MSC is called a gateway MSC (GMSC).

2.7.3 THE GATEWAY MOBILE SERVICES SWITCHING CENTER (GMSC)

A gateway is a node interconnecting two networks. The GMSC is the interface between the mobile cellular network and the public switch telephone network (PSTN). It is in charge of routing calls from the fixed network towards a GSM user. The GMSC is often implemented in the same machines as the MSC.

2.7.4 VISITOR LOCATION REGISTER (VLR)

The VLR is a database that contains information from a subscriber's HLR necessary in order to provide the subscribed services to visiting users. When a subscriber enters the covering area of a new MSC, the VLR associated with this MSC will request information about the new subscriber to its corresponding HLR. The VLR will then have enough information in order to assure the subscribed services without needing to ask the HLR each time a communication is established. The VLR is always implemented together with an MSC. The area under the control of the MSC is also the area under control of the VLR [4, 5, 6].

2.7.5 The AUTHENTICATION CENTER (AuC)

The AuC register is used for security purposes. It provides the parameters needed for authentication and encryption functions. These parameters are used to verify the user's identity.

2.7.6 THE EQUIPMENT IDENTITY REGISTER (EiR)

The EiR is also used for security purposes. It is a register containing information about the mobile equipment. More particularly, it contains a list of all valid terminals. A

terminal is identified by its International mobile equipment identity (IMEI). The EIR allows them to forbid calls from stolen or unauthorized terminals (e.g, a terminal which does not respect the specifications concerning the output RF power) [1, 6].

2.7.7 THE GSM INTERWORKING UNIT (GIWU)

The GIWU corresponds to an interface to various networks for data communications. During these communications, the transmission of speech and data can be alternated.

2.7.8 THE OPERATION AND SUPPORT SUBSYSTEM (OSS)

The OSS is connected to the different components of the NSS and to the BSC, in order to control and monitor the GSM system. It is also in charge of controlling the traffic load of the BSS. However, increasing the number of base stations, due to the development of cellular radio networks, has necessitated that some of the maintenance tasks are transferred to the BTS. This transfer decreases considerably the costs of the maintenance of the system [6].

2.7.9 THE BASE STATION SUBSYSTEM (BSS)

The BSS connects the Mobile Station and the NSS. It is in charge of the transmission and reception. The BSS can be divided into two parts:

- The Base Transceiver Station (BTS) or Base Station.
- The Base Station Controller (BSC) [1, 6].

2.7.10 THE BASE TRANSCEIVER STATION (BTS)

The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the center of a cell. Its transmitting power defines the size of a cell. Each BTS has between one and sixteen transceivers depending on the density of users in the cell.

2.7.11 THE BASE STATION CONTROLLER (BSC)

The BSC controls a group of BTS and manages their radio resources. It has a maximum capacity of 512/1024 transceivers, Maximum traffic processing ability of 3600 Erlang. A BSC is principally in charge of handovers, frequency hopping, exchange functions and control of the radio frequency power levels of the BTS [6].

2.7.12 MOBILE STATION (MS)

A Mobile Station consists of two main elements:

- The mobile equipment or terminal.
- The subscriber identity module (SIM).

2.7.13 THE TERMINAL

There are different types of terminals distinguished principally by their power and application:

- The `fixed' terminals are the ones installed in cars. Their maximum allowed
- output power is 20 Watts.
- The GSM portable terminals can also be installed in vehicles. Their maximum allowed output power is 8 Watts.
- The handheld terminals have experienced the biggest success thanks to their weight and volume, which are continuously decreasing. These terminals can emit up to 2 Watts. The evolution of technologies allows decreasing the maximum allowed power to 0.8 Watts. [5]

2.7.14 THE SIM

The SIM is a smart card that identifies the terminal. By inserting the SIM card into the terminal, the user can have access to all the subscribed services. Without the SIM card, the terminal is not operational. The SIM card is protected by a four-digit personal identification number (PIN). In order to identify the subscriber to the system, the SIM card contains some parameters of the user such as its international mobile subscriber identity (IMSI). Another advantage of the SIM card is the mobility of the users. In fact, the only element that personalizes a terminal is the SIM card. Therefore, the user can have access to its subscribed services in any terminal using its SIM card. [4, 5]

CHAPTER THREE

QUALITY OF SERVICE IMPROVEMENT

3.1 INTRODUCTION

Network improvement serves the objectives for a maximum application of network resources and the improvement of the quality of service. These contribute to the foundations of future network expansion. Improvement here refers to a sound implementation of network planning. Quality of service improvement can be achieved by expanding the coverage area and by optimally utilizing the available resources on both the access and the core network parts. An “improved” network: increases network availability and efficiency, and it increases subscriber satisfaction by improving the overall network quality. It also increases competitiveness and reduces operational costs [7, 9].

3.2 PROCESSES OF NETWORK IMPROVEMENT

The mobile communication network of GSM generally falls into mobile switching-transporting part and radio part. Due to the mobility of subscribers and the complexity of radio waves in propagation, the radio part always becomes the decisive factor affecting the quality of service (QoS) of the GSM network. Wireless network improvement refers to reasonable modification to planning and designing of communication networks according to certain principles so that a more reliable, more economic network operation, a higher quality of service (QoS), and a higher utilization ratio for network resource can be achieved. Undoubtedly, this is of great significance for network operators and subscribers. Procedures for network improvement are shown in figure 3.1

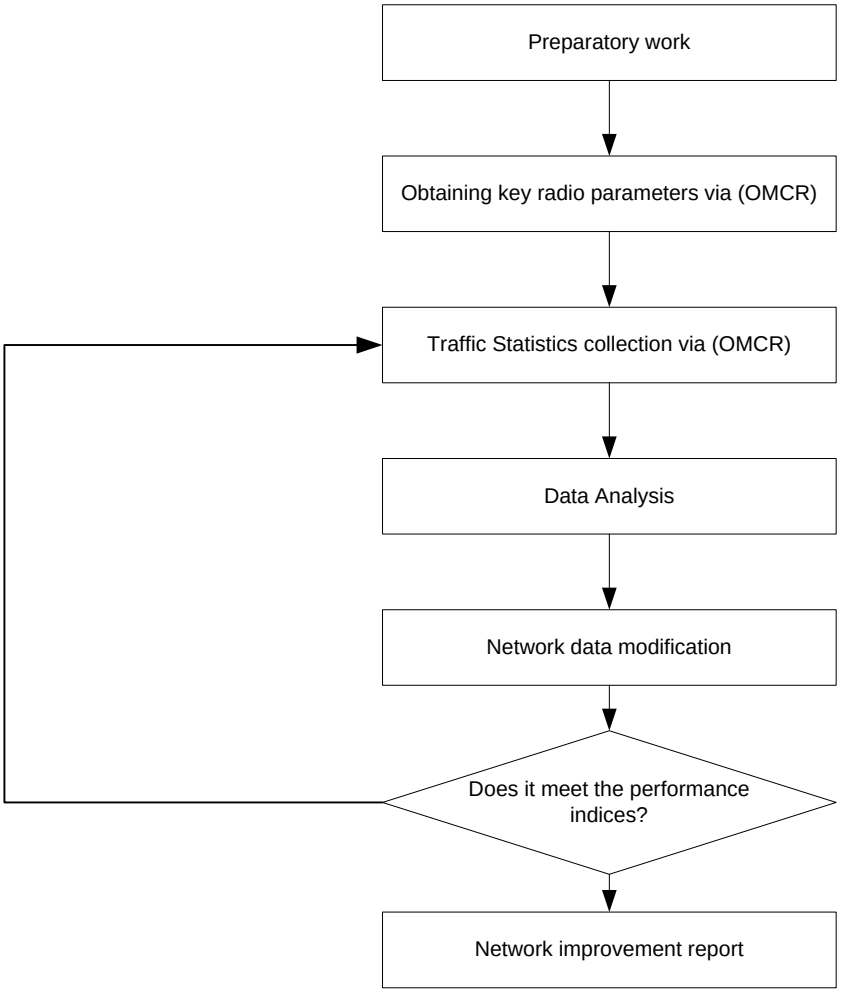


Figure: 3.1 Flow chart of Quality of service Improvement

Preparatory work at early stages include obtaining knowledge of progressive status in network construction, analyzing the operation status of network, preparing for improvement test equipment and software, network planning report, collection of engineering and designing documents, etc. Obtaining basic network information at site include further inspections on local radio environment, hot spots of traffic, confirmation of engineering parameters and network indices for practical installation, communication with customers to understand their specific demands. Data collection covers subjective reflection of mobile subscribers, data collection in drive test, OMC data collection, etc. Data analysis includes background analysis and use of improvement software. [3].

3.3 COMMON TOOLS USED IN NETWORK IMPROVEMENT

3.3.1 ADVANCE NETWORK TESTER (ANT)

ANT software can be used in re-selection test with mobile station in idle state, frequency scanning test, timed call-up test, continuous connection test, etc. Through simulating the actual state of subscribers in practical application, field intensity distribution, Carrier-to-Interference ratio, voice quality and other on site data can be obtained. Meanwhile, the actual installation status of antenna and feeders can also be verified. Various test measures can be applied in combination with others according to demand. According to the test result, modification to system parameters and antenna status shall be implemented accordingly. Among them, modifications to system parameters covers modification to transmission power, frequency configuration, handover level, parameters of adjacent cells, traffic load, the numbers of SDCCH and TCH channels for configuration, etc. Modification to antenna state has an important effect on coverage improvement and interference reduction. It mainly covers adjustment to antenna height azimuth, down tilt, etc [10].

3.3.2 GLOBAL POSITIONING SYSTEM (GPS)

Improved software applies high precision GPS in geographical positioning. Path of drive test and all performances of a handset (as Call Drop, handover failure, assignment failure, etc) can be displayed in real time icons. In background analysis, data play back, problem positioning and geographical representation of all indices can be implemented.

3.3.4 SIGNAL ANALYZER

Signal Analyzer can be used in on-line test of the Abis interface signaling information. It can also be applied in testing of error code covering. With Signal Analyzer MA-10, a

network engineer can collect and analyze data of Abis interface and A interface, survey the complete process of signaling connection, extract survey report, and carry out contrastive study of these data against downlink signal collected from drive test (This ingenuous use of time points as indices and a combined application of latitude and longitude stored in equipment for downlink drive test can generate an uplink coverage graph and quality graph), so that the operation state of the entire network can be obtained. In this way, major causes and locations of Call Drop, handover failure, traffic congestion and other problems in a cell can be spotted [10].

3.3.5 TRAFFIC STATISTICAL DATA

From major indices including TCH call drop rate, TCH congestion rate, SDCCH call drop rate, SDCCH congestion rate, handover completion rate, etc. Network operation status can be understood with regard to the traffic volume on the network, as well as providing statistical data to understand network performance [11].

3.4 COVERAGE

Range of cell coverage is one of the important indices in quality of service (QoS) evaluation for GSM networks. Major factors affecting coverage are as follows:

3.4.1 BLIND ZONE FOR SIGNAL

A blind zone results from no overlapping between coverage areas of two base stations or no overlapping caused by obstructions. Should there be more subscribers in the non-overlapping area of two base stations, or dimension of the area is relatively bigger, construction of a new base station is expected [11].

A blind zone caused by valley and back hillside can be recovered by constructing new base stations and repeaters in those areas. Repeaters can effectively recover blind zones in coverage area and expand the scope of coverage. On the other hand, repeaters can

also bring about inter-modulation interference, co-channel interference and adjacent channel interference to other cells [10].

Blind Zones within tunnels, underground garages, and tall buildings can be recovered by introduction of repeaters, leak cables, or micro station technologies. In actual networks, signals emitted from high base stations can be transmitted on hilly land forms or along roads to places far way. Hence the “island” problem was created. When a call is connected into the “island” of a base station, which is far from the base station, configuration handover in this cell may immediately result in call drop once the mobile station leaves this “island” area. To solve this problem, down tilt or gain of the antenna should be modified. Transmission directly along road should be largely avoided so as to eliminate island effect by reducing the coverage of base stations. [11]

3.4.2 TRAFFIC CONGESTION

With Operation and Maintenance Centre and Radio (OMCR) traffic statistics data, TCH congestion rate can be obtained (with occupation at all busy). It is also possible to judge the traffic congestion status by comparing the busy hour traffic volume against calculation capacity of each base station cell. For congestion cells, it is recommended that more carriers be added, or cell split, or construction of new base stations in common sites be adopted. It is also advisable to adopt new dual frequency networks, micro cells [11, 12].

3.4.3 TRAFFIC BALANCE

For some base stations with congestions, measures to ease the congestion are as follows:

(1) Modify the antenna height, down-tilt, transmission power of base stations and handset.

(2) Modify the configuration for part of parameters in overloaded areas, The minimum access level may be suitably increased and handover threshold may be appropriately

decreased to reduce traffic. Accordingly, the minimum access level may be properly reduced and handover threshold may be appropriately increased to increase traffic.

3.5 INTERFERENCE

Public land mobile network (PLMN) cellular system makes use of frequency multiplexing to improve application efficiency of the spectrum and to increase system capacity. Meanwhile, it also brings forth co-channel interference and adjacent channel interference (This is called internal interference of the system.)

3.6 OPERATION MAINTENANCE CENTRE AND RADIO (OMCR)

The GSM network is monitored and controlled from a central point. This is the operation and maintenance centre and radio (OMCR). The OMCR has the following tasks, the fault management systems analysis alarms from the BSS elements, when fault occurred they are eliminated when necessary by a software command or restore by technicians. The configuration management system installed software when new BSS elements are implemented, it manages hardware inventory list and changes operational parameters i.e for radio frequency of a BTS. The software management system feeds in new software or updates and manages software inventory list. In the performance management system, alarms and fault elimination time are evaluated statistically, capacity bottlenecks in the network are detected and the service quality is monitored [13].

3.6.1 CONFIGURATION MANAGEMENT

Configuration management refers to configuration of the BSS system equipment and the radio resource data. It comprises integrated configuration management, radio resource management, software loading and dynamic data management.

3.6.2 PERFORMANCE MANAGEMENT

To make the network run more efficiently and provide users with the best service quality, the network maintenance personnel should be well familiar with different performance indices of BSC and the wireless network. These include traffic of each cells congestion of SDCCH and TCH with successful or unsuccessful handover. Such basic data information is provided by the performance management. By analyzing the information, the maintenance personnel can find such problems as network load allocation, excessively high or low load existing in a system. In this case, the maintenance personnel can take appropriate measures to balance the network load and improve the network performance. Performance management aims to monitor the performance of a network, network unit or equipment, collects related statistical data of performance, evaluates the effectiveness of a network and network unit, reports the status of the telecommunication equipment, monitor the quality of service of a network and supports network planning and network analysis. Thus, practical network running can be used to obtain the technical data to optimize a network, to improve the manifestation and efficiency of network performance and to provide data bases and reasonable suggestion for allocation and planning of the network resources [13].

A performance management system consists of four modules: Performance management, performance analyzer, invoke tracing and signaling tracing but the main area of interest in this work is performance management in communication networks with particular interest on Mobile Telecommunication Limited (M-TEL)

3.6.3 PERFORMANCE MANAGEMENT OBJECTIVE

Extensive studies on busy hour measurements clearly show that the maximum traffic that can be accommodated is not a constant value, but varies according to the traffic load scenario. It appears that in most of the congestion scenarios, radio networks remain under utilized but do not allow subscribers to set-up calls, while at the same time, the

operators are unable to serve a large number of requests. However, the network resources are still available. Performance management implements the following functions [14, 13].

1. Create a measurement job to collect the system running data and store them in the measurement database. The user can analyze these data through the performance analyzer or export these data for other analysis platforms or network optimization software to use.
2. For a measurement job that is collecting data, the current value of a certain counter of a certain measurement object can be observed on demand.
3. Observe some specified events in a cell, including handover observation and channel assignment observation. Handover observation consists of observation of handover in a cell, observation of incoming/outgoing handover in BSS, observation of incoming/outgoing handover between BSSs.
4. Enhancing radio planning is the most common mechanism to increase the system performance. The operator monitors the system performance constantly and stores the data in the network data warehouse (DW). The data can be post processed and shows on a daily, weekly, or monthly basis the behavior of the KPIs of the network. In case KPIs fall below predefined satisfaction thresholds in a physical area, network resources can be reallocated in a way that supports traffic demand. This can be achieved in systems based on frequency division multiple access (FDMA) or time division multiple access, such as GSM by adding transceiver (TRX) in the existing sites, there by offering additional communication channels, If on the other hand the problem is not only an increase demand for traffic, but also insufficient coverage, then additional base stations might need to be placed, or existing areas should be modified. This can also be done to increase the maximum traffic that can be accommodated [13, 14].

3.6.4 FAULT MANAGEMENT

Fault management is a major management function of the Telecommunication Management Network (TMN). For normal operation and maintenance of the ZXG10-BSS system. Fault management detects reports and processes the abnormality of a telecommunication network and its environment. The functions of fault management are implemented through fault alarm and alarm diagnosis. Function of fault management; alarm display and query, management of the alarm rack diagram, management of the alarm processing knowledge base, and diagnosis test management [15].

3.6.5 MAIN FEATURES OF FAULT MANAGEMENT

1) Real time: Monitoring the status and change in the whole system in real time and reporting the abnormality in time;

2) Correct: Reporting the abnormality correctly without missing or false alarms;

3) Automatic: Processing intelligently and automatically the fault to a certain extent, except that the operator employs the mode of sending the fault processing command, prevention of fault spread, enabling of backup resources and automatic recovery;

4) Network characteristic: query, setting and command operations of multiple terminals

3.6.6 SECURITY MANAGEMENT

Security management involves user access security and network security. The ultimate requirement on user access security is that only users with legal identities and network resources access authorities can access the network resources. To this end, there is identity authentication, access authority authentication, and illegal access reject. Network transfer security includes prevention of the data transmitted on the network line from being eavesdropped, intercepted, modified or falsified. Node security includes security of the application process and protection of the data integrity. In conclusion, security management comprises four parts: user access control, network transfer

security, application process security and data integrity control. Security management includes two modules: user management and operation log. User management is used to set the legal users and the corresponding operation management authorities, while operation log is used to record login information and system fault detection [13].

3.6.7 SYSTEM FEATURES

OMCR (V2) controls the BSS, which consists of BSC and BTS. MCR (V2) serves to perform effective configuration management on the BSS equipment, show the fault information generated in the running of BSS in real time, make performance analysis and statistics of BSS, and upwardly provide the access interface of NMC (Network Management Centre). The OMCR (V2) system is based on the client server structure. The applications are implemented through the application server, and the client application does not directly establish connection with MP of BSC. They only enable the operator to input the operation commands and output the operation results [13, 15].

CHAPTER FOUR

KEY PERFORMANCE INDICATORS (KPIS)

4.1 INTRODUCTION

Performance of the improvement function is typically measured for operational control purposes. Since improvement also has a strategic dimension, its performance measurement system should be linked to the strategy of the function in order to get the maximum impact. This chapter presents a structured approach and definitions of some of the factors affecting the key performance parameters of the GSM network. The measurement system features a balanced scorecard composed of key performance indicators (KPIs). The key parameters of the base station controller (BSC) are used [16].

4.2 CALL STATISTICS INDEX

Major indices such as the call drop rate, TCH congestion rate, SDCCH disconnection rate, SDCCH congestion rate, and handover success rate can be ranked according to their weights. And the above indices are usually associated with each other. That is, when problems related to one index are solved, other indices will be improved correspondingly. For instance, after the problem of a low handover success rate is solved during network improvement, the disconnection rate index will also be improved to some extent. To solve a problem in the network by call statistics, it is suggested to focus on a certain major index in association with other index analysis.

4.3 CALL DROP

In GSM network operation, call drop is a major problem frequently complained by subcribers, and the call drop rate is an important index of the wireless network quality. In this work, it is intended to analyze the causes of call drop based on the data collected on the operation and mantenance centre of the radio (OMCR), and discuss how to locate and solve the problem so as to reduce the call drop rate and improve network quality.

There are two types of call drop: call drop on the SDCCH (Stand alone Dedicated Control Channel) and that on the TCH (Traffic Channel). Call drop on the SDCCH takes place when the BSC has assigned the MS the SDCCH but has not successfully assigned it the TCH. Call drop on the TCH is an abnormal disconnection ocurring after the BSC has successfully assigned the MS the TCH [11, 12].

From the global perspective, there are three types of causes of call drop:

1. Fault with the RL (Radio Link), that is, messages can not be received normally during communication

2. T3103 (timer) timeout (occuring during handover, that is, the MS fails to seize the channel in the target cell, nor can it return to the original channel)

3. Fault with the system (all possible faults such as fault with the equipment) [4]. However, fault with the RL is a major cause. The M-tel network call drops are caused by failure due to radio link and other causes are as a result of failure for the call to handover to neigbouring cell [11].

4.3.1 FACTORS LEADING TO CALL DROP

1. Discontinuous coverage (blind areas) : Call drop is caused by an isolated site. The signal is weak and signal quality is poor at the edge of such a site, and handover to other cells can not be implemented, therefore call drop takes place. Due to the various geographic topography (like mountainous roads, rolling hills and mountains) and complex radio promulgate environment in the area covered by the BTS, signals are obstructed in transmission, leading to discontinuous coverage and finally call drop.

2. Poor indoor coverage: Some places have a high density of buildings, resulting in significant fading of signals in transmission; signals have to penetrate the thick walls of the buildings, leading to serious loss and a low indoor level. In this case, call drop takes place during communication.

3. Crosscell coverage (isolated island): Crosscell coverage takes place in the serving cell due to various causes (like power too high). As a result, the mobile station, MS, still uses the signal in its original serving cell A, when it is in cell C after having moved out of its defined neighbor cell B, and cell C has not been defined as a neighbor cell of cell A. Now when the MS wants to conduct handover according to the neighbor cell B provided by the original serving cell, it fails to find the appropriate cell, and call drop will occur [11, 12].

4. Coverage too small: Coverage too small can take place due to fault with the hardware equipment in a certain cells, like the antenna is blocked or the carrier of the Broadcasting Channel (BCCH) is faulty (in the power amplification part).

4.3.2 CALL DROP DUE TO HANDOVER

1. Unreasonable parameter settings: Some MSs will be handed over to the neighbor cell if the signal levels in the crossing area between two cells are both very low, the level parameter for the candidate cell for handover is set to a value too low, and the level in the neighbor cell is marginally stronger than the serving cell in a certain period of time. Right at the time of handover to this neighbor cell, the signal there fades, and there is no appropriate cell for handover. As a result, call drop occurs [11,12]
2. Incomplete definition of the neighbor cell: As a result of an incomplete definition of the neighbor cell, the MS will hold in the serving cell until it goes beyond the border of coverage of this cell. Now call drop occurs because the MS can not be handed over to a cell providing a stronger signal.
3. Traffic congestion : Call drop occurs when there is no channel for handover in the target base transceiver station (BTS) due to traffic imbalance, and channel reestablishment also fails. Now call drop occurs.

4.3.3 CALL DROP DUE TO TRANSMISSION FAULT

Call drop may occur when the transmission quality is poor on the link between the base station controller and base transceiver station or the link between the base station controller and mobile switching centre.

4.4 TCH CONGESTION RATE

Major factors related to the high TCH congestion rate are:

1. Limited system capacity
2. Serious interference
3. Coverage
4. Handover causes

5. Unsuitable parameter settings (system information)

4.5 SDCCH CONGESTION RATE

Factors affecting the high SDCCH congestion rate include:

1. Unsuitable parameter setting (system message)

2. Insufficient capacity

4.6 HANDOVER SUCCESS RATE

Handover is a process that transfers mobile station (MS) that is in setting up or busy status to a new traffic channel. Generally handover will occur under the following conditions:

A busy mobile station which is roaming from a cell into another or a mobile station is making a call at overlapping area of two cells one of which is very busy in traffic, base station controller (BSC) notify Mobile station to measure signal intensity and channel quality of adjacent cells. This call will be handed over to the cell which is not busy in traffic Objects to be analyzed: the neighbor cells with a low out coming handover success rate and the serving cell with a low incoming handover success rate. First, judge the incoming and the out coming handover success rate through inter-cell performance measurement: if it is low. If the out coming handover success rate is low, check cell performance measurement to find out to which neighbor cell the out coming handover success rate is low. Major factors related to the low handover success rate:

1. Congestion

2. Problem with the equipment (certain carrier board and so on are damaged) [12].

4.7 BUSY HOUR TRAFFIC

The measurement of network traffic load is done during the busiest hour because this period represents the maximum traffic load that the network must support, the results gives a traffic load measurement commonly referred to as the Busy Hour traffic (BHT).

4.8 GRADE OF SERVICE

Grade of service is defined as the probability that calls will be blocked while attempting to seize circuits.The grade of service (GOS) of a telephone route between

any two exhanges in a circuit switched network is the fractional quality of calls, which can not be completed due to network congestion. The lowest numerical value used in GSM is 2% or 0.02 (in other words 2% of calls can not be completed owing to network congestion, the other 98% can.

4.9 TRAFFIC

Traffic is said to be that series of homogenous events occuring one after another at random moments in time. Traffic can also mean the aggregate calls including call attempts offered to or carried by some defined parts of a network, such as a group of circuits or switches with account being taken of both the number of calls and their duration. The amount of traffic carried by a group of circuits will always exhibit daily and seasonal variations. Of more significance, however, are the changes that occur with the time of the day, leading to the concept of the busy hour when the volume of traffic carried is as its peak. During such a period, the numbers of call arrivals and departures are essentially equal and the system is said to be in a state of statistical equilibrium. In this state, the average number of calls existing simultaneously gives a number of the density of the traffic.It can be deduce that, the number of subscribers in an hour of BSC, (No. of Subscibers)= (Erlang value/hour)/0.025 [17].

CHAPTER FIVE

DATA ANALYSIS

5.1 M-TEL KADUNA AREA VI

The M-tel Area VI Kaduna switch is made up of one mobile switching centre (MSC), one base station controller (BSC), and ninety nine base transceiver station (BTS). It also has one visitor location register (VLR), two operation and maintenance center (OMCR), one for the MSC and the other for the BSC, where the data used for this thesis were obtained**.**

5.2 FREQUENCIES

As with any radio, the M-tel network operates in a given frequency band. The GSM-900 system operates at frequencies around 900 MHz, the GSM-1800 system (also called DCS) operates around 1800 MHz The available frequency band is divided into individual frequencies, also called channels. This technique is called frequency division multiple access (FDMA). This means that more than one radio can operate at the same time, each radio operating at a different frequency (ie. different channel). While time division multiple access **(**TDMA**)** is a technology for shared medium (usually radio) networks. It allows several users to share the same frequency by dividing it into different time slots. The users transmit in rapid succession, one after the other, each using their own timeslot. This allows multiple users to share the same transmission medium (e.g. radio frequency) whilst using only the part of its bandwidth they require. A major advantage of TDMA is that the radio part of the mobile only needs to listen and broadcast for its own timeslot. For the rest of the time, the mobile can carry out measurements on the network, detecting surrounding transmitters on different frequencies. This allows safe inter- frequency handover s, something which is difficult in Code Division Multiple Access (CDMA) [12].

5.3.1 TRAFFIC CHANNEL

The service channel that bears code voice or user data distinguishes full-rate service channel (TCH/F) and half-rate service channel (TCH/H). The voice services are:

TCH/F: full rate voice service channel, with a total rate of 22.8kb/s

TCH/H: half-rate voice service channel, with a rate of 11.4kb/s

5.3.2 CONTROL CHANNEL (CCH)

The control channel is designed to bear signaling or synchronous data. There are three kinds of control channel: broadcast channel, common control channel and dedicated control channel.

1. The broadcast channel

The broadcast channel is a one-point-to-multiple-point one-way downstream control channel, which is a one-way transmission from BS to mobile station. It is designed to broadcast all kinds of messages to MS. There are three kinds of channels:

1) FCCH: Frequency Calibration Channel, which bears the information for MS frequency correction.

2) SCH: Synchronous Channel, bearing the ID information about MS frame synchronization and BS transceiving station (BTS).

3) BCCH: Broadcast Control Channel, designed to send cell information. There is always a transceiver in each BTS containing this channel to broadcast system information to all the mobile stations of the cell [11].

5.3.3 COMMON CONTROL CHANNEL

The common control channel is a one-point-to-multiple-point two-way control channel, shared by MS on the network. There are three kinds of common control channel:

1) PCH: Paging Channel, designed to help BTS page MS (downstream channel).

2) RACH: Random Access Channel, designed to help MS submit network entry request randomly; that is, to request the allocation of dedicated control channels (upstream channels).

3) AGCH: Agreed Access Channel, designed to help BTS to respond to the random access request; that is, to allocate a dedicated control channel or allocate directly a TCH (downstream channel) [12, 18].

5.3.4 DEDICATED CONTROL CHANNEL

The dedicated control channel is a point-to-point two-way control channel. At the time of service, BTS allocates it to MS for point-to-point transmission between BTS and MS.

1) SDCCH: standalone dedicated control channel, designed to transport information like channel allocation. The kinds of SDCCH are as follows:

- Specified Control Channel
- SDCCH/4: Standalone Dedicated Control Channel combined with BCCH/CCCH.

2) FACCH: Fast Associated Control Channel, used together with a service channel and bearing the same signals as SDCCH, but it allocates FACCH and establishes connection through the frames (called “stolen frames”) via the service channel and transports commands like “cross-cell switchover” only when SDCCH is not allocated. There are 2 kinds of FACCH as follows:

- FACCH/F: full-rate fast associated control channel
- FACCH/H: half-rate fast associated control channel

5.4 CHANNEL COMBINATION

In actual applications, the logical channels of different types are always mapped to the same physical channel. This is called channel combination.

There are nine types of channel combination:

1. TCH Full TCH/F+FACCH/F+SACCH/TF full rate service channel
2. TCH Half TCH/H+FACCH/H+SACCH/TH half-rate service channel
3. TCH Half TCH/H+FACCH/H+SACCH/TH+TCH/H half-rate 1 service channel
4. Specified Control Channel
5. Main BCCH FCCH+SCH+BCCH+CCCH main broadcast control channel

6. BCCH Combined FCCH+SCH+BCCH+CCCH+SDCCH+SACCH combined broadcast control channel

7. BCH FCCH+SCH+BCCH broadcast channel

8. BCCH with CBCH + FCCH+SCH+BCCH+CCCH+SDCCH+SACCH+CBCH cell broadcast channel

9. Slow dedicated control channel where,

1) CCCH=PCH+RACH+AGCH.

2) CBCH: Only the downstream channel bears the cell broadcast information, sharing the same physical channel with SDCCH.

Each cell broadcasts one FCCH and one SCH. Its basic combination contains one FCCH, one SCH, one BCCH and one CCCH (PCH+AGCH) in the downstream direction and allocates them strictly to TN0 of BCCH carrier frequency configured for the cell.

5.4.1 ARRANGEMENT OF CHANNELS IN THE CELL

The following are examples of channel combination in a cell and their respective sub-channel.

1. The combination of channels for the small capacity cell with only one Transceiver unit (TRX)

a) FCCH + SCH + BCCH + CCCH + SDCCH/4 (0.3) + SACCH/C4 (0.3)

b) TCH/F + FACCH/F + SACCH/TF

2. Mid-size cell with 4 Transceivers (TRXs)

a) 1 TN0 group: FCCH+SCH+BCCH+CCCH

b) SDCCH/8 (0 .7) + SACCH/C8 (0. 7)

c) TCH/F + FACCH/F + SACCH/TF

3. High-capacity cell with 12 Transceivers (TRXs)

a) 1 TN0 group: FCCH+SCH+BCCH+CCCH

b) 1 TN2 group, one TN4 group and 1 TN6 group: BCCH+CCCH

c) SDCCH/8 (0 .7) + SACCH/C8 (0. 7)

d) TCH/F + FACCH/F + SACCH/F

5.4.2 CALL PROCESSING AND RELIABILITY

Reliability is an important characteristic of switching systems. Loss of the switching system can result in data loss, loss of revenue and loss of customer confidence. To improve swiching system reliability, it is common to use redundant componets, such that a single component failure will not result in system unavailability. The ZTE switch at M-tel Kaduna Area VI has two memory processors. The resource module is connected to a data bus, but only the active resource module has control of the data bus. A call processor connection client operating on the resource module transmits a connection request message to the call processor system. A call processor server operating on the call processor system can receive the connection request message and assign the resource module active.The call processor system is a general purpose computing platform, such as a Pentium IV based computing platform, that includes suitable hardware and software sytems to support telecommunication data processing. The call processor preferably includes one or more systems that allow it to perform the function of a base station controller system and a message switching system. In addition, the call processor provides other elements that take part in processing calls directed to or initiated by the subscriber unit. The call processing include a call processing application that provides various call processing and signalling functions, such as call origination and termination function, as well as location updating and handover of mobile subscribers.

The data for this thesis are collected from the Operation and Maintenance Center and Radio (OMCR) at the M-tel Kaduna Switch.

5.4.3 PRESENTATION OF RESULTS

The results of the summarised data collected for each month from March to August 2006 are presented in Tables in appendices A to F and in figures 5.1 to 5.9 , to reflect all the parameters being taken at the measuring station. A visual representation of each parameter is depicted using Line chart

5.5 SDCCH IN SERVICE RATE (MARCH – MAY 2006)

SDCCH --- Stand- alone dedicated control channel is one of the most important parameter obtained from the base station controller (BSC). On the Base Station Subsystem (BSS), the SDCCH is allocated to a Mobile Station (MS) before onward availability of traffic channel (TCH).

SDCCH = Number of SDCCH allocated/Total number of SDCCH configured*100

From figure , it is noticed that the stand alone dedicated control channel (SDCCH) in service rate for May 2006 was very poor.,possible reasons include,

1) Congestion, 2) Transmission failure, 3) Channel configuration

4) Power failure, 5) problem with the equipment , In this analysis it was observed that the problem can be attributed to the epileptic power situation in the Abis transmission network.The result for March 2006 were considerably good at the beginning of the month but deteriorated by the end of the month. The month of April was considerably good throughout the month. In conclusion, the month of April had better service rate (SDCCH) on the average, compared to the other two months of March and May as indicated in figure 5.1.

5.5.1 SDCCH IN SERVICE RATE (JUNE – AUGUST 2006)

In the Month of June, the service rate was poor on the average. There were three days (12^{th},,13^{th},14^{th},) for which there was no record of service rate. This was as a result of failure of transmission (Abis network), causing the whole base station to be down. On the whole June and August the results were considerably bad Even though the higest result for June is about 80% while the lowest was 0% when the entire network was down June (11,12, &13).as shown in figure 5.1. Possible solutions to this include: uniterrupted power supply, increased cell capacity, and regular routine check on the equipment.

5.5.2 SDCCH IN CONGESTION RATE (MARCH – MAY 2006)

High traffic load in the particular cell may result in SDCCH congestion causing call set-up failures.

SDCCH in congestion rate= Total number of failed SDCCH allocation/Total number of SDCCH requested*100.

On March 15^{th} and April 28^{th} , the congestion rate was at its peak (about 30%). Further investigation needs to be done on site by site basis in order to pinpoint the exact site where congestion was being experienced. When congestion rate was lowest, it was considered that the network had performed considerably well as can be observed on May 15^{th} that recorded the lowest congestion rate of just (1%) in the three months period.it also shows that the service rate on this date was below 40%. It was observed that most of the sites that normally experience SDCCH in congestion were down at this date as indicated in figure 5.2.

5.5.3 SDCCH IN CONGESTION RATE (JUNE – AUGUST 2006)

The following dates; June 6th,8th,11th,19th;July 25th, August 4th, 5th,6th recorded SDCCH in congestion rate below 5%. On this same date,it is observed that the SDCCH in Service Rate was considerably low. This means that sites that experienced heavy traffic were low. On the other hand, there was a peak value of about 37% in June 7th.as shown in figure 5.2.

5.5.4 HANDOVER SUCCESS RATE (MARCH - AUGUST 2006)

Handover success rate = Total number of handover/total number of handover request*100

The causes for bad handover are weak signal,bad signal quality, severe interference and the mobile station being far away from the Base station,

The handover success rate and dual handover success rate are equally fair above 80% only for the month of May (2nd) , it dropped down to almost 25% due to down time on the backbone leaving only sites within Kaduna town functioning and they were separated by large distance making handover difficult. Even though both results shown in figures 5.3,5.4 is fairly good but both rates should be beefed up to about ninety percent (90%). Also additional Base Transceiver Stations (BTS) are required in most locations.. Also the months of June (9, 11,13,15, & 19) and also month of May (1st & 3rd) and August (29th), the entire network was down and the results shows 100% as indicated in figures 5.3 and 5.4.

5.5.5 CALL SUCCESS RATE (MARCH- AUGUST)

Call success rate = Number of successful calls/ Number of call setup*100

In August it was observed that the call success rate was better because the radio resources configured for the entire network subscribers were available to a few subscribers as indicated in figure 5.5.

5.5.6 CALL DROP RATE (MARCH- AUGUST)

For the call drop, apart from Nitel transmision going on and off, most of the M-tel sites are located in remote areas, so once a subscriber moves from one location to another, it is difficult for the cells to handover to its neighbour cell because of wide distance, It was also observed that from the Operation and Maintenance Centre (OMC), most of the transceiver units board have major and minor alarms, which needs to be replaced immediately.For the period May-June-August, NITEL staff embarked on strike action which affected the performance of the entire network as indicated in figure 5.8.

5.5.7 TRAFFIC IN ERLANG (MARCH- AUGUST 2006)

Traffic refers to flow of data over telephone lines or other communications networks. In digital telecommunications, the Erlang is a unit of traffic density [4]. One Erlang is the equivalent of one call including call attempts and holding time in a specific channel for 3600 seconds in an hour, this makes it possible for one channel to carry numerous calls simultaneously by means of multiplexing. In thirty minutes (1800 seconds) of time during the hour; it might consist of 180 calls, each of which occupy one minute (60 seconds) of time during an hour. No of Subscribers = Traffic value in Erlang/0.025 [15] from figure 5.9, it is shown that there is a decline in subscriber base. For example, the month of March 2006 had the highest subscriber base of almost forty eight thousand which dropped down to sixteen thousand subscribers. This was caused by the frequent power outage on the network as indicated in figure 5.9.

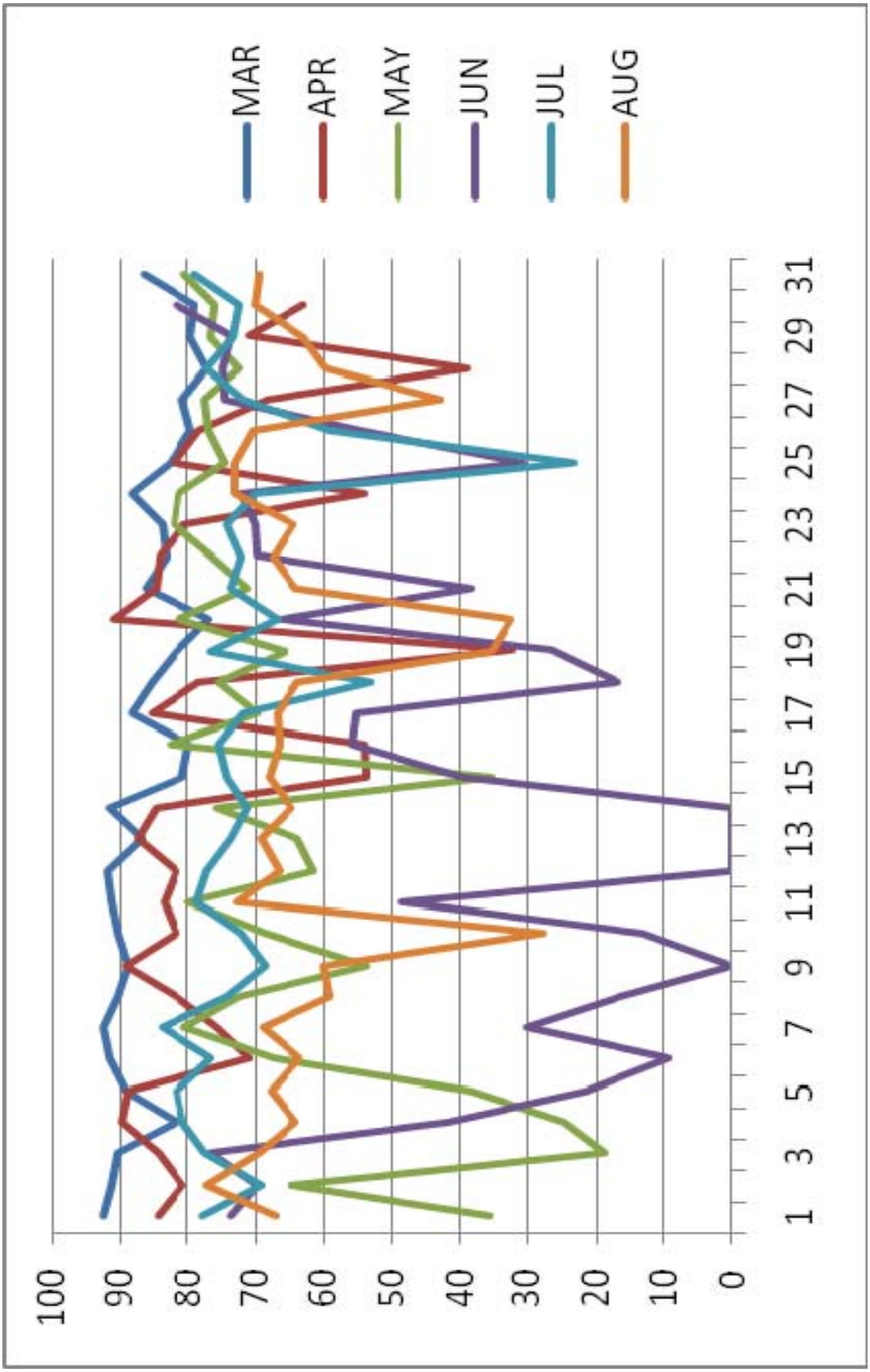


FIG 5.1 SDCCH IN SERVICE RATE (MARCH - AUGUST 2006)

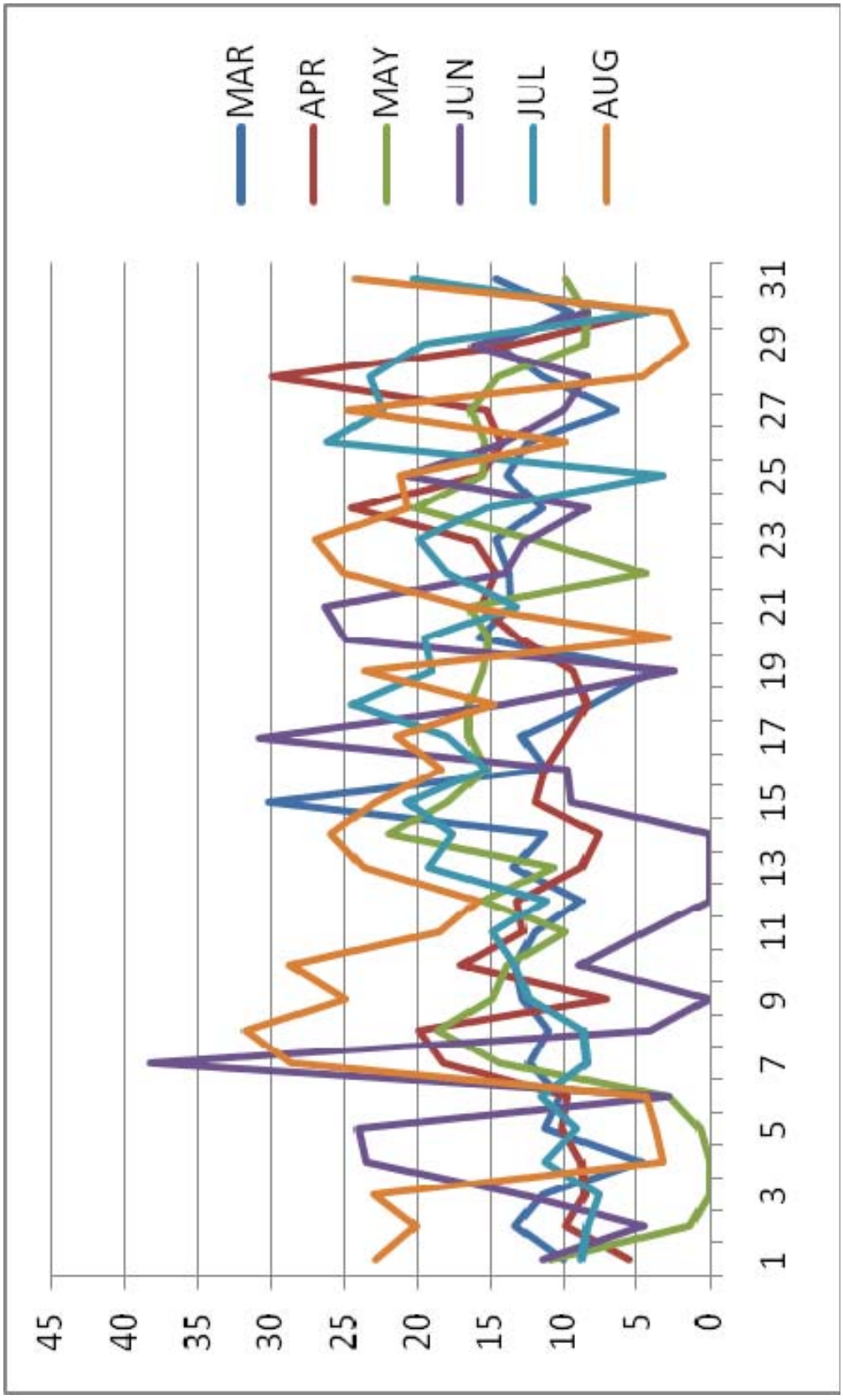


FIG 5.2 SDCCH CONGESTION RATE (MARCH - AUGUST 2006

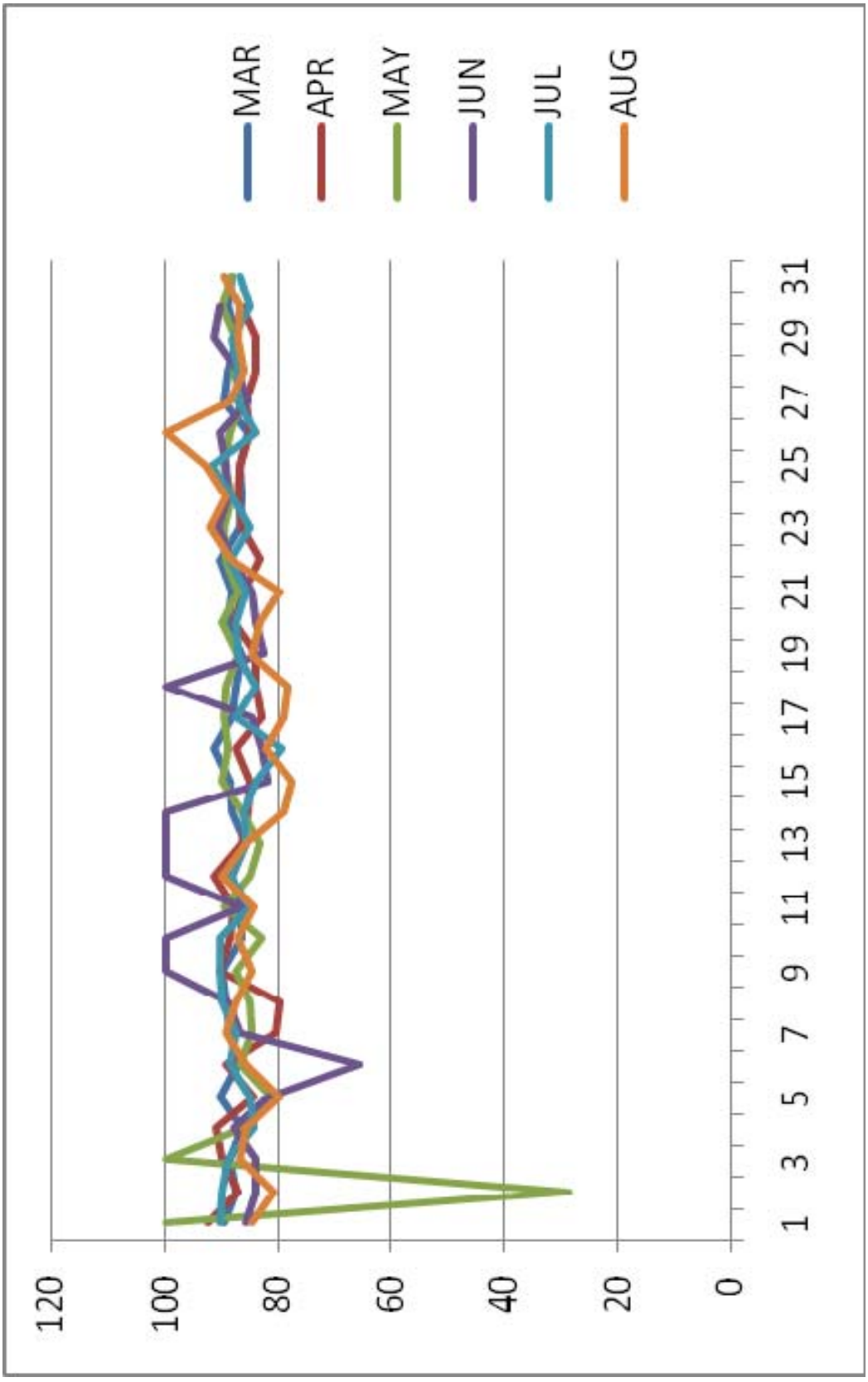


FIG 5.3 HANDOVER SUCCESS RATE (MARCH – AUGUST 2006)

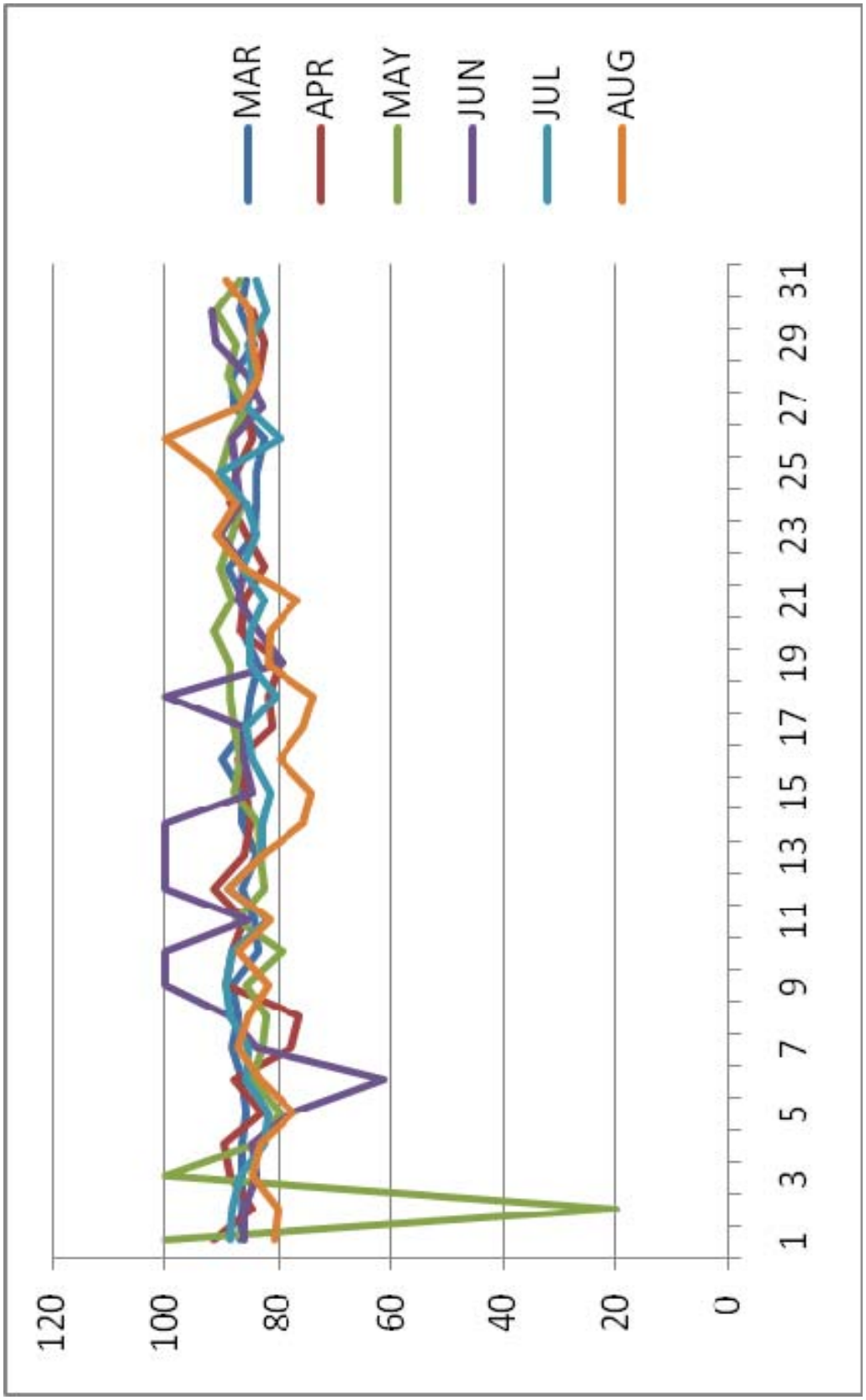


FIG 5.4 DUAL BAND HANDOVER SUCCESS RATE (MARCH – AUGUST 2006)

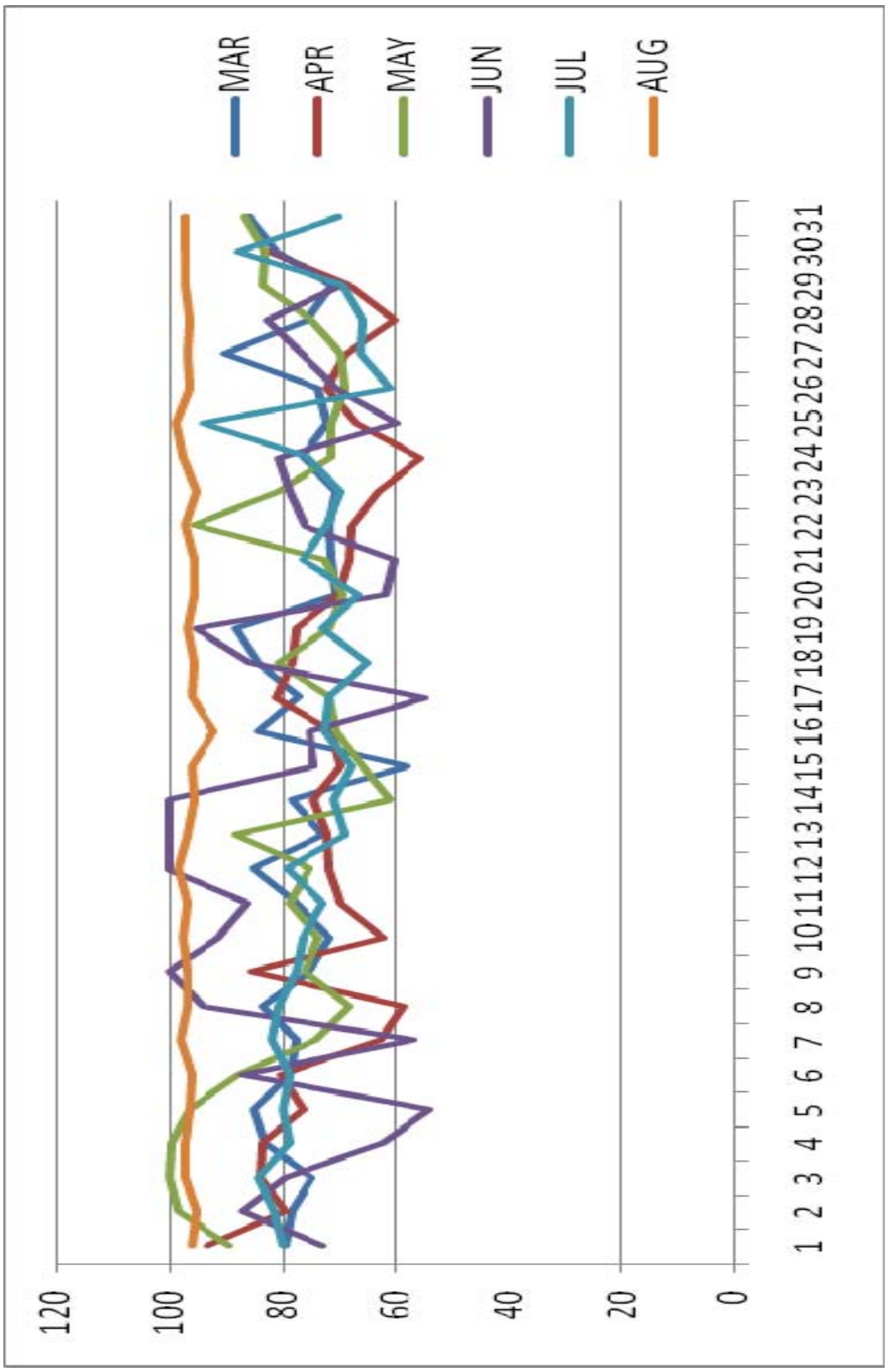


FIG 5.5 CALL SUCCESS RATE (MARCH – AUGUST 2006)

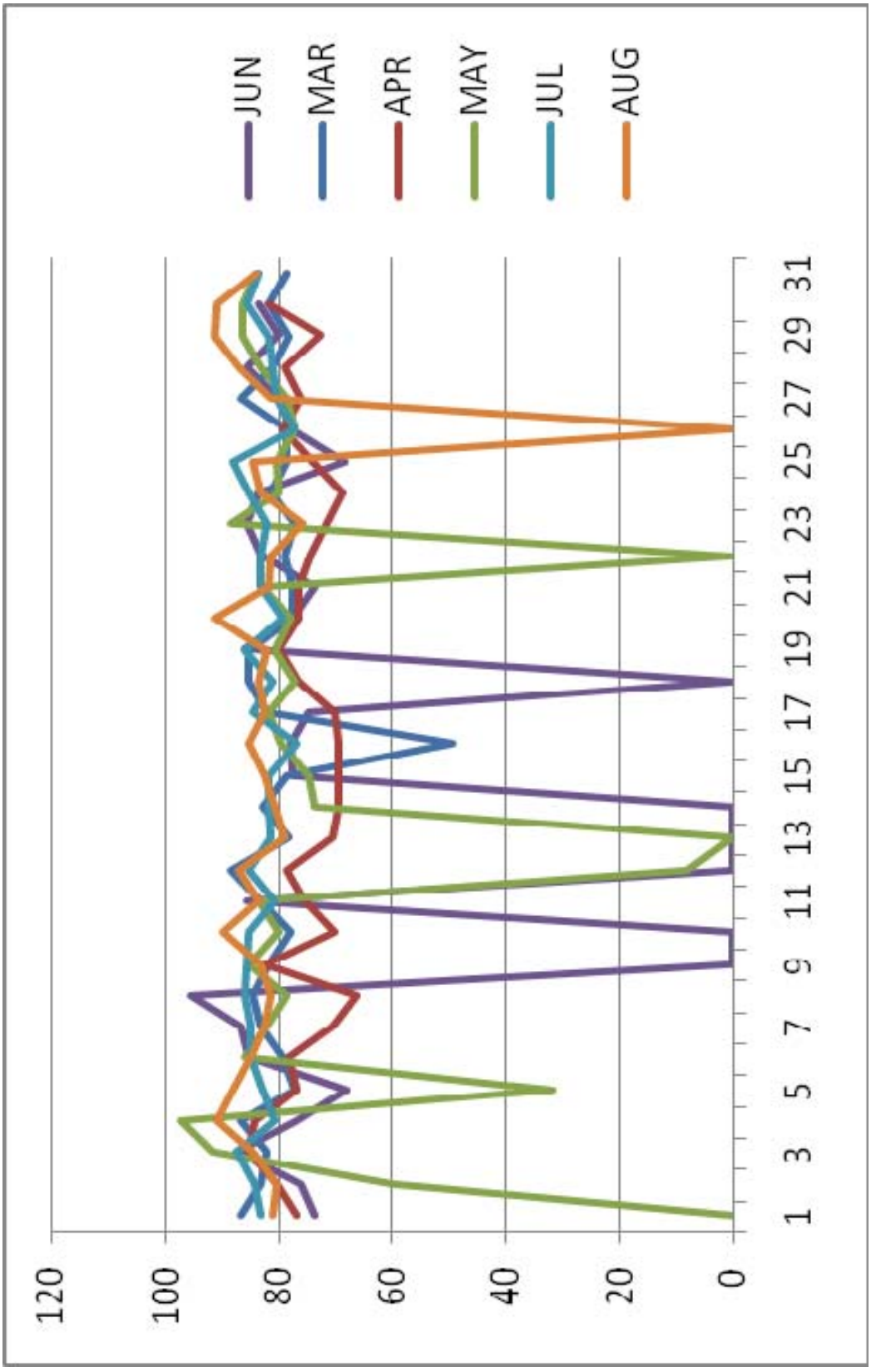


FIG 5.6 TCH IN SERVICE RATE (MARCH – AUGUST 2006)

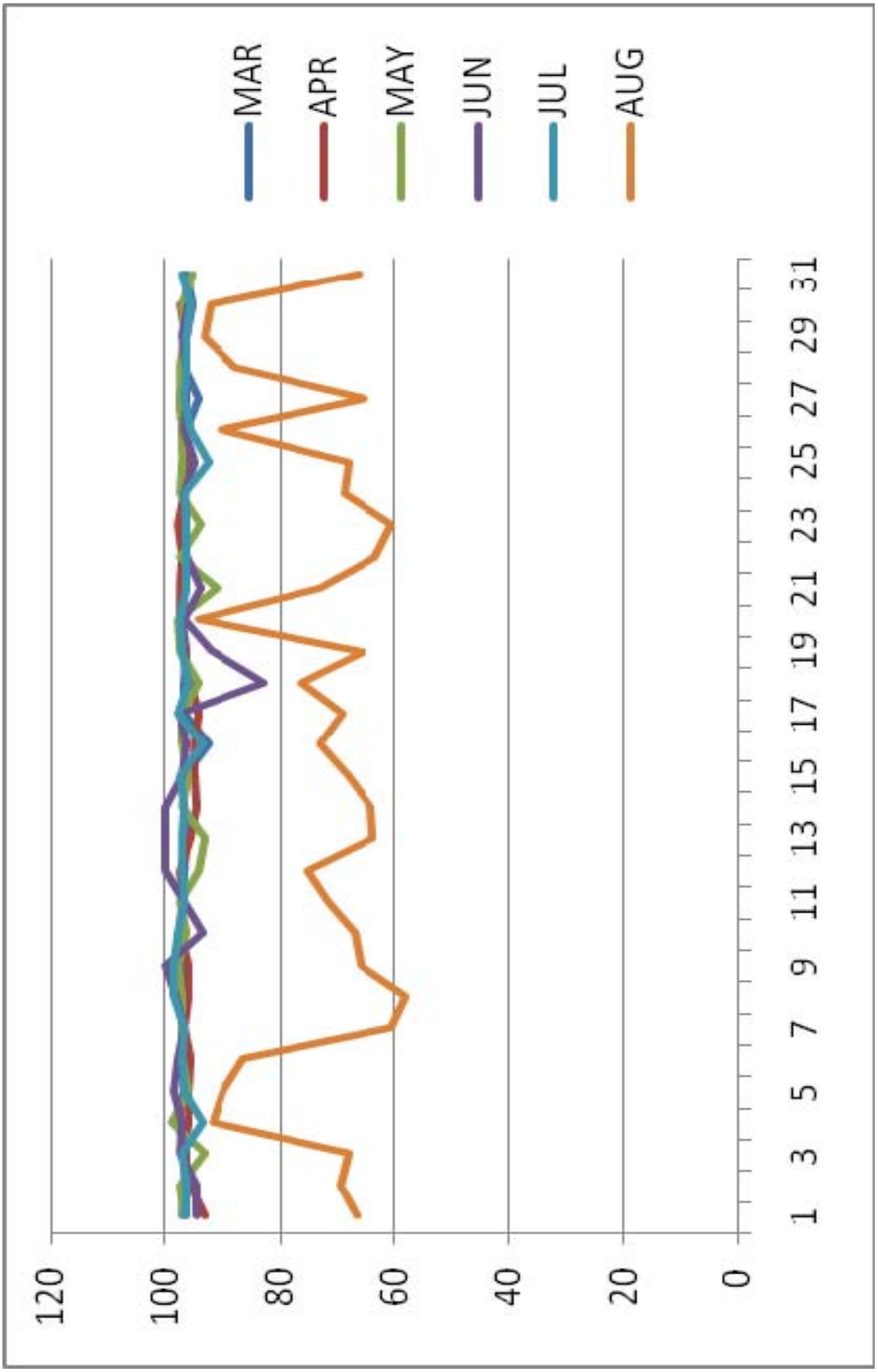


FIG 5.7 RADIO SWITCH RATE (MARCH – AUGUST 2006)

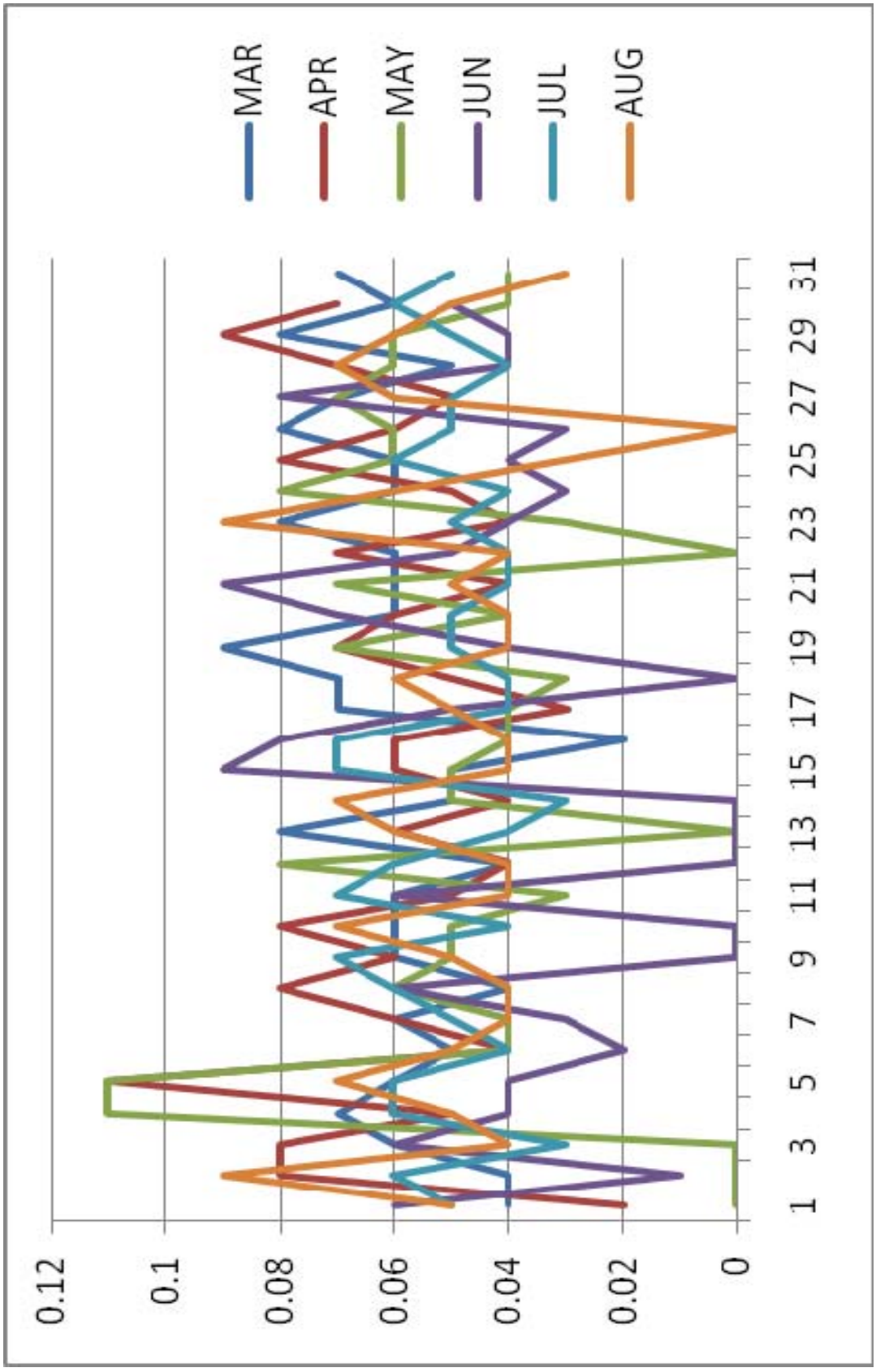


FIG 5.7 CALL DROP RATE (MARCH – AUGUST 2006)

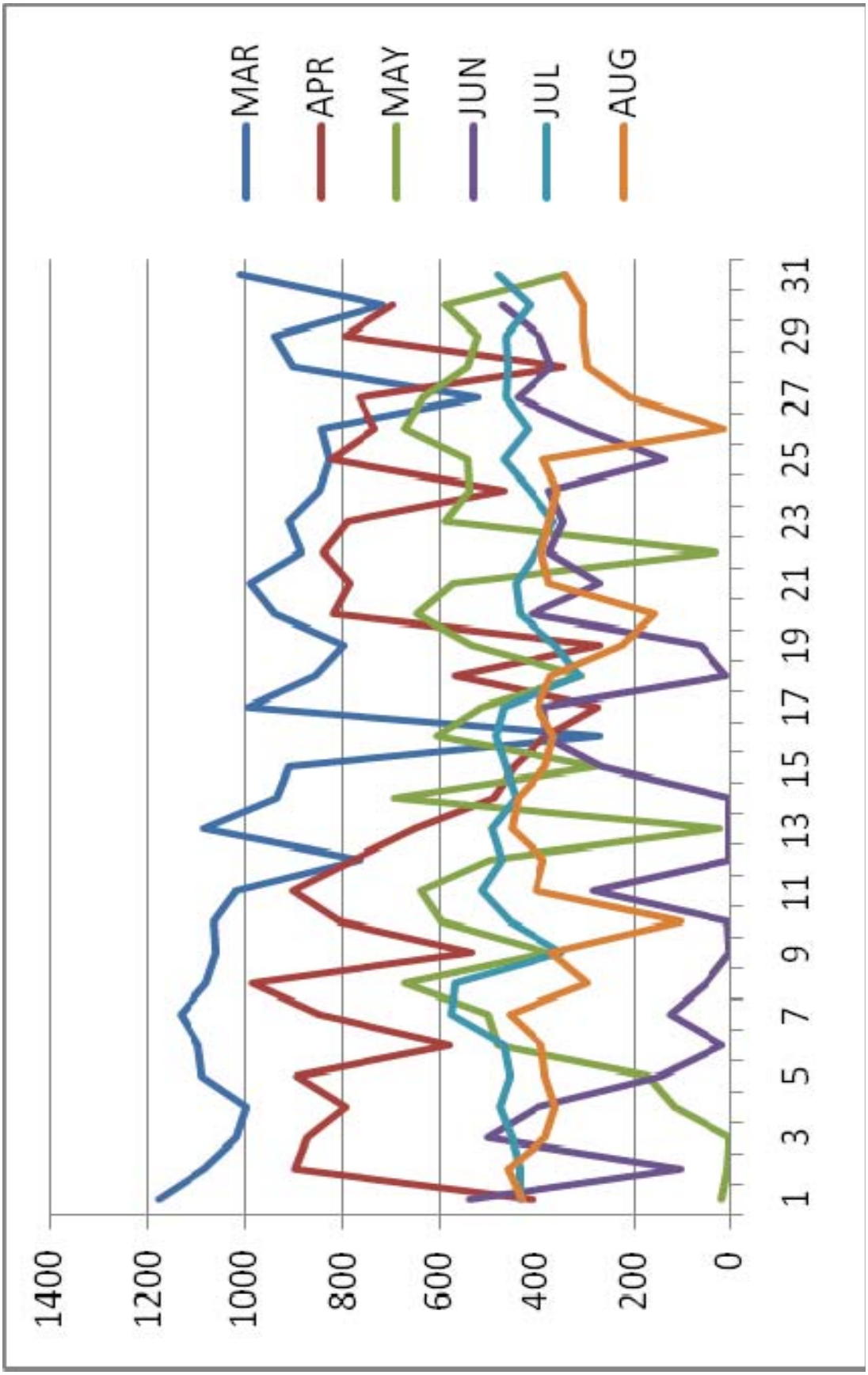


FIG 5.9 TRAFFIC IN ERLANG (MARCH – AUGUST 2006)

5.6 COMMENTS ON THE DATA OBTAINED

There was decline in daily BSC traffic(Erl) as the days of the month advanced. The highest BSC daily traffic was recorded in March 2006. The SDCCH in congestion is considerably high. This means that there is urgent need for an expansion of the network, because this could lead to loss of confidence by users as they are constrained to make calls.in the areas of congested network resulting in drop calls.etc

The handover success rate and dual band success rate are equally fair. The handover parameters need to be looked into so as to allow for smooth handovers. The call success and call setup success rates should be beefed up to about ninety percent (90%).

The BSC daily traffic for the month of August was very low compared to the values for the other months, but the handover success rate (both inter cell and dual band) improved. This shows that the concentration of bad handovers is localized where the network was down. Call success rate also improved on that same day. For the traffic it shows a decline from the month of March to August 2006. Among the reasons for this were the over reliance on Nitel transmission. Once Nitel transmission goes down it goes along with M-tel transmission especially along Abuja route since all M-tel calls have to re route to Abuja before a call is established. This is bacause both the billing server and HLR are located at M-tel Abuja MSC. For the Call Drop, apart from Nitel transmission going on and off, most of M-tel sites are located in remote areas. For example in Kaduna area, M-tel has only about fifteen functional sites, so once a subscriber moves from one location to another it is difficult for the cells to hand over to its neigbour because of the wide distance. Other areas have only one BTS like Zuru in Birnin Kebbi state, so once a subscriber moves from a coverage area the call will drop because there is no available cell to hand over to. Other reasons include equipment failure. It was observed from the OMC that most of the TRU boards have major and minor alarms,which need to be replaced immediately. For the period between May to July

2006 ,Nitel Staff embarked on strike, which affected the performance of the Network seriously. Because of steep competition, once a subscriber is lost, it is extremely difficult to get the subscriber back and the traffic reduces to only about less than twenty thousand as compared to sixty thousand in March 2006, as shown in figure 5.9.

CHAPTER SIX

CONCLUSION

6.1 INTRODUCTION

M-tel Nigeria Limited is one of the licensed GSM companies in Nigeria. The company utilizes the GSM technology employing both frequency division multiple access (FDMA) and time division multiple access (TDMA) for mobile telephony. The main features of GSM are mobility, roaming and data messaging. Giving the versatility of the GSM technology.

The place of Quality of service improvement in a GSM network can not be overemphasized because it goes a long way to confirm the reliability of the network. It also ensures that the subscribers in the network retain the services of the network and there is a high possibility of more subscribers coming to the network. Though a rigorous and time consuming exercise, it is a very important aspect of the GSM network. It can be visualized as a GSM maintenance tool used for tuning up the network and also identifying and removing bottlenecks (congestion, interference, call drop etc) from the network.

6.2 SUMMARY OF RESULTS

A study on Quality of service carried out at the Kaduna M-tel Switch has shown (from the data collected) most of the faults occur at the Abis and the A interface, link between the Base Transceiver Station (BTS), the Base Station Controller (BSC) and the Mobile Switching centre (MSC) respectively. The faults include power outage, malfunctions of some components and modules in both the BSC and BTS rack, lack of cooling systems in both BTS and repeater stations. In the BTS side there are faults like call drop as a result of poor handover which also occurred frequently. Network system must perform reliably

in the face of fierce competition as success or failure will be the direct impact of customer satisfaction.

6.3 SIGNIFICANCE OF WORK

This thesis serves as a useful tool for the performance improvement of M-tel Nigeria Limited and also to test the quality of service for any other GSM operators. It is common knowledge that the GSM subscriber population density has been on a rapid increase from the inception of the technology. At the last count, the total subscriber density is about twenty - five million. As observed, Quality of service improvement is carried out to identify the following bottlenecks experienced in the network and proffer solutions to them: congestion, call drop, poor hand over and black spots. The results have shown that there is a complete neglect by the network over these issues, and there are no prompt responses to faults on the network.

The advantages of Quality of service are so enormous that it can not be overlooked. When done on a periodic schedule, it tunes up the network. The application of the results obtained can also be used to determine the overall subscriber base of the network

6.4 LIMITATION

Unavailability of data from other GSM operators to make comparison, as their Quality of service data were classified as top company secret, this is because the data can be used to determine the overall performance of these networks. Also there was the unavailability of tools in obtaining and analyzing the data in this thesis.

6.5 CONCLUSION

All the causes of every fault have been identified and solutions for better performance have equally been proffered. The analysis of data obtained from the Operation and Maintenance Center for– Radio (OMCR) using bar and line charts inferred that the M-tel network performance in Kaduna zone needs to be improved with emphasis placed on the Quality of service improvement exercise, continuous training of operation staff as well as finding a lasting solution to the power outages in the BTS and repeater stations. The result obtained from this thesis shows how gradually the network traffic reduced from 1100 (Erlang) to less than 200 (Erlang) as shown in fig 5.9. The result also shows a frequent call drop in the six months period, even though for the month of March to May 2006, the result was considerably fair. But it worsened for the months of June to August 2006 as in fig 5.8. The SDCCH in service rate was good for the months of March to May 2006, but was poor for the months of June to August 2006 as in figure 5.1. Also the SDCCH in congestion rate for June to August 2006 was very poor (above 15%) but comparatively better for the months of March to May 2006 as in fig 5.2. Both the hand over and dual handover success rates for the six months period is fair (above 70%), even though the threshold is >95% as in figures 5.3 and 5.4.The radio switch rate was also good for the five months period above 90% but very poor for the month of August 2006 as shown in figure 5.7. TCH in service rate was better for the months of June to August 2006, but fair for March, April and May 2006 as in figure 5.6.

6.6 RECOMMENDATION FOR FURTHER WORK

1. This investigation is only on some few parameters for voice measurement. For further work, other parameters should be studied and they should include; call completion rate, minimum call setup time, maximum call setup time, speech quality, number of blocked calls, and location updates

2. Data measurement should also be included in further investigation such as in GPRS radio link parameters, with respect to reliability, throughput and delay

3. Quality of service comparison with other operators should also be encouraged in further research.

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APPENDIX A KPIs for March 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	92.42	9.93	89.45	86.84	79.49	86.63	96.89	0.04	1178.36
2ND	91.31	13.23	87.53	86.65	78.43	82.94	96.78	0.04	1083.34
3RD	90.18	11.42	88.46	86.56	74.77	81.85	96.29	0.06	1017.95
4TH	81.52	4.64	86.56	86.44	82.79	86.71	97.76	0.07	994.83
5TH	89.01	11.34	90.23	85.65	84.99	77.06	96.78	0.06	1088.01
6TH	91.64	10.2	87	86.54	78.75	79.3	96.46	0.05	1096.36
7TH	92.42	12.3	88.63	88.12	77.64	83.12	97.01	0.06	1132.1
8TH	90.23	11.06	89.2	87.32	83.21	84.42	96.96	0.04	1078.23
9TH	88.91	12.74	90.1	88.22	75.16	81.58	96.87	0.06	1058.57
10TH	90.41	13.3	86.35	83.7	71.74	77.79	97	0.06	1063
11TH	91.13	12	86.64	84.44	77.47	83.13	96.97	0.06	1016.59
12TH	91.7	8.74	88.23	86.65	84.95	88.37	96.83	0.04	765.25
13TH	86.78	13.42	85.75	83.86	72.99	78.06	96.27	0.08	1084.95
14TH	91.62	11.24	88.02	86.36	78.34	82.79	96.68	0.05	932.76
15TH	80.7	30.09	88.58	86.42	58.05	78.42	96.88	0.05	909.24
16TH	79.78	11.16	91.4	90	83.97	49.21	92.48	0.02	268.54
17TH	88.33	12.9	88.16	85.76	77.05	81.94	96.79	0.07	990.38
18TH	85.18	8.1	87.6	85.19	83.97	85.37	96.53	0.07	856.185
19TH	81.52	3.88	86.25	83.49	87.9	85.17	96.45	0.09	799.73
20TH	76.88	15.85	88.77	86.41	70.44	77.39	97.08	0.06	937.84
21ST	86.18	13.5	88.34	86.21	71.14	77.55	96.67	0.06	986.38
22ND	83.16	13.62	90.27	88.88	71.77	78.93	97.04	0.06	883.27
23RD	83.65	14.57	86.6	84.39	70.48	77.25	96.45	0.08	910.69
24TH	88.3	11.37	86.4	84.11	76.5	81.28	96.6	0.06	848.57
25TH	82.51	13.81	86.66	84.19	72.08	78.57	96.52	0.06	826.76
26TH	79.58	12.35	85.34	82.61	73.57	78.36	96.18	0.08	845.14
27TH	80.79	6.33	89.79	87.86	89.98	86.5	94.17	0.07	520.94
28TH	77.05	11.48	88.98	88.36	75.48	80.81	96.71	0.05	902.25
29TH	79.69	14.66	87.08	84.49	71.4	78.22	96.46	0.08	936.8
30TH	78.89	9.39	88.9	86.66	80.9	81.64	95.18	0.06	714
31ST	86.5	14.66	88.15	85.81	71.81	78.5	96.36	0.07	1008.62

APPENDIX B KPIs for April 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	84.31	5.42	92.57	91.37	93.25	76.98	93.01	0.02	410.23
2ND	80.93	9.89	87.2	84.61	79.5	80.41	95.61	0.08	895.76
3RD	84.53	8.51	90.26	88.67	83.63	85.51	96.72	0.08	870.79
4TH	89.76	8.82	91.14	89.59	83.39	84.42	95.84	0.05	791.54
5TH	88.93	10.14	84.28	82.98	76.45	76.92	95.76	0.11	893.89
6TH	71.22	9.77	89.23	87.79	80.47	78.46	95.39	0.04	576.56
7TH	75.82	18.16	80.68	77.68	62.53	70.23	96.54	0.06	845.06
8TH	81.73	19.89	79.81	76.17	58.82	66.09	95.77	0.08	983.13
9TH	89.09	7.06	90.49	89.33	85.55	82.8	95.93	0.06	534.48
10TH	81.76	17.03	88.52	88.08	62.22	70.07	97.13	0.08	805.4
11TH	83.61	12.79	87.85	86.14	69.69	75.29	97.02	0.05	900.17
12TH	81.74	13.17	91.61	91.42	71.65	78.65	97.26	0.04	775.95
13TH	87.43	8.72	86.71	86.03	72.1	70.4	95.36	0.06	647.29
14TH	84.65	7.59	85.55	85.12	74.4	69.24	94.53	0.04	486.84
15TH	53.94	11.97	85.23	85.58	69.79	69.21	94.82	0.06	444.61
16TH	54.13	11.3	87.57	87.26	71.44	69.33	94.62	0.06	382.83
17TH	85.32	9.83	82.98	81.29	80.96	69.94	94.11	0.03	273.39
18TH	78.5	8.38	84.2	81.99	78.29	76.51	95.34	0.05	567.78
19TH	32.18	9.32	83.99	79.57	77.57	80.18	96.44	0.07	268.27
20TH	90.99	12.86	87.84	86.84	70.07	76.43	97.28	0.06	818.6
21ST	84.89	15.72	86.25	86.22	67.93	76.63	97.33	0.04	785.4
22ND	84.07	14.56	83.26	82.42	67.75	74.43	96.79	0.07	836.71
23RD	80.53	16.02	86.38	85.71	62.96	71.4	97.64	0.04	789.15
24TH	54.27	24.45	87.33	88.59	55.55	68.59	96.56	0.05	465.33
25TH	82.08	15.74	86.87	87.53	66.83	73.91	96.62	0.08	823.86
26TH	78.48	14.26	85.06	84.71	72.22	79.56	96.9	0.06	729.81
27TH	68.49	15.26	85.91	85.63	68.91	76.1	97.24	0.05	762.81
28TH	39.01	29.89	84.24	83.55	60.11	78.91	96.42	0.07	341.29
29TH	71.15	13.79	84.18	82.67	67.78	72.67	96.28	0.09	794.34
30TH	63	4.53	86.68	84.58	82.34	81.91	97.38	0.07	694.65

APPENDIX C: KPIs for May 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	35.59	10.81	100	100	89.18	0	96.58	0	15.42
2ND	64.69	1.37	28.57	20	98.49	59.7	97.29	0	3.82
3RD	18.67	0.01	100	100	99.98	91.8	93.24	0	0.03
4TH	24.6	0	85.98	83.94	99.68	97.33	98.82	0.11	115.29
5TH	38.3	0.68	81.01	79.77	96.42	31.95	96.11	0.11	170.76
6TH	67.48	2.73	86.74	84.62	87.64	86.08	97.19	0.04	481.62
7TH	80.3	14.36	84.87	83.01	73.9	82.19	97.15	0.04	500.92
8TH	72.28	18.52	84.91	82.24	67.9	78.67	96.96	0.06	672.23
9TH	53.7	14.81	87.55	85.81	76.05	85.45	97.61	0.05	376.37
10TH	68.55	13.75	83.05	79.62	73.47	79.93	96.52	0.05	596.67
11TH	79.87	9.86	89.62	87.7	78.65	83.6	97.37	0.03	637.69
12TH	61.46	15.5	84.98	82.68	75.2	8	94.35	0.08	498.18
13TH	63.7	10.63	83.33	83.33	88.27	0	93.09	0	19.32
14TH	75.68	21.88	86.36	83.87	60.94	73.48	96.94	0.05	691.67
15TH	35.44	17.95	89.97	87.96	65.78	74.62	96.08	0.05	278.38
16TH	82.5	15.26	88.98	86.73	70.57	79.63	97.1	0.04	605.45
17TH	69.79	16.44	89.74	88.04	71.71	81.76	96.9	0.04	513.76
18TH	75.38	16.48	89.25	88.58	80.68	77.28	94.19	0.03	307.12
19TH	65.67	15.57	87.22	88.52	71.54	80.83	97.42	0.07	534.72
20TH	81.26	15.07	90.2	91.61	69.19	77.74	97.64	0.04	644.05
21ST	71.16	16.42	87.04	88.26	72.43	82.85	91.05	0.07	570.56
22ND	76.17	4.32	89.23	90.47	95.47	0	97.42	0	28.48
23RD	81.99	12.12	89.57	88.31	80.75	88.31	93.84	0.03	589
24TH	81.38	20.16	88.34	86.63	71.27	79.94	97.29	0.08	539.09
25TH	74.51	15.57	89.55	90.59	71.13	80.33	97.11	0.06	544.16
26TH	76.75	15.34	88.61	88.74	68.89	77.11	97.08	0.06	670.65
27TH	77.54	16.28	86.51	85.87	69.51	78.56	97.39	0.07	632.51
28TH	72.51	14.4	87.8	88.94	74.56	83.14	97.24	0.06	540.93
29TH	76.62	8.44	87.7	87.61	83.56	86.3	96.53	0.06	523.37
30TH	75.83	8.42	89.93	91.02	82.91	86.52	97.08	0.04	587.61
31ST	80.51	9.78	88.33	86.92	86.63	83.73	95.25	0.04	341.42

APPENDIX D KPIs for June 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	73.67	11.43	85.71	86.09	72.64	73.56	94.58	0.06	539.06
2ND	69.83	4.48	83.93	86.18	86.94	76.12	94.58	0.01	104.74
3RD	76.74	12.89	84.04	83.92	79.31	87.35	97.6	0.06	499.92
4TH	41.63	23.42	87.99	84.66	62.17	76.74	97.19	0.04	399.47
5TH	21.31	24	81.72	77.43	53.88	67.98	98.53	0.04	144.38
6TH	9.13	2.8	65.45	61.09	86.81	85.08	97.95	0.02	16.01
7TH	29.87	38.18	86.94	83.93	56.56	86.6	96.77	0.03	123.97
8TH	16.36	4.07	88.87	88.47	94.26	95.45	98.35	0.06	49.33
9TH	0	0	100	100	100	0	100	0	0
10TH	13.06	8.82	100	100	91.17	0	93.58	0	2.41
11TH	48.5	4.34	86.57	85.33	86.33	85.52	96.89	0.06	283.78
12TH	0	0	100	100	100	0	100	0	0
13TH	0	0	100	100	100	0	100	0	0
14TH	0	0	100	100	100	0	100	0	0
15TH	39.44	9.36	81.85	84.61	74.56	77.3	97.19	0.09	266.92
16TH	55.72	9.73	82.84	86.17	75.17	77.63	96.4	0.08	378.92
17TH	55.15	30.76	84.57	86.19	54.51	74.49	97.4	0.05	386.9
18TH	16.65	14.04	100	100	85.95	0	82.94	0	7.72
19TH	26.4	2.41	82.62	79.3	95.16	85.81	92.01	0.04	62.84
20TH	66.21	24.8	83.91	83.59	61.79	77.29	96.88	0.07	410.66
21ST	38.23	26.2	84.69	87.04	60.17	73.38	93.89	0.09	268.72
22ND	69.89	13.89	88.15	85.92	75.93	83.1	96.36	0.05	374.45
23RD	69.97	12.59	90.91	90.36	78.72	85.48	96.47	0.04	343.77
24TH	72.1	8.4	88.93	86.86	80.58	83.57	96.79	0.03	374.7
25TH	30.73	20.83	89.46	87.59	59.75	68.15	94.97	0.04	136.47
26TH	54.76	14.24	90.41	88.1	70.37	77.88	96.97	0.03	303.01
27TH	74.65	9.95	85.52	82.89	76.5	79.72	96.41	0.08	437.91
28TH	74.78	8.37	87.11	85.2	82.74	85.38	96.5	0.04	370.59
29TH	73.78	16.21	91.4	91	69.97	79.89	97.33	0.04	395.74
30TH	81.68	8.33	90.37	91.92	81.45	83.47	95.96	0.05	471.85

APPENDIX E KPIs for July 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	77.74	8.77	90.41	88.55	80.14	83.22	96.53	0.05	433.08
2ND	69.22	8.36	89.84	88.27	81.64	84.02	96.24	0.06	434.06
3RD	77.26	7.51	88.99	86.99	84.58	87.41	97.07	0.03	452.09
4TH	80.6	11.22	84.16	82.56	78.87	80.52	93.51	0.06	476.41
5TH	81.67	8.95	85.13	81.76	79.97	82.6	96.62	0.06	454.15
6TH	76.39	11.56	88.38	85.6	78.7	84.75	97.09	0.04	467.63
7TH	83.63	8.31	87.34	85.47	81.91	84.73	96.77	0.05	574.13
8TH	74.01	8.65	89.93	88.71	80.84	85.9	98.49	0.06	565.09
9TH	68.42	12.3	90.31	89.14	77.58	85.75	98.43	0.07	345.57
10TH	72.03	13.3	90.39	88.25	76.44	85.13	97.87	0.04	453.93
11TH	78.57	14.88	84.87	81.82	72.82	80.57	96.67	0.07	513.91
12TH	77.1	11.13	88.69	88.8	79.11	85.11	97.16	0.06	470.3
13TH	73.62	19.27	85.72	82.99	69.14	81.22	96.99	0.04	489.94
14TH	71.28	17.48	85.87	82.79	71.06	81.53	96.82	0.03	441.69
15TH	74.1	20.72	83.8	81.61	67.97	81.62	97.44	0.07	461.81
16TH	75.37	15.31	79.31	84.88	72.62	76.71	93.53	0.07	483.51
17TH	71.85	17.9	87.5	85.83	72.02	84.52	97.89	0.04	467.04
18TH	53.21	24.47	83.75	80.46	64.99	80.85	96.18	0.04	310.48
19TH	76.4	19.04	87.09	84.92	72.94	85.85	97.02	0.05	358.6
20TH	66.77	19.58	87.46	84.94	66.77	79.16	97.34	0.05	433.99
21ST	73.41	13.19	85.8	82.44	76.54	83.04	96.43	0.04	441.53
22ND	72.12	17.87	88.64	86.3	72.26	83.04	96.52	0.04	402.71
23RD	74.24	19.95	85.07	84.01	69.85	82.1	96.37	0.05	363.47
24TH	70.14	15.3	88.04	85.6	75.78	85.13	96.85	0.04	415.06
25TH	23.15	3.15	91.72	90.35	94.21	88.07	92.53	0.06	467.24
26TH	58.99	26.19	84	79.78	61.22	77.13	95.59	0.05	417.22
27TH	71.74	22.3	87.07	85.93	66.14	80.43	96.59	0.05	462.26
28TH	77.08	23.23	87.23	84.79	65.98	81.11	96.49	0.04	457.88
29TH	73.3	19.54	88.09	85.55	69.59	81.6	96.38	0.05	464.21
30TH	72.34	4.26	85.16	82.3	87.81	85.75	95.82	0.06	411.75
31ST	79.02	20.24	86.77	84.1	70.13	83.58	96.96	0.05	479.65

APPENDIX E KPIs FOR AUGUST 2006

DAYS OF THE MONTH	SDCCH in service rate	SDCCH congestion rate	Handover success rate	Dual Handover Success rate	Call success rate	TCH in service rate	Radio switch rate	Call drop rate	Traffic
1ST	67.22	22.87	84.5	80.6	96.25	80.98	66.53	0.05	432.11
2ND	77.17	20.04	80.64	79.83	95.48	80.28	69.45	0.09	460.66
3RD	69.44	23.01	86.59	84.44	97.18	84.58	68.18	0.04	383.56
4TH	64.19	3.21	85.56	83.05	97.18	90.76	91.81	0.05	359.43
5TH	67.79	3.76	79.48	77.08	96.65	87.99	89.85	0.07	383.7
6TH	63.49	4.35	85.62	83.04	96.14	84.98	86.3	0.05	391.26
7TH	69.03	28.59	89.15	87.15	98.02	82.25	60.7	0.04	456.56
8TH	59.02	31.78	87.48	85.4	97.02	81.32	58.22	0.04	295.4
9TH	59.96	24.84	84.76	81.66	96.75	83.27	65.97	0.05	371.26
10TH	27.85	28.74	87.2	87.19	97.5	89.98	67.09	0.07	104.15
11TH	72.65	18.44	84.26	81.52	96.94	83.37	71.69	0.04	404.03
12TH	66.63	15.85	90.12	88.95	98.4	87	75.28	0.04	384.72
13TH	69.26	23.63	85.66	82.9	96.92	79.05	63.75	0.06	451.59
14TH	64.78	25.97	78.86	75.37	95.77	80.7	64.36	0.07	439.86
15TH	67.98	22.9	77.44	74.02	95.92	82.37	68.15	0.04	380.49
16TH	66.48	18.32	82.02	79.64	92.32	85.42	73.14	0.04	363.87
17TH	66.98	21.42	78.91	75.28	96.12	82.31	69.29	0.05	399.23
18TH	63.83	14.83	78.09	73.52	95.88	83.63	76.29	0.06	368.84
19TH	35.51	23.65	84.71	81.8	96.98	81.89	65.77	0.04	224.94
20TH	32.54	2.86	83.15	81.39	95.79	91.26	94.22	0.04	156.99
21ST	64.28	16.66	79.75	76.41	95.71	81.54	73.19	0.05	374.64
22ND	67.46	25.06	88.23	86.18	97.39	81.23	63.54	0.04	389.3
23RD	64.53	26.98	92.04	91.1	95.26	75.57	60.85	0.09	372.81
24TH	72.9	20.65	89.28	87.62	97.54	83.09	68.88	0.06	358.52
25TH	72.99	21.21	92.86	92.06	98.73	84.42	67.96	0.03	386.3
26TH	70.27	9.82	100	100	96.45	0	90.17	0	13.19
27TH	42.89	24.8	88.52	86.61	96.74	81.47	65.14	0.06	209.43
28TH	59.84	4.63	86.05	83.53	96.43	87.19	87.95	0.07	293.1
29TH	63.09	1.61	87.05	84.48	97.4	91.14	93.3	0.06	304.31
30TH	69.94	2.64	86.63	84.92	97.36	90.84	91.97	0.05	304.25
31ST	69.38	24.2	89.68	89.32	97.24	83.9	66.36	0.03	342.55

APPENDIX G SDCCH IN SERVICE RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	92.42	84.31	35.59	73.67	77.74	67.22
2	91.31	80.93	64.69	69.83	69.22	77.17
3	90.18	84.53	18.67	76.74	77.26	69.44
4	81.52	89.76	24.6	41.63	80.6	64.19
5	89.01	88.93	38.3	21.31	81.67	67.79
6	91.64	71.22	67.48	9.13	76.39	63.49
7	92.42	75.82	80.3	29.87	83.63	69.03
8	90.23	81.73	72.28	16.36	74.01	59.02
9	88.91	89.09	53.7	0	68.42	59.96
10	90.41	81.76	68.55	13.06	72.03	27.85
11	91.13	83.61	79.87	48.5	78.57	72.65
12	91.7	81.74	61.46	0	77.1	66.63
13	86.78	87.43	63.7	0	73.62	69.26
14	91.62	84.65	75.68	0	71.28	64.78
15	80.7	53.94	35.44	39.44	74.1	67.98
16	79.78	54.13	82.5	55.72	75.37	66.48
17	88.33	85.32	69.79	55.15	71.85	66.98
18	85.18	78.5	75.38	16.65	53.21	63.83
19	81.52	32.18	65.67	26.4	76.4	35.51
20	76.88	90.99	81.26	66.21	66.77	32.54
21	86.18	84.89	71.16	38.23	73.41	64.28
22	83.16	84.07	76.17	69.89	72.12	67.46
23	83.65	80.53	81.99	69.97	74.24	64.53
24	88.3	54.27	81.38	72.1	70.14	72.9
25	82.51	82.08	74.51	30.73	23.15	72.99
26	79.58	78.48	76.75	54.76	58.99	70.27
27	80.79	68.49	77.54	74.65	71.74	42.89
28	77.05	39.01	72.51	74.78	77.08	59.84
29	79.69	71.15	76.62	73.78	73.3	63.09
30	78.89	63	75.83	81.68	72.34	69.94
31	86.5		80.51		79.02	69.38

APPENDIX H SDCCH IN CONGESTION RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	9.93	5.42	10.81	11.43	8.77	22.87
2	13.23	9.89	1.37	4.48	8.36	20.04
3	11.42	8.51	0.01	12.89	7.51	23.01
4	4.64	8.82	0	23.42	11.22	3.21
5	11.34	10.14	0.68	24	8.95	3.76
6	10.2	9.77	2.73	2.8	11.56	4.35
7	12.3	18.16	14.36	38.18	8.31	28.59
8	11.06	19.89	18.52	4.07	8.65	31.78
9	12.74	7.06	14.81	0	12.3	24.84
10	13.3	17.03	13.75	8.82	13.3	28.74
11	12	12.79	9.86	4.34	14.88	18.44
12	8.74	13.17	15.5	0	11.13	15.85
13	13.42	8.72	10.63	0	19.27	23.63
14	11.24	7.59	21.88	0	17.48	25.97
15	30.09	11.97	17.95	9.36	20.72	22.9
16	11.16	11.3	15.26	9.73	15.31	18.32
17	12.9	9.83	16.44	30.76	17.9	21.42
18	8.1	8.38	16.48	14.04	24.47	14.83
19	3.88	9.32	15.57	2.41	19.04	23.65
20	15.85	12.86	15.07	24.8	19.58	2.86
21	13.5	15.72	16.42	26.2	13.19	16.66
22	13.62	14.56	4.32	13.89	17.87	25.06
23	14.57	16.02	12.12	12.59	19.95	26.98
24	11.37	24.45	20.16	8.4	15.3	20.65
25	13.81	15.74	15.57	20.83	3.15	21.21
26	12.35	14.26	15.34	14.24	26.19	9.82
27	6.33	15.26	16.28	9.95	22.3	24.8
28	11.48	29.89	14.4	8.37	23.23	4.63
29	14.66	13.79	8.44	16.21	19.54	1.61
30	9.39	4.53	8.42	8.33	4.26	2.64
31	14.66		9.78		20.24	24.2

APPENDIX I HAND OVER SUCCESS RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	89.45	92.57	100	85.71	90.41	84.5
2	87.53	87.2	28.57	83.93	89.84	80.64
3	88.46	90.26	100	84.04	88.99	86.59
4	86.56	91.14	85.98	87.99	84.16	85.56
5	90.23	84.28	81.01	81.72	85.13	79.48
6	87	89.23	86.74	65.45	88.38	85.62
7	88.63	80.68	84.87	86.94	87.34	89.15
8	89.2	79.81	84.91	88.87	89.93	87.48
9	90.1	90.49	87.55	100	90.31	84.76
10	86.35	88.52	83.05	100	90.39	87.2
11	86.64	87.85	89.62	86.57	84.87	84.26
12	88.23	91.61	84.98	100	88.69	90.12
13	85.75	86.71	83.33	100	85.72	85.66
14	88.02	85.55	86.36	100	85.87	78.86
15	88.58	85.23	89.97	81.85	83.8	77.44
16	91.4	87.57	88.98	82.84	79.31	82.02
17	88.16	82.98	89.74	84.57	87.5	78.91
18	87.6	84.2	89.25	100	83.75	78.09
19	86.25	83.99	87.22	82.62	87.09	84.71
20	88.77	87.84	90.2	83.91	87.46	83.15
21	88.34	86.25	87.04	84.69	85.8	79.75
22	90.27	83.26	89.23	88.15	88.64	88.23
23	86.6	86.38	89.57	90.91	85.07	92.04
24	86.4	87.33	88.34	88.93	88.04	89.28
25	86.66	86.87	89.55	89.46	91.72	92.86
26	85.34	85.06	88.61	90.41	84	100
27	89.79	85.91	86.51	85.52	87.07	88.52
28	88.98	84.24	87.8	87.11	87.23	86.05
29	87.08	84.18	87.7	91.4	88.09	87.05
30	88.9	86.68	89.93	90.37	85.16	86.63
31	88.15		88.33		86.77	89.68

APPENDIX J DUAL HAND OVER SUCCESS RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	86.84	91.37	100	86.09	88.55	80.6
2	86.65	84.61	20	86.18	88.27	79.83
3	86.56	88.67	100	83.92	86.99	84.44
4	86.44	89.59	83.94	84.66	82.56	83.05
5	85.65	82.98	79.77	77.43	81.76	77.08
6	86.54	87.79	84.62	61.09	85.6	83.04
7	88.12	77.68	83.01	83.93	85.47	87.15
8	87.32	76.17	82.24	88.47	88.71	85.4
9	88.22	89.33	85.81	100	89.14	81.66
10	83.7	88.08	79.62	100	88.25	87.19
11	84.44	86.14	87.7	85.33	81.82	81.52
12	86.65	91.42	82.68	100	88.8	88.95
13	83.86	86.03	83.33	100	82.99	82.9
14	86.36	85.12	83.87	100	82.79	75.37
15	86.42	85.58	87.96	84.61	81.61	74.02
16	90	87.26	86.73	86.17	84.88	79.64
17	85.76	81.29	88.04	86.19	85.83	75.28
18	85.19	81.99	88.58	100	80.46	73.52
19	83.49	79.57	88.52	79.3	84.92	81.8
20	86.41	86.84	91.61	83.59	84.94	81.39
21	86.21	86.22	88.26	87.04	82.44	76.41
22	88.88	82.42	90.47	85.92	86.3	86.18
23	84.39	85.71	88.31	90.36	84.01	91.1
24	84.11	88.59	86.63	86.86	85.6	87.62
25	84.19	87.53	90.59	87.59	90.35	92.06
26	82.61	84.71	88.74	88.1	79.78	100
27	87.86	85.63	85.87	82.89	85.93	86.61
28	88.36	83.55	88.94	85.2	84.79	83.53
29	84.49	82.67	87.61	91	85.55	84.48
30	86.66	84.58	91.02	91.92	82.3	84.92
31	85.81		86.92		84.1	89.32

APPENDIX K CALL SUCCESS RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	79.49	93.25	89.18	72.64	80.14	96.25
2	78.43	79.5	98.49	86.94	81.64	95.48
3	74.77	83.63	99.98	79.31	84.58	97.18
4	82.79	83.39	99.68	62.17	78.87	97.18
5	84.99	76.45	96.42	53.88	79.97	96.65
6	78.75	80.47	87.64	86.81	78.7	96.14
7	77.64	62.53	73.9	56.56	81.91	98.02
8	83.21	58.82	67.9	94.26	80.84	97.02
9	75.16	85.55	76.05	100	77.58	96.75
10	71.74	62.22	73.47	91.17	76.44	97.5
11	77.47	69.69	78.65	86.33	72.82	96.94
12	84.95	71.65	75.2	100	79.11	98.4
13	72.99	72.1	88.27	100	69.14	96.92
14	78.34	74.4	60.94	100	71.06	95.77
15	58.05	69.79	65.78	74.56	67.97	95.92
16	83.97	71.44	70.57	75.17	72.62	92.32
17	77.05	80.96	71.71	54.51	72.02	96.12
18	83.97	78.29	80.68	85.95	64.99	95.88
19	87.9	77.57	71.54	95.16	72.94	96.98
20	70.44	70.07	69.19	61.79	66.77	95.79
21	71.14	67.93	72.43	60.17	76.54	95.71
22	71.77	67.75	95.47	75.93	72.26	97.39
23	70.48	62.96	80.75	78.72	69.85	95.26
24	76.5	55.55	71.27	80.58	75.78	97.54
25	72.08	66.83	71.13	59.75	94.21	98.73
26	73.57	72.22	68.89	70.37	61.22	96.45
27	89.98	68.91	69.51	76.5	66.14	96.74
28	75.48	60.11	74.56	82.74	65.98	96.43
29	71.4	67.78	83.56	69.97	69.59	97.4
30	80.9	82.34	82.91	81.45	87.81	97.36
31	85.81		86.63		70.13	97.24

APPENDIX L RADIO SWITCH RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	96.89	93.01	96.58	94.58	96.53	66.53
2	96.78	95.61	97.29	94.58	96.24	69.45
3	96.29	96.72	93.24	97.6	97.07	68.18
4	97.76	95.84	98.82	97.19	93.51	91.81
5	96.78	95.76	96.11	98.53	96.62	89.85
6	96.46	95.39	97.19	97.95	97.09	86.3
7	97.01	96.54	97.15	96.77	96.77	60.7
8	96.96	95.77	96.96	98.35	98.49	58.22
9	96.87	95.93	97.61	100	98.43	65.97
10	97	97.13	96.52	93.58	97.87	67.09
11	96.97	97.02	97.37	96.89	96.67	71.69
12	96.83	97.26	94.35	100	97.16	75.28
13	96.27	95.36	93.09	100	96.99	63.75
14	96.68	94.53	96.94	100	96.82	64.36
15	96.88	94.82	96.08	97.19	97.44	68.15
16	92.48	94.62	97.1	96.4	93.53	73.14
17	96.79	94.11	96.9	97.4	97.89	69.29
18	96.53	95.34	94.19	82.94	96.18	76.29
19	96.45	96.44	97.42	92.01	97.02	65.77
20	97.08	97.28	97.64	96.88	97.34	94.22
21	96.67	97.33	91.05	93.89	96.43	73.19
22	97.04	96.79	97.42	96.36	96.52	63.54
23	96.45	97.64	93.84	96.47	96.37	60.85
24	96.6	96.56	97.29	96.79	96.85	68.88
25	96.52	96.62	97.11	94.97	92.53	67.96
26	96.18	96.9	97.08	96.97	95.59	90.17
27	94.17	97.24	97.39	96.41	96.59	65.14
28	96.71	96.42	97.24	96.5	96.49	87.95
29	96.46	96.28	96.53	97.33	96.38	93.3
30	95.18	97.38	97.08	95.96	95.82	91.97
31	96.36		95.25		96.96	66.36

APPENDIX M CALL DROP RATE DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	0.04	0.02	0	0.06	0.05	0.05
2	0.04	0.08	0	0.01	0.06	0.09
3	0.06	0.08	0	0.06	0.03	0.04
4	0.07	0.05	0.11	0.04	0.06	0.05
5	0.06	0.11	0.11	0.04	0.06	0.07
6	0.05	0.04	0.04	0.02	0.04	0.05
7	0.06	0.06	0.04	0.03	0.05	0.04
8	0.04	0.08	0.06	0.06	0.06	0.04
9	0.06	0.06	0.05	0	0.07	0.05
10	0.06	0.08	0.05	0	0.04	0.07
11	0.06	0.05	0.03	0.06	0.07	0.04
12	0.04	0.04	0.08	0	0.06	0.04
13	0.08	0.06	0	0	0.04	0.06
14	0.05	0.04	0.05	0	0.03	0.07
15	0.05	0.06	0.05	0.09	0.07	0.04
16	0.02	0.06	0.04	0.08	0.07	0.04
17	0.07	0.03	0.04	0.05	0.04	0.05
18	0.07	0.05	0.03	0	0.04	0.06
19	0.09	0.07	0.07	0.04	0.05	0.04
20	0.06	0.06	0.04	0.07	0.05	0.04
21	0.06	0.04	0.07	0.09	0.04	0.05
22	0.06	0.07	0	0.05	0.04	0.04
23	0.08	0.04	0.03	0.04	0.05	0.09
24	0.06	0.05	0.08	0.03	0.04	0.06
25	0.06	0.08	0.06	0.04	0.06	0.03
26	0.08	0.06	0.06	0.03	0.05	0
27	0.07	0.05	0.07	0.08	0.05	0.06
28	0.05	0.07	0.06	0.04	0.04	0.07
29	0.08	0.09	0.06	0.04	0.05	0.06
30	0.06	0.07	0.04	0.05	0.06	0.05
31	0.07		0.04		0.05	0.03

APPENDIX N TCH IN SERVICE RATE DATA
(MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	86.63	76.98	0	73.56	83.22	80.98
2	82.94	80.41	59.7	76.12	84.02	80.28
3	81.85	85.51	91.8	87.35	87.41	84.58
4	86.71	84.42	97.33	76.74	80.52	90.76
5	77.06	76.92	31.95	67.98	82.6	87.99
6	79.3	78.46	86.08	85.08	84.75	84.98
7	83.12	70.23	82.19	86.6	84.73	82.25
8	84.42	66.09	78.67	95.45	85.9	81.32
9	81.58	82.8	85.45	0	85.75	83.27
10	77.79	70.07	79.93	0	85.13	89.98
11	83.13	75.29	83.6	85.52	80.57	83.37
12	88.37	78.65	8	0	85.11	87
13	78.06	70.4	0	0	81.22	79.05
14	82.79	69.24	73.48	0	81.53	80.7
15	78.42	69.21	74.62	77.3	81.62	82.37
16	49.21	69.33	79.63	77.63	76.71	85.42
17	81.94	69.94	81.76	74.49	84.52	82.31
18	85.37	76.51	77.28	0	80.85	83.63
19	85.17	80.18	80.83	85.81	85.85	81.89
20	77.39	76.43	77.74	77.29	79.16	91.26
21	77.55	76.63	82.85	73.38	83.04	81.54
22	78.93	74.43	0	83.1	83.04	81.23
23	77.25	71.4	88.31	85.48	82.1	75.57
24	81.28	68.59	79.94	83.57	85.13	83.09
25	78.57	73.91	80.33	68.15	88.07	84.42
26	78.36	79.56	77.11	77.88	77.13	0
27	86.5	76.1	78.56	79.72	80.43	81.47
28	80.81	78.91	83.14	85.38	81.11	87.19
29	78.22	72.67	86.3	79.89	81.6	91.14
30	81.64	81.91	86.52	83.47	85.75	90.84
31	78.5		83.73		83.58	83.9

APPENDIX O TRAFFIC IN ERLANG DATA (MARCH – AUGUST 2006)

	MAR	APR	MAY	JUN	JUL	AUG
1	1178.36	410.23	15.42	539.06	433.08	432.11
2	1083.34	895.76	3.82	104.74	434.06	460.66
3	1017.95	870.79	0.03	499.92	452.09	383.56
4	994.83	791.54	115.29	399.47	476.41	359.43
5	1088.01	893.89	170.76	144.38	454.15	383.7
6	1096.36	576.56	481.62	16.01	467.63	391.26
7	1132.1	845.06	500.92	123.97	574.13	456.56
8	1078.23	983.13	672.23	49.33	565.09	295.4
9	1058.57	534.48	376.37	0	345.57	371.26
10	1063	805.4	596.67	2.41	453.93	104.15
11	1016.59	900.17	637.69	283.78	513.91	404.03
12	765.25	775.95	498.18	0	470.3	384.72
13	1084.95	647.29	19.32	0	489.94	451.59
14	932.76	486.84	691.67	0	441.69	439.86
15	909.24	444.61	278.38	266.92	461.81	380.49
16	268.54	382.83	605.45	378.92	483.51	363.87
17	990.38	273.39	513.76	386.9	467.04	399.23
18	856.185	567.78	307.12	7.72	310.48	368.84
19	799.73	268.27	534.72	62.84	358.6	224.94
20	937.84	818.6	644.05	410.66	433.99	156.99
21	986.38	785.4	570.56	268.72	441.53	374.64
22	883.27	836.71	28.48	374.45	402.71	389.3
23	910.69	789.15	589	343.77	363.47	372.81
24	848.57	465.33	539.09	374.7	415.06	358.52
25	826.76	823.86	544.16	136.47	467.24	386.3
26	845.14	729.81	670.65	303.01	417.22	13.19
27	520.94	762.81	632.51	437.91	462.26	209.43
28	902.25	341.29	540.93	370.59	457.88	293.1
29	936.8	794.34	523.37	395.74	464.21	304.31
30	714	694.65	587.61	471.85	411.75	304.25
31	1008.62		341.42		479.65	342.55

APPENDIX P BENCH MARK

KEY PERFORMANCE INDICATORS (KPIs)	DEFINITIONS	EQUATIONS	BENCHMARK/THRESHOLDs
Call Set-up Success Rate	A measure showing the number of calls that are successfully set-up or connected through the overall length of time required to establish a call between users	(Call Completed +Dropped Calls /Call Attempted) * 100	**≥ 75.00%**
Call Success Rate	The ratio of successfully completed calls to the total number of attempted calls	Completed Calls / Call Attempted * 100	**>50.00%**
Call Retention Rate	A measure showing the ability of an established call connection /conversation to be successfully completed without dropping abnormally	100 – (Dropped Calls/Call Attempts) * 100	**> 95%**
Call Drop Rate	A measure of premature disconnection of a call during the 70 – second holding period.	Dropped Calls / Call Attempts * 100	**< 3.5%**
Peak Hour Measured Traffic	The carried traffic in Erlang during the busy hour. It is that hour during the day in which traffic intensity is at its peak		
Post Dialling Delay	Time interval between the time when the customer has completed dialling the required number and the time when the customer receives a confirmation tone		
TCH Congestion Rate	The failure by a network to accept a bid to establish a call		**< 3.0%**
Handover Success Rate	A measure of number of call handover request commands, handover failures and the handover release messages from the network		**> 95%**