UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

EFFECTS OF HANDOFF ON NETWORK CAPACITY AND QUALITY OF SERVICE: KENYA GSM NETWORKS CASE STUDY.

BY

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SUPERVISOR

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Submitted in partial fulfillment of the requirement of Master of Science in Information Science of the University of Nairobi.

DECLARATION

I David N. Mburu hereby declare that this research project is my original work and where there's work or contributions of other individuals, it has been dully acknowledged. To the best of my knowledge, this research work has not been carried out before or previously presented to any other education institution in the world for similar purposes or forum.

Signature.. Date 31/05/2011

David Ng'ang'a Mburu
P56/71604/2008

This research project has been submitted with my approval as the University of Nairobi Supervisor.

Signature .... Date 13/6/2011

Professor W. Okelo Odongo

DEDICATION

I dedicate this project to my wife Monicah, and children Daniel, Bernard and Michelle for their invariable and unrelenting support, encouragement, sacrifice and patience during my difficult times in the course of my studies.

I truly cherish all of you.

May the Almighty God bless you today and forever more.

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Finally, my utmost gratitude goes to our creator the Almighty God for giving me good health and strength without which I would not have come this far.

Thank you Lord.

ABSTRACT

Telecommunication has evolved from the early days where information was conveyed using smoke signs and drum beating through fixed wire communication to today's modern mobile wireless cellular communication systems. In a Public Land Mobile Network, coverage is achieved through application of the cellular concept and the principle of frequency reuse. The overall region is subdivided into small units of area called cells which are covered with radio waves radiated from Base Stations and which provide connection of the Mobile Stations to the Network. As the mobile Subscriber traverses the network, there is need to have the resources that maintain and manage the connection transparently transferred between neighbouring cells. This process is referred to as Handoff and requires to be catered for in planning of the network through implementation of an efficient Handoff Scheme. The effects of Handoff is determined through the PCB and PHD, and their cumulative resultant the GoS.

The methods encountered in literature highlight theoretical methods of determining Network GoS. Most of these methods start by modeling hypothetical networks for analysis where factors that influence the quantities (PCB and PHD) to be determined like cell shape, capacity, MS speed are approximated. As a result of the inefficiency of these existing methods for determining QoS, a case study was conducted to determine the QoS offered by the Kenyan GSM mobile Operators.

Two sets of data were collected from the leading three GSM operators. In the first set of data it was deduced that the three Telecommunication Operators have implemented the non priority Handoff scheme.

The numerical data obtained carried details of the recorded numbers of request to setup calls and to handoff calls to the neighboring cells. This data was analyzed using simple statistics and probability methods. The results revealed that Telecommunication Operator One offered a GoS of 41% during busy Hour. This indicated a lot of congestion in the network. Due to this extremely high GoS another set of data was acquired from the same Operator covering the non BH. On analysis of non busy hour data it gave a GoS of 1.7% which is within the recommended limits. The deterioration of QoS during busy hour has been attributed to the big number of Customers being served using equal resources to TO with less than a fifth of the customers. Analysis of the other data from Telecommunication Operator Two and Three revealed that the networks did not suffer from the problem of overload. The good QoS found with TO two and Three was due to their small customer bases.

A solution to the problem of congestion was conceptualized in the form of Advanced Adaptive Multi-Rate (AAMR) Codec and its suitability assessed. It was established that if deployed it is capable of reducing congestion in TO Ones Network from 41% to 2%. This solution does not call for major modification of the network and as demonstrated manages to reduce congestion during BH by a factor of more than twenty.

Further research is recommended in the field of capacity expansion with minimal network changes. Such network improvement can be achieved through exploration of the possible increase of the number of timeslots per the 200Khz frequency channel and revision of the modulation schemes employed.

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LIST OF ABBREVIATIONS

Abbreviation	Description
2G	Second Generation
AAMR	Advanced Adaptive Multi-Rate codec
AMPS	Advanced mobile Phone System
AMR	Adaptive Multi-Rate codec
AV	Available
AVER	Average
BH	Busy Hour
BHBD	Busy Hour Busy Day
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CBP	Call Blocking Probability
CD	Call Duration
CDMA	Code Division Multiple Access
CEPT	Conference European des Administrations des Postes et des Telecommunications
CI	Cell Identity
CP	Cell Capacity
CP_t	Cell load at time t-Seconds
CRT	Cell Residence Time
d	Mean Call holding time (mean call duration)
EFF	Effective
Erl	Unit of Telephone Traffic Measurements Erlang
E-TACS	Extended Total Access Cellular System
ETSI	European Telecommunication Standard Institute
FDMA	Frequency Division Multiple Access
FR/2	Half Full Rate
FR/4	Quarter Full Rate
FR	Full Rate
GMSK	Gausian Minimum Shift Keying
GoS	Grade of Service
GSM	Global System for Mobile communication
HO	Handoff or Handover
HOR	Handoff Request
HR	Hour
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union-Radio

ITU-T.....................................International Telecommunication Union-Telecommunication
KPI.....................................Key Performance Indicators
KSM.....................................Kisumu
LC.....................................Location
MAHO.....................................Mobile Assisted HO
MOS.....................................Mean Opinion Score
MOS_{CQE}.....................................MOS Conversational Quality Estimated
MSA.....................................Mombasa
MSC..................................... Mobile Switching Center
NBC.....................................Number of Blocked Channels
NBC.....................................Number of Blocked Calls
NCSR.....................................New Call Setup Request
NHO.....................................Number of HandOffs
NKU.....................................Nakuru
NMT.....................................Nordic Mobile Telephone
NP.....................................No Priority(Zero)
NRB.....................................Nairobi
NSS.....................................Network Sub-System
NTCHD.....................................Number of TCH Denied
OMC.....................................Operation and Maintenance Center
P_b.....................................Probability of Call Blocking
PCB.....................................Probability of Call Blocking
P_d.....................................Probability of Handoff Dropping
PHD.....................................Probability of Handoff Dropping
QoS.....................................Quality of Service
R.....................................Transmission Rating factor
r.....................................TCH requests as a percent of Cell capacity
RQ.....................................Request
RSS.....................................Received Signal Strength
SIR..................................... .Signal – Interference- Ratio
SSS..................................... .Switching Sub-System
STC.....................................Sub Technical Committee
TACS.....................................Total Access Cellular System
TDMA.....................................Time Division Multiple Access
TMN.....................................Telecommunication Management Network
TO.....................................Telecommunication Operator
TRX.....................................Transceiver i.e. Transmitter/Receiver
TTL.....................................Total
WLAN..................................... Wireless Local Area Network
XR..................................... Unspecific bit rate (or Any intermediate bit-rate).

CHAPTER 1: INTRODUCTION

1.1 Background Information.

Telecommunication has its roots in the 1888 discovery of electromagnetic waves by Hertz, and the demonstration of the Transatlantic radio telephony by Marcon in 1897 (Rappaport, 1996). There were many advances in research that lead to the discovery of telephone by Graham Bell in 1946.
There has been a lot of evolution of technologies in this field of telecommunications since the introduction of the fixed telephone services. Fixed telephone networks that were optimized for voice were the most common mode of telecommunication before 1980. Due to demand for Data communication data handling equipments were installed in the network switching nodes together with Data circuit terminating equipments to enable the network carry data. This appeared to be like a single network but it was truly a parallel combination of two networks, the voice network and the data networks. The demand from different categories of users like businesspersons, researchers and people on holiday (Tourists) could not be met by fixed telecommunication networks services. To satisfy the market new technologies that could offer more flexibility in access were the short term solutions. This lead to the 1980's increased deployment of the wireless systems. Later the need for high capacity connectionless systems was found to be the ultimate solution.
The first wireless systems of the 1980s were analog. Most of the technologically developed countries manufactured their own systems. Britain developed and deployed an analog System called Total Access System (ETACS), America Advanced Mobile Phone System (AMPS), Nordic Countries (Finland, Sweden, Norway and Denmark) Nordic Mobile Telephone (Rappaport, 1996). The problem of mobility was reduced but not fully solved.
The world had perches of network coverages' where a given Mobile equipment could not communicate between any pair of networks. This was due to diverse technology standards applied in the development of the network hardware. As a result there was no inter-region service provision. This reduced the network subscriber mobility. To solve this problem a group of standards organizations from different countries came together to try and harmonize the standards so that equipments specifications would no longer depend on the manufacturers. The Groupe Special Mobile was formed to develop a pan-European digital cellular system in 1982. This group later worked under the European Telecommunications Standards Institute (ETSI) and produced the GSM specifications in 1989 (De vriendt, et al.2002).
GSM was later interpreted to mean Global System for Mobile Communication. This basically intended to mean that the system was targeted to make the whole globe (world) appear like it's covered by a single network.
Telecommunication has evolved from the fixed line services that were the dominant type of telecommunications up to the early 1990s, to the present mobile telecommunication. The main difference between the mobile and fixed telecommunications systems is the ability of the mobile system to maintain connection irrespective of the location of the communication terminal devices. This unlimited mobility is achieved through two major modifications of the telecommunications service

area. One is the subdivision of the service area into smaller areas called cells and the allocation of the radio resources necessary to establish and maintain connection to the network. The other one is the implementation of the necessary technology to allow the sustenance of the radio resources to maintain a session as the subscribers crosses the cell boundaries i.e. efficient handovers.

The handover criteria are based on signal quality and distance. These two factors have a lot of effect on the quality of service and the communication systems capacity. Signal quality that is the bit error rate determines the clarity of the voice. Bit error rate is reduced through introduction of redundancy bits and coding. The distance from the base station determines the delay due to the distance covered, while sharing of the channels results to scheduling delay, these delays are countered through timing advance. When handoff is implemented additional negative effects arise such as handoff interference, handoff delay, handoff dropping and increased chances of call blocking.

1.1 Problem Statement

In mobile telecommunication the area served by a given base station (macro, micro or Pico cell) and its immediate neighbourhood appear to be like the only network to a subscriber considering a mean call duration time of 2minutes and vehicular mobility. This is so because within such a duration any given subscriber can only cross one cell boundary. In such a situation a number of subscribers get the impression of the whole network as got from the Quality offered by two or one cell only.
The success of setting up a call and transferring a call from a given cell to the neighbouring cell depends on the planning of the specific area/region. Due to the population distribution and the anticipated pattern of daily movement, cell capacity and the overall planning are never identical for any given two cells. As a result resource demands are not uniform over the whole network. The gravity of this problem is further complicated by the fact that Handoff must be catered for in the network for it to qualify to be a mobile network but it offers varying and unpredictable network resource demands. Furthermore in developing countries there are regions where the coverage or network availability is not normally provided due to demand but is done to meet licensing requirements and telecommunication regulator incentives. It follows that the quality of service for a given network turns out to be almost guaranteed in some regions and in the areas where it is less it falls below the expected level.

Telecommunications standards are set and enforced by the International Telecommunications Union (ITU) through the local communication regulators. Standards are defined as references for delivery of services. In mobile voice communication the chances of failure, to establish a connection and, to transfer an on going call to a new cell are some of the most important standards. ITU has set a standard of less than 2% for the combined call failure (stated as the failure to acquire a traffic channel) that is both call blocking and handoff dropping. A more critical investigation of the determination of this 2% QoS reveals some assumptions of homogeneity in the networks and combination of the network Busy and non Busy Hours. Even though the set standard seem to be adequate as a probability of 0.02 according to statistics is justified to be considered negligibly small. While this is supposed to be the actual situation, the effects of handoff dropping and call blocking are not uniformly distributed (over the network and on time basis) as the standard generalizes.

As expected in any public telecommunication network there turns out to be regions of high, medium, low and sparse network demands. The two Quality of service performance standards of Handoff and Calldrop are more pronounced in the high demand regions. This means that if these two metrics of measurement standards are combined and determined with reference to the affected regions only, i.e. by establishing both the probabilities of call dropping and (meaning-as used in probability) handoff failure by considering the capacities of the congested regions, the result would be expected to be higher than the 2% and hence indicate a worse quality of service than the allowable upper limit. As noted by Leu (2008) most of handoff performance deal with simplified scenarios, which may not fully characterize the overall performance of the network. The actual quality of service prevailing in these networks which is brought about by the effect of handoff on the network capacity is not known.

Both the network operators and their subscribers have used and continue to use the generalized ITU formula irrespective of the important factors like time and the location of the circuits under consideration. The resulting QoS is normally found acceptable to subscribers since it gives a success rate of at least 98% when averaged over a long duration and an expansive area of the network. But the actual state in the field is that if there is any chance of being affected by the network constraints that lead to excessive call drops and handoff failures then the Grade of Service (GoS) can only be higher as it actually need to be determined as a fraction of the subscribers in the affected area only and small time durations. The impact of this problem is averaging lower GoS than the allowed 2% in isolated regions and very good GoS of almost 0% in the major part of the network. The resulting GoS is normally of a value less than 1%. With such a small value or chance of failure it gives a wrong impression of very good GoS. Hence there is need to carry out practical research to determine the effect of Handoff capacity demand on the available capacity and its subsequent negative effects on the GoS, when the network is expected to be experiencing the heaviest load.

1.2 Research Objectives

The objectives of this study were to:

1. Identify the Handoff schemes implemented by the three leading GSM network operators in Kenya and evaluate their performance by determining the effect of catering/provisioning for Handoff calls on network capacity.
2. Determine the effect of Handoff calls on the network Quality of Service using the probability of handoff call dropping, probability of call blocking and the probability of failure of allocation of traffic channel (GoS) metrics of measurement.
3. Develop a suitable conceptual Handoff and network configuration framework that optimizes the network capacity and Quality of service.

1.3 Research Questions

a) What are the different types of Handoff schemes (algorithms) deployed by the three leading mobile Network operators in Kenya?
b) What are the effects of the Handoff schemes used by the three Network Operators in Kenya on network available capacity?
c) What are the effects of the Handoff schemes used by the three Network Operators in Kenya on network Quality of Service with reference to probability of call blocking, probability of handoff dropping and GoS metrics of measurement?
d) How can a Handoff and network configuration conceptual framework be synthesized that can perform better than those handoff schemes being used by the three leading network operators?

1.4 Justification

The effect of handoff on system capacity is not as well understood as other aspects of cellular systems, such as equalization, modulation, and coding. Most studies of handoff performance deal with simplified scenarios, which may not fully characterize the overall performance of the network. Handoff performance is typically quantified in terms of assignment probability and handoff probability at each point along a trajectory taken by a given mobile station (Leu et al, 2008). The system capacity is what determines the two QoS factors of CBP and HDP which are the most valued metrics by the network operator and the subscribers' respectivefully. It follows that to determine the GoS of a network for the purpose of comparing the results with the ITU stated value of 2% a quantitative study was required.
The main cause for handoff is the channel deterioration as the MS nears the cell boundary. The highest contributor to the signal decay is the effect of the inverse square law in propagation of electromagnetic waves. The other cause for signal power reduction is multipath effects. As noted by Zhang, (2010), the fading channel is time-varying, unreliable, and erroneous. Seriously degraded signal may lead to physical link breakdown, and hence, the forced termination of an active call. As a result, similar to the limited bandwidth, the fading channel also plays an equally important role on handoff performance. The number of handoffs recorded by the Telecommunication Management Network (TMN) cannot be differentiated on the basis of their causes. This is true for handoff calls which are directed to new cells. It is clear that handoffs are triggered by multiple effects where some of these effects are time deterministic. This means that the best method to determine such effects is through a survey.
Yu and Lung (2001) argued that it is impractical to completely eliminate handoff call dropping (P_{hd}), the best one could do is to keep P_{hd} below a target level. Moreover, maximizing resource utilization while keeping probability of new call blocking P_{nb}, below a target value is another critical factor for evaluating call admission control algorithms. This means that in a handoff scheme a compromise acceptable value of the P_{hd} and P_{nb} is derived through a balancing act.
It is against the culmination of the above observations that we found it justifiable to carry out a case study to determine the effects of handoff on network capacity and handoff calls on the quality of service. The research also came up with a suitable conceptual framework that optimized capacity and quality of service.

1.5 Scope of the study

In this research we evaluated the performance of the various handover algorithms employed by the leading mobile telecommunications operators with a view towards establishing their effects on quality of service and the network capacity. The network planning was studied together with the ITU/GSM guidelines on the recommended standards and reference made to the key performance indicators intended to be achieved by the networks. This research collected data from the leading three Kenyan telecommunication operators for the total number of the new calls and handoff requests, total successful new calls, handoff requests and the total number of active calls from both newly generated and handoff calls within the cell under study. The data was analyzed and interpreted in line with the existing ITU set standards. Finally a conceptual framework was synthesized that if deployed could perform better and hence mitigate on the problem of congestion. This study was not meant to address other factors that affect quality of service e.g. delay, jitter, Doppler Effect etc. Handoff in this study has been used to represent the net Handoffs into the cell under investigations and specifically voice calls and not other types of communication as referred to as a call.

1.6 Assumptions and limitations

For a research such as this one to yield the desired results the telecommunications network to be investigated required to have well established networks. Networks which have not matured enough have problems of prolonged durations of idle capacity. This results from the fact that the networks subscriber base is in the stage of development. As a consequence any handover request has a chance of one to succeed since the required resources are abundantly available. Thus the quality of service is almost guaranteed. In this case the three leading networks were assumed to have stabilized with respect to the subscriber base growth rate.

The network available capacity was taken to be the maximum number of calls that the section of the network could concurrently maintain. This is different from effective capacity which was taken to mean the number of new calls that could be setup and be supported by the section of the network. Hence the handoff effect was conspicuously brought out through the comparison of the available and effective capacities. Another major presumption was that at the time of observation of the Network the call setup time was negligible because the wireless system is open all the way to near acquisition of TCH. Also adherence to ErlangB planning techniques which do not take queuing into consideration was assumed.

However the network availability is contrary to the Erlang theory which assumes that a network cannot be available throughout. Due to the availability of the medium (air-space)with sufficient RACH, and the fact that our analysis focused on the high demand time, it was legitimate to assume that a given channel could be engaged practically through out since the calls destination was unlikely to be the same It was also assumed that the system was to achieve its upper limit at FR (fixed bit-rate). That is there was no (or zero) chance of the system increasing capacity through extra resource sharing.

The calling behavior of the network subscribers was assumed to be independent of the number of the week of the month and the Month, but dependent on the day of the week.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Wireless transmission systems send signals through air or space without being tied to a physical line. All wireless media rely on various parts of the electromagnetic spectrum. Some types of wireless transmission, such as Microwave or Infrared, by nature occupy specific spectrum frequency ranges. Other types of wireless transmissions, such as Cellular telephones and paging devices, have been assigned a specific range of frequencies by National regulatory agencies and international agreements. Each frequency range has characteristics that determine the specific function or data communications niche assigned to it.

Cellular telephones work by using radio waves to communicate with radio antennas (towers) placed within adjacent geographic areas called cells. A telephone message is transmitted to the local cell by the cellular telephone and then is passed from antenna to antenna cell to cell until it reaches the cell of its destination, where it is transmitted to the receiving telephone. Old cellular systems are analog and newer cellular systems are digital.

Digital cellular services use several different competing standards that do not interoperate with each other. This means that digital cellular handsets cannot work on networks that use another wireless standard. The two widely deployed second-generation (2G) cellular systems are GSM and CDMA (Code Division Multiple Access).

In Europe and much of the rest of the world outside the United States, the standard used is GSM, short for Global Systems for Mobile communication. (Khan, 2009)

The design objective of the early mobile radio systems was to achieve a large coverage area by using a single, high powered transmitter with an antenna mounted on a tall tower. While this approach achieved very good coverage, it also meant that it was impossible to reuse those same frequencies throughout the system, since any attempts to achieve frequency reuse would result in interference. Faced with the fact that government regulatory agencies do not make spectrum allocations in proportion to the increasing demand for wireless services, it becomes imperative to restructure the radio telephone system to achieve high capacity with limited radio spectrum, while at the same time covering very large areas. The demand for radio coverage with limited resource (frequency spectrum) calls for utilization of the cellular concept through the principle of frequency reuse and implementation of efficient handoff schemes.

2.2. The cellular concept

In a Public Land Mobile Telecommunication Network (PLMN) system, Mobile Subscribers (MS) traversing the area covered by the network require communication services through a wireless connection. In such a system, coverage area is normally divided into smaller regions referred to as cells to allow the reuse of frequency spectrum to increase the network capacity. Each cell is served by its own transmitter and receiver (base transceiver station, BTS) to manage the mobiles within their area of jurisdiction. As the number of mobile subscribers' increases, cell capacities can be increased or new cells can be deployed to accommodate the growth. This is practical since frequencies used in one cell cluster can be reused in other cells. The planning and network management is done such that conversations can be handed over from cell to cell to maintain constant phone service as the subscriber moves between cells.

Problem of Spectral congestion and user capacity is solved using frequency reuse

Advantages of frequency reuse include:

- Offers high capacity with limited spectrum allocation
- Covers the whole service area using a number of low power transmitters

A portion of the total channels available is allocated to each base station.

To reduce interference, neighboring cells are assigned different set of frequency channels. It is important then to establish the cell shape that can achieve the best coverage. Consider rectangular cells shown figure 2.1

The distance from the center to the edge of the cells varies as indicated by R_1 and R_2 hence this choice cannot provide uniform signal coverage at the cell edges. Another possible choice is circular cell shape as shown in figure 2.2 The circular cell shapes have a problem of dark areas i.e. regions that do not have any signal coverage at all. The advantage of this cell type is its uniform radius. But this advantage is undermined by the presence of the dark regions which have no signal at all.

The third possible cell shape is the hexagonal shape, as shown in figure 2.3.

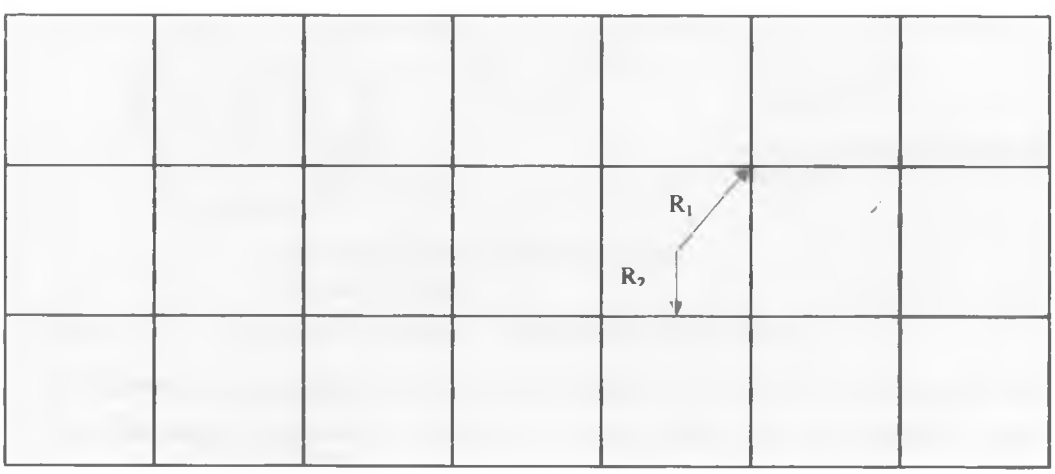


Figure 2.1 Rectangular Cell Shapes (Adopted from CETTM, 2007)

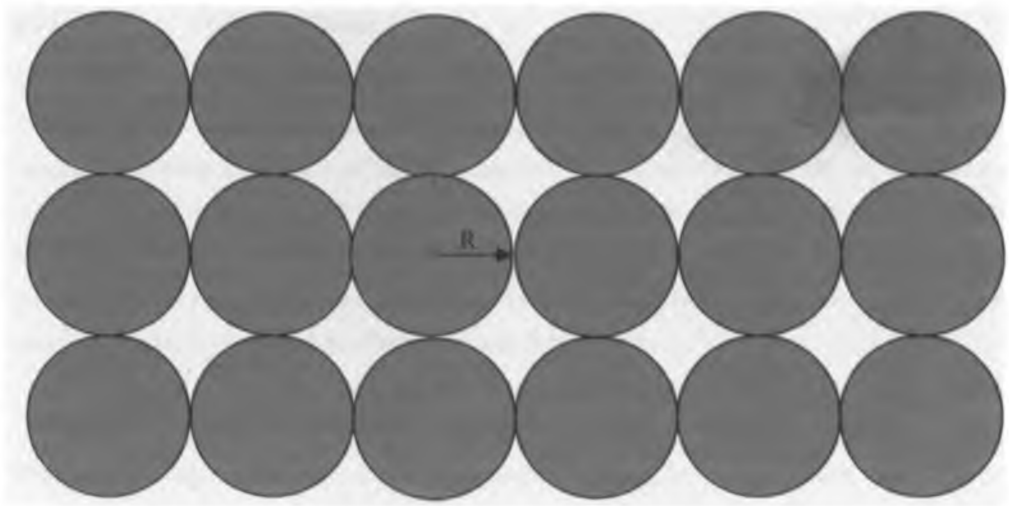


Figure 2.2 Circular Cell Shapes (Adopted from CETTM, 2007)

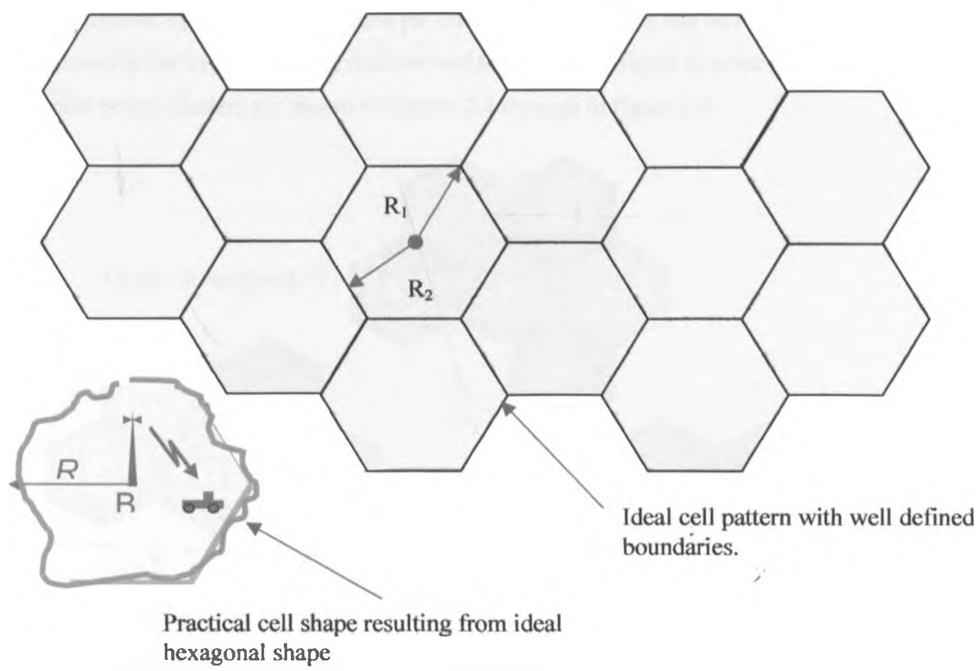


Figure 2. 3 Hexagonal Cell Shapes (Adopted from CETTM,2007))

The hexagonal cell shape approximates to the desired ideal cell coverage of a well planned network. This arises from the approximate uniform cell radius inherent from the hexagonal shape. On implementation of the Real Shape of a Cell becomes irregular due to terrain, physical obstructions, and practical problem of finding acceptable BTS sites at the center of the hexagonal area. These effects results in rounded edges which pushes the shape closer to being circular hence resulting to a near uniform signal strength at the edges with no dead zones as in the case of circular cells. This makes the hexagonal cell shape the most suitable for application in network planning.

2.2.1 Frequency Reuse

RF bandwidth is the primary constraint in wireless systems. Efficient use of this precious resource involves what is called frequency reuse. A radio channel is simultaneously used by multiple transmitters as long as they are sufficiently separated to avoid interference. Cells are assigned a group of channels that is completely different from neighbouring cells. The coverage area of cells (called footprint) is limited by a boundary so that the same group of channels can be reused. Frequency reuse is exercised with extra care on its adverse effect by minimizing the Probability of interference between same frequencies (Co-channel interference) which is reduced by

- Increasing the frequency reuse distance
- Lowering the transmitted power levels by the concerned cells

Thus, a combination of power control and frequency planning is used in cellular systems to prevent interference. The regular repetition of frequencies results in a clustering of cells. All the frequency allocated to an operator can be used in a single cluster. The size of the cluster and the frequency reuse distance are determined by the number of cells per cluster. No frequency can be reused within a cluster. The larger a cluster is the larger the reuse distance and the larger the signal to noise ratio (Elberspacher, 2001). Examples of cell clusters are shown in figures 2.4 through to figure 2.6.

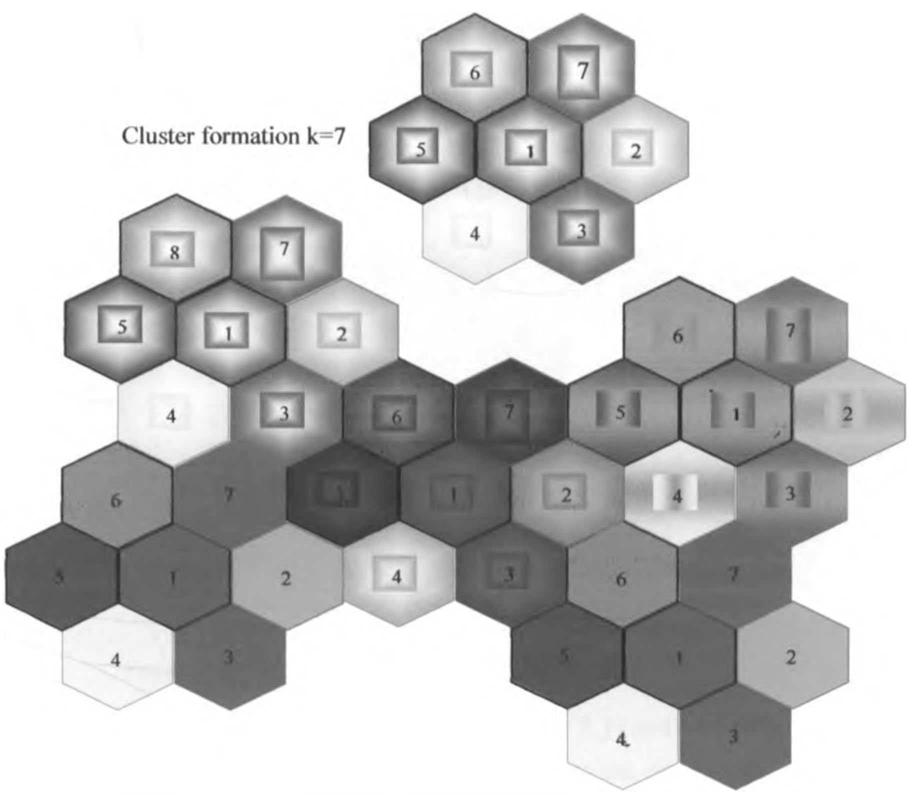


Figure 2. 4 Frequency reuse with cluster formation K = 7

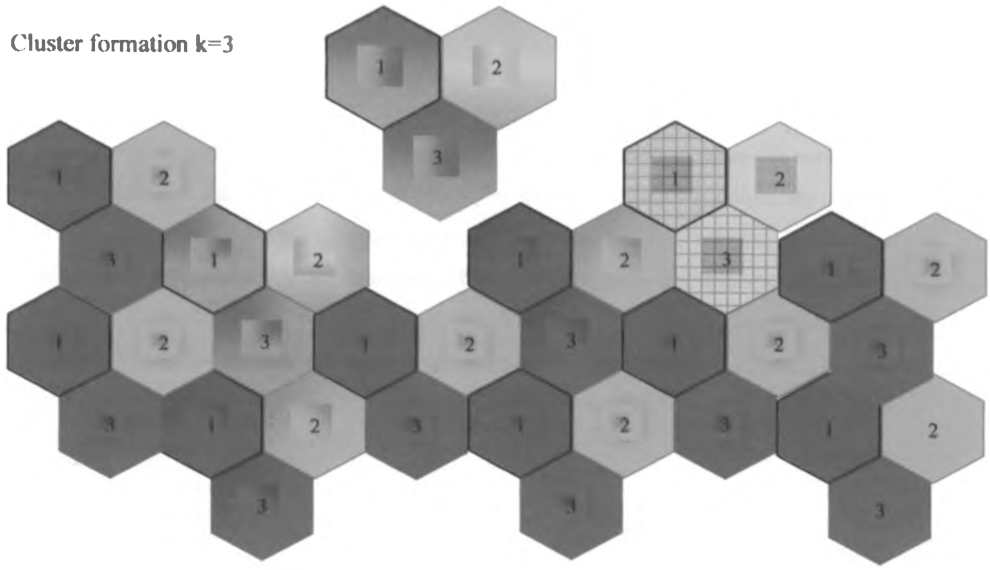


Figure 2.5 Frequency reuse with cluster formation K = 3

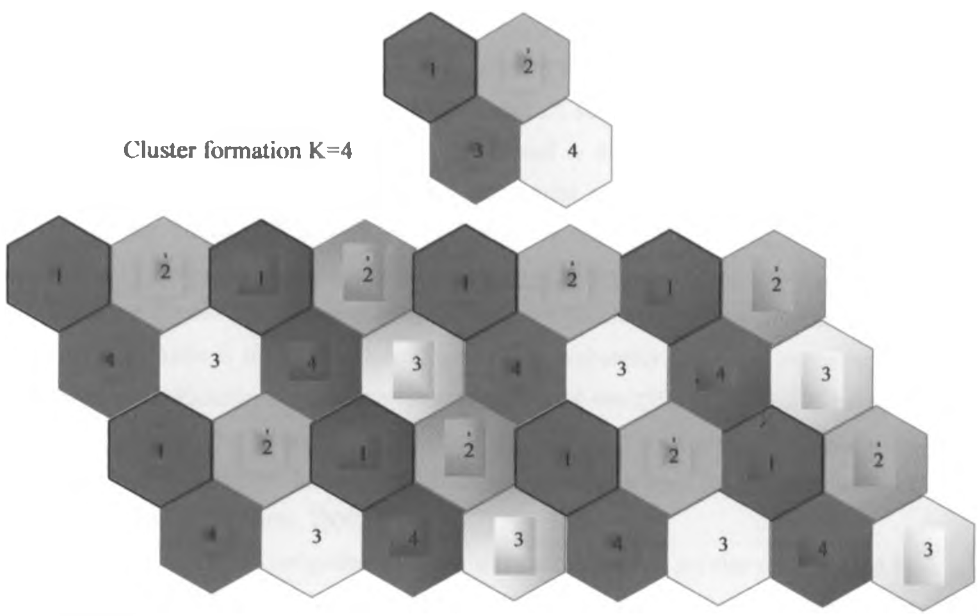


Figure 2. 6 Frequency reuse with cluster formation K = 4

The most widely used cluster formations are for values of K = 7, 12 and 19.

The difficulty in development of cellular networks involves the problem created when a mobile subscriber crosses a boundary between two cells when engaged in a call. As adjacent areas do not use the same radio channels, a call must either be dropped or transferred from one radio channel to another when a user crosses the boundary between adjacent cells. Since dropping of calls would be retrogressive and contrary to the concept of mobility, the process of handoff was created.

2. 3. Handoff (Handover)

Handoff in wireless mobile networks deal with the mobility of the end users in a mobile network, it guarantees the continuity of the wireless services when the mobile user moves across the cellular boundaries. In first and second-generation mobile networks, hard handoff is employed; in third and fourth generation networks, which are predominantly based on the code division multiple access (CDMA) technology, the soft handoff concept is introduced. Compared with the conventional hard handoff, soft handoff has the advantages of smoother transmission and less ping-pong effects. Handoffs in wireless mobile networks are mainly used for maintaining service continuity during mobility through Handoff Management. (Akyildiz, et al., 1999).

Cellular systems apply smaller radii cells in order to get high capacity systems. This is because of the limited frequency spectrum. The frequency band is divided into smaller bands and those bands are reused in noninterfering cells. Smaller cells cause an active mobile station (MS) to cross several cells during an ongoing conversation. This active call should be transferred from one cell to another one in order to maintain call continuity during boundary crossings. Handoff (or handover) process is transferring an active call from one cell to another. The transfer of current communication channel could be in terms of time slot, frequency band, or code word to a new cell. If new cell has some unoccupied channels then it assigns one of them to the handed off call. If all of the channels are in use at the handoff time there are two possibilities, to drop the call or to delay it for a while. Different handoff techniques are proposed in literature and two of the most important metrics for evaluating a handoff technique are forced call termination (dropping) probability (HDP) and call blocking probability (PCB). The forced termination probability is the probability of dropping an active call due to handoff failure and the call blocking probability is probability of blocking a new call request. The aim of a handoff procedure is to decrease forced termination probability while not increasing call blocking probability significantly. Handoff represents a process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress. It is often initiated either by a cell boundary crossing or by a deteriorated quality of signal in the current channel (Hentschl, 2009).
Handoff is divided into two broad categories, hard and soft handoffs. They are also characterized by "break before make" and "make before break". As the name implies, in hard handoff, current resources are released before new resources are utilized, while in soft handoff, both existing and new resources are used during the handoff process.

Handoff is a process of automatically transferring a call in progress from one radio cell to another one while e.g. the subscriber is roaming. This process is started each time the base station controller (BSC) in charge has selected a new radio cell which can offer a better radio transmission quality. This will occur if for example the subscriber moves into the new radio cell during a call or if the radio reception characteristics change for any other reason. The switching element is informed so that communication can be switched over from a channel in a given cell to another channel in another cell. However, in order to efficiently allocate radio resources to a mobile station (MS) requiring so, a handoff can be initiated in an earlier phase, i.e. before call setup has been started. In the assignment phase the switching element requests specific radio resources from the BSC. If a proper source is not available due to congestion or another unfavorable radio condition, the BSC can initiate a handoff to another cell as early as in the assignment phase. GSM recommendation 03.09 denotes this as a directed retry handoff. As a consequence of such handoff, the serving cell is replaced by a redirected cell during the assignment. The physical connection path between the mobile station and the switching element is improved. In this way, handoff ensures that the connection is always assigned to the most suitable radio link.

There are different types of handoffs (Fig. 2.7), depending on the switching element controlling the old radio cell and new radio cell within the network. The location of the switching element strongly affects the procedures to be used as stipulated below.

- **BSC-controlled handover**

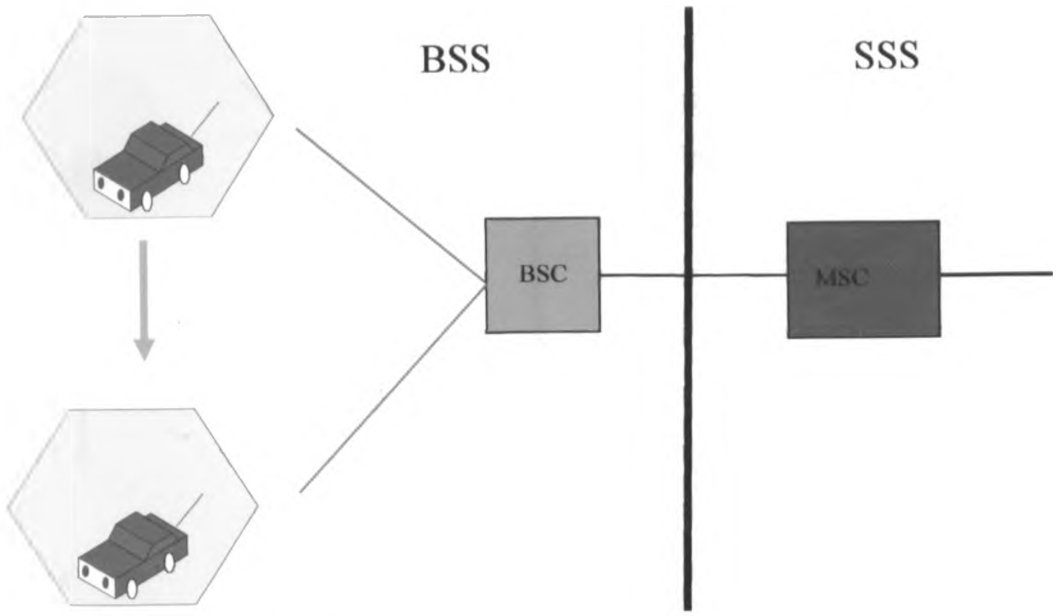
Old and new radio cell belong to the same Base Station Controller (BSC). This BSC is the switching element and executes the handover process all by itself because it is aware of all relevant information. However, its Mobile-services Switching Center (MSC) is informed about the new radio cell.

- **Intra-MSC handover** is MSC-controlled

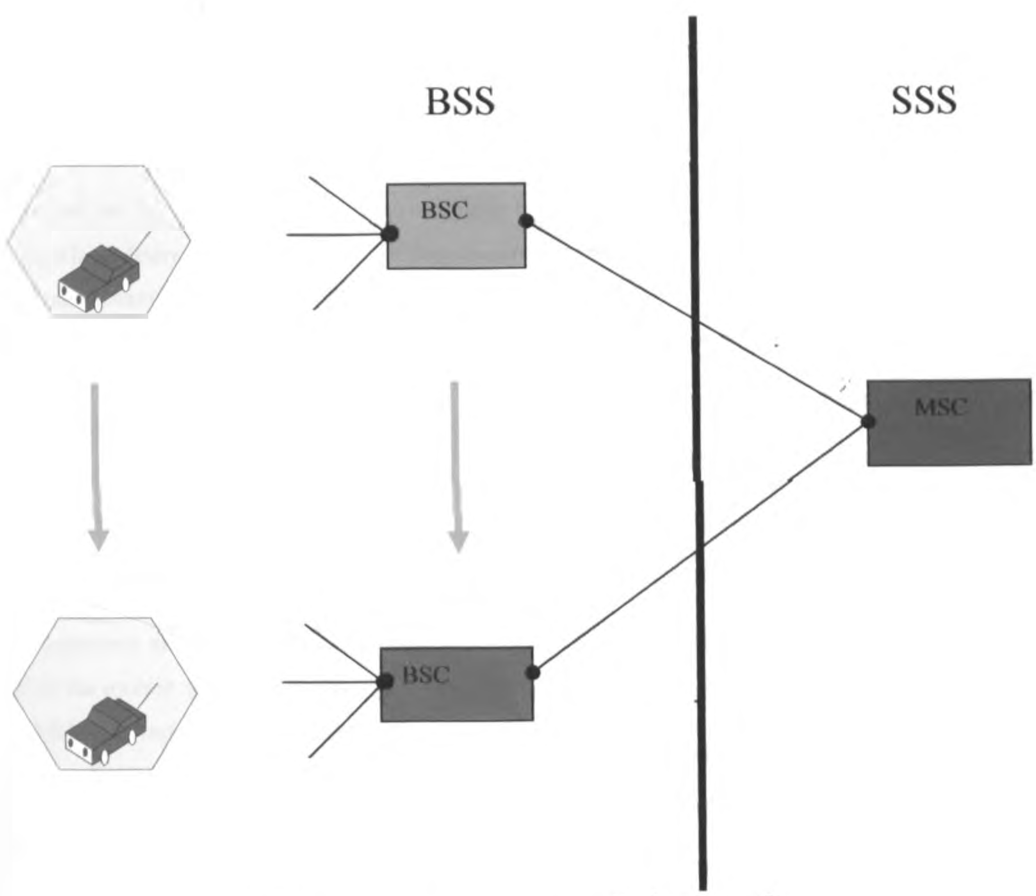
Old and new radio cell belong to the same MSC, but to different BSCs. The handover process is completely controlled by this MSC.

- **Inter-MSC handover** too is MSC-controlled

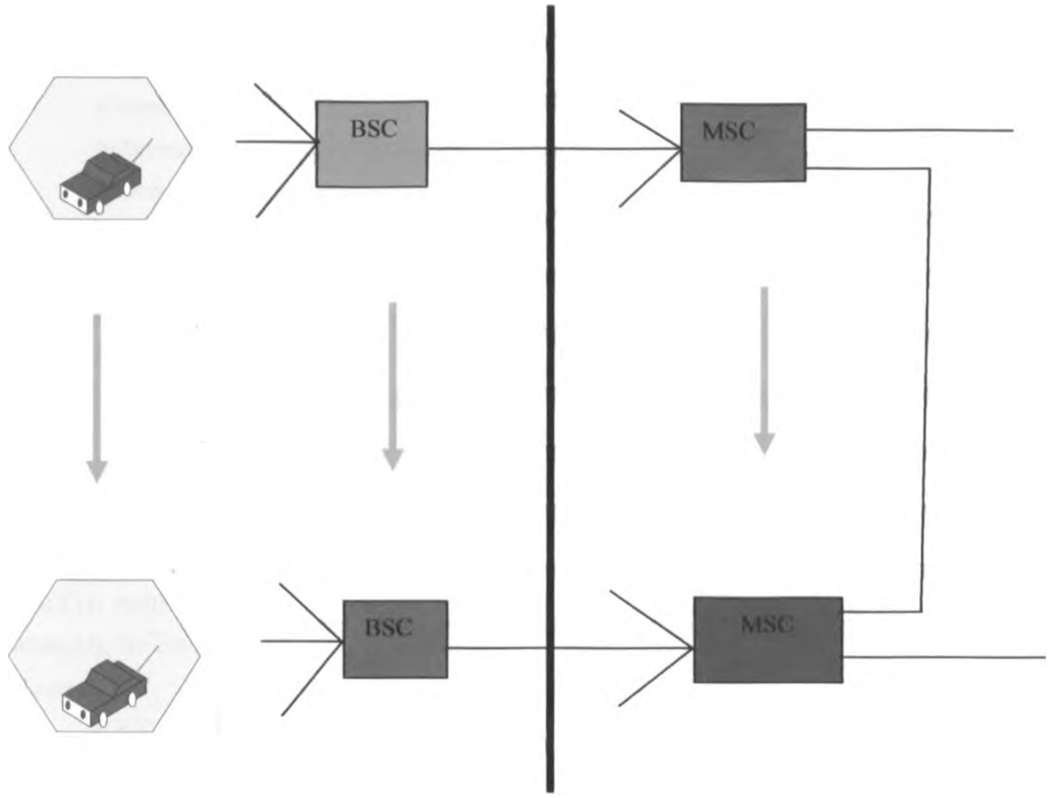
Old and new radio cell now belong to different MSCs. In this case, the first MSC (at which handover is originated) is the switching element. Call control (including charge data registration and signaling) remains in this first MSC for the entire duration of the connection; this is the anchor principle to which GSM Recommendation 03.09 refers (Siemens, 1998)



(a) BSC controlled Handoff



(b) Intra MSC handoff



(c) Inter MSC handoff

Figure 2. 7 Types of Handoff (Adopted from Information call handling-Siemens, 1998)

Handoffs can be initiated from the network side or by the ME. This results to two major categories of Handoffs as determined by the source of the measurement data.

Network Controlled Handoff (NCHO)

NCHO is used in first generation cellular systems such as Advanced Mobile Phone System (AMPS) where the mobile telephone switching office (MTSO) is responsible for overall handoff decision. In NCHO, the network handles the necessary received signal strength (RSS) measurements and handoff decision.

Mobile Assisted Handoff (MAHO)

In NCHO the network load is high since the network handles the all the HO processes itself. In order to reduce the loading of the network, the MS is charged with the responsibility for doing RSS measurements and send them periodically to BS in MAHO. Based on the received measurements, the BS or the mobile switching center (MSC) decides when to handoff. MAHO is used in Global System for Mobile Communications (GSM)

2.3.2 Criterions for Handoff

Some of the parameters to be taken into consideration while a handover decision is to be made are:

Static data:

a) Maximum transmit power of the mobile station

b) Maximum transmit power of the serving BTS

c) Maximum transmits power of the neighboring BTSs'.

Measurements made by Mobile station:

a) Downlink transmission quality (Bit error rate)

b) Downlink reception level of the serving cell

c) Downlink reception level of the neighboring cells

Measurements made by the BTS:

a) Uplink transmission quality

b) Uplink reception level on current channel

c) Timing advance.

Traffic considerations: Cell capacity and load of the serving and neighboring cells are the traffic considerations done to assess the need for handoff..

2.3.3 Handover Process

For making a handover decision the BSS will process, store and compare certain parameters from the measurements made and predefined thresholds. During every slow associated control channel (SACCH) multiframe, the BSS compares each of the processed measurements with the relevant thresholds. We can broadly classify the handover causes into four broad categories.

a) RXLEV-Received signal level.

b) RXQUAL-Received signal quality.

c) DISTANCE

d) PGBT (Power budget) (Hentscthel, 2009)

2.3.4 Handoff Schemes

Handover scheme is the implementation of the necessary technology which automatically changes channel/frequency to maintain an active speech connection over cell boundaries when a mobile station moves from one cell to another during an ongoing conversation.

When allocating a channel, a simple scheme employed by cellular technologies handles both types of calls (new calls and handoffs) without preference. This means that the probabilities of new call blocking and handoff failure are the same. This scheme is referred to as the non-prioritized scheme (NPS). However, from the user's point of view, the forced termination of an ongoing call is considered to be worse than blocking a new call attempt. Therefore, it becomes necessary to introduce methods for decreasing the probability of handoff failure as well as new call blocking.

There exist various handoff prioritization schemes which can be sorted into four classes:

- Reserving a number of channels exclusively for handoffs
- Queuing handoff requests
- Sub-rating an existing call to accommodate a handoff
- Combination of the above classes

Different handoff techniques are proposed in literature and two of the most important metrics for evaluating a handoff technique are forced termination probability and call blocking probability. The forced termination probability is the probability of dropping an active call due to handoff failure and the call blocking probability is the probability of blocking a new call request (CBP). Reserving a number of channels exclusively for handoffs greatly improves the HDP. While dedicating a number of channels to be used for newly generated calls improves the CBP. The best handoff scheme is the one that is able to strike a compromise to optimize on the two performance indices. Political issues and market forces create a very dynamic situation such that it is difficult to zero onto a perfect Handoff scheme. Another cause of unprecedented changes are frequent enforcement of Regulatory requirements e.g. number portability requirement enforcement by the Communication Commission of Kenya (CCK) Kenyan Government communication regulator (Nyabiage 2010) and lowering of inter-connection rate. These changes cause subscriber movement among the Operators which causes unexpected redistribution of resource demands.

2.3.5 Handoff Initiation

Handoff initiation is the process of deciding when to request a handoff. Handoff decision is based on received signal strengths (RSS) from current BS and neighboring BSs. In Fig 2.8 we examine RSSs of current BS (BS1) and one neighboring BS (BS2). The RSS gets weaker as MS goes away from BS1 and gets stronger as it gets closer to the BS2 as a result of signal propagation. The received signal is averaged over time using an averaging window to remove momentary fadings due to geographical and environmental factors. There are four main handoff initiation techniques namely relative signal strength, relative signal strength with threshold, relative signal strength with hysteresis, and relative signal strength with hysteresis and threshold.

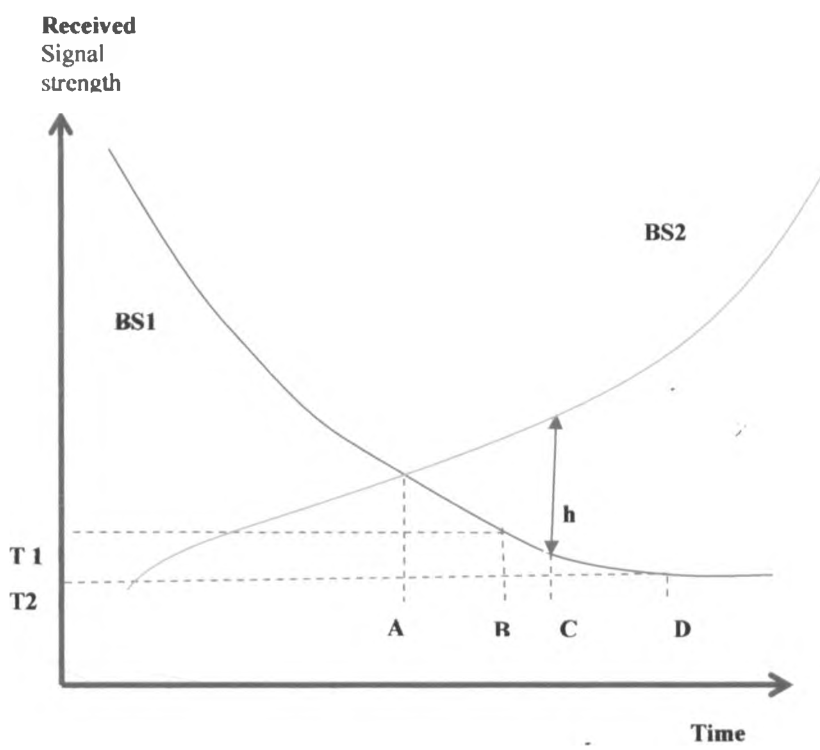


Figure 2. 8 Relative signal strength (Adopted from Siemen, 2007)

Relative Signal Strength

In relative signal strength, the RSSs are measured over time and the BS with strongest signal is chosen to handoff to. In Figure 2.8 BS2's RSS exceeds RSS of BS1 at point A and handoff is requested. Due to signal fluctuations, several handoffs can be requested while BS1's RSS is still sufficient to serve

MS. These unnecessary handoffs are known as ping-pong effect. As the number of handoffs increase, forced termination probability also increases. So, handoff techniques should avoid unnecessary handoffs.

Relative Signal Strength with Threshold

Relative signal strength with threshold introduces a threshold value (T1 in Fig 2.8) to overcome the ping-pong effect. The handoff is initiated if BS1's RSS is lower than the threshold value and BS2's RSS is stronger than BS1's. The handoff request is issued at point B in Fig. 2.8

Relative Signal Strength with Hysteresis

This technique uses a hysteresis value (h in Fig.2.8) to initiate handoff. Handoff is requested when the BS2's RSS exceeds the BS1's RSS by the hysteresis value h (point C in Fig. 2.8).

Relative Signal Strength with Hysteresis and Threshold

The last technique combines both the threshold and hysteresis values concepts to come with a technique with minimum number of handoffs. The handoff is requested when the BS1's RSS is below the threshold (T1 in Fig.2.8) and BS2's RSS is stronger than BS1's by the hysteresis value h (point C in Fig. 2.8). If we would choose a lower threshold than T1 (but higher than T2) then the handoff initiation would be somewhere at the right of point C. All the techniques discussed above initiate handoff before point D where it is the "receiver threshold". Receiver threshold is the minimum acceptable RSS for call continuation (T2 in Fig. 2.8). If RSS drops below receiver threshold, the ongoing call is then dropped. The time interval between handoff request and receiver threshold enable cellular systems to delay the handoff request until the receiver threshold time is reached when the neighboring cell does not have any empty channels. This technique is known as queuing of handoff calls. In a handoff algorithm using multi-level thresholds, it assigns different threshold values to the users according to their speed. Since low speed users spend more time in handoff zone they are assigned a higher threshold to distribute high and low speed users evenly. High speed users are assigned lower thresholds.

2.4 Global Systems for Mobile communication (GSM)

The first generation systems (e.g. AMPS, E-TACS and C-450) as mentioned in the previous section were all analog systems. Analog systems suffer from adverse effects of noise interference, low capacity, and lack of data communication capability (Rappaport, 1996). Further to these disadvantages there was no interoperability between different systems. The culmination of these problems lead to the development of a pan European standard for digital cellular mobile radio by the Groupe Special Mobile Team in 1982 (Eberspacher et al., 2002). Goupe Special Mobile Team was formed from the Conference European des Administrations des Postes et des Telecommunications (CEPT) to develop the required standards. The GSM group became a Technical Committee of European Telecommunication Standard Institute (ETSI) in 1989. This group later worked under the European Telecommunications Standards Institute (ETSI) and produced the GSM specifications in 1989 (De vriendt et al., 2002). The group adopted the name Special Mobile Group (SMG) and further subdivided itself into smaller working groups called Sub technical Committees (STCs) each with a specified task. The proposed standards were presented to ETSI for approval which led to GSM networks official launch in 1992. By the end of 1993 more than 1 million subscribers made calls in GSM networks. In 2000 all the SMG work was transferred to the Third Generation Partnership Project (3GPP) which was to develop the third Generation (3G) system (Eberspacher et al., 2002).

GSM was later interpreted to mean Global System for Mobile Communication. This was basically intended to mean that the system was targeted to make the whole globe (world) appear like it's covered by a single network through application of common standards by all telecommunication equipment manufacturers. This goal was not achieved but as De vriendt et al.(2002), noted GSM Market had grown to 60% and was still rising in 2000. In a recent study Khan (2009) noted that GSM was the dominant wireless cellular standard with over 3.5 billion subscribers worldwide covering more than 85% of the global mobile market.

2.4.1 GSM Architecture

GSM network as shown in figure 2.9 is comprised of three subsystems namely Operation SubSystem (OSS) also referred to as Operation and Maintenance Subsystem (OMS), Network SubSystem (NSS) and the Base Station Subsystem (BSS).

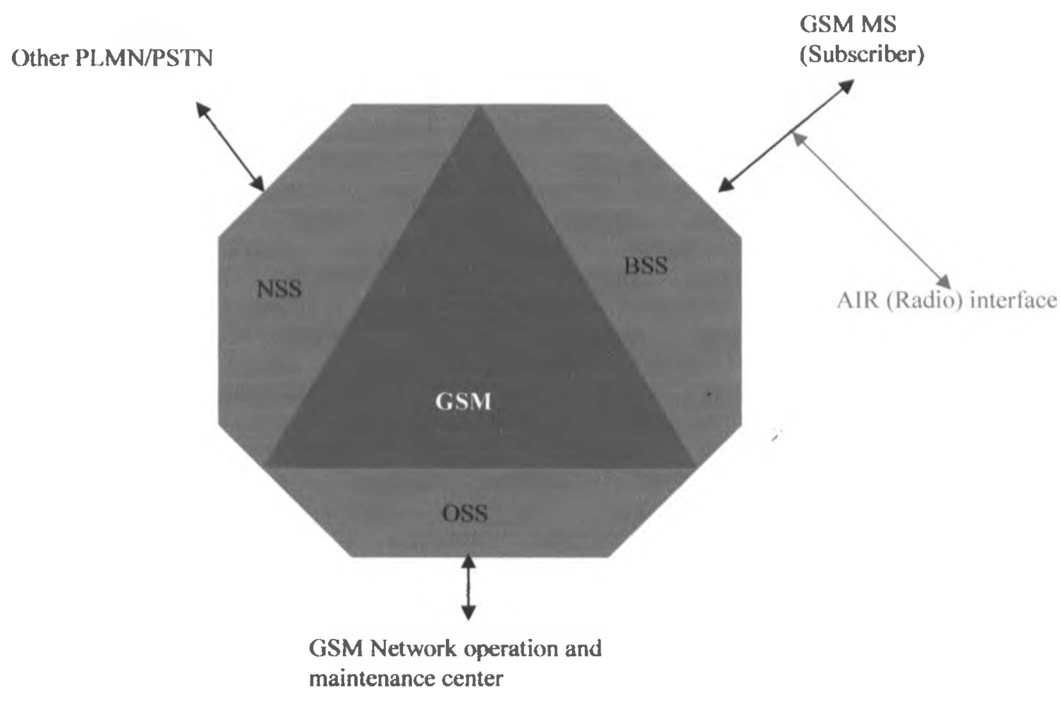


Figure 2. 9 GSM Subsystems (Adopted from CETTM, 2007)

These three subsystems are further comprised of other smaller elements as shown in figure 2.10.below.

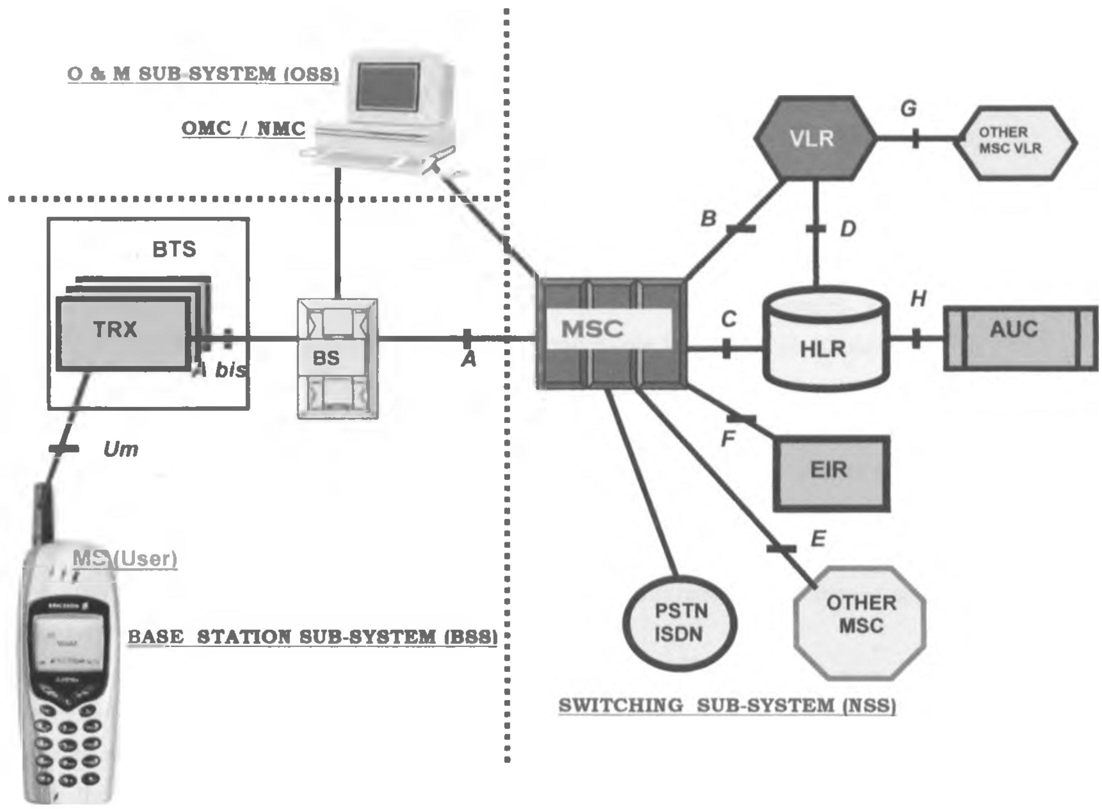


Figure 2. 10 Components of the GSM architecture (Adopted from CETTM, 2007)

OPERATION AND MAINTENANCE SUBSYSTEM (OMS)

This subsystem is at times referred to as Operation SubSystem (OSS). It is a centralized facility for supporting the day to day management of a cellular network. This is the part of the network that runs the network relevant Telecommunication Management Network (TMN) which among other functions provides database for long term network engineering and planning tools. The subsystem is divided into two major parts namely OMC-B: Charged with the control specifically of the BSS subsystem

OMC-S: This is responsible of controlling specifically the NSS subsystem. The operation and maintenance for NSS and BSS are independent of each other. The OMC-B and OMC-S may be combined in the same location (Siemen, 2000).

NETWORK SUBSYSTEM (NSS)

The network components of the Network Subsystem also known as the Switching Subsystem (SSS) are:

- Mobile Services Switching Center (MSC).
- Home Location Register (HLR).
- Visitor Location Register (VLR).
- Authentication Center (AC).
- Equipment Identification Register (EIR)

THE NETWORK ELEMENT MSC.

The MSC is the major unit of the NSS the other four components are actually data bases for its use. MSC is responsible for establishing traffic channels to the BSS, other MSCs and to other networks (e.g. Public Switched Telephone Network [PSTN]). The databases contain information for the routing of traffic channel connections and handling of the basic and supplementary services. The MSC also performs administration of cells and location areas.

THE NETWORK ELEMENTS HLR AND VLR.

Due to Subscriber mobility where the MS is allowed to traverse areas which are administered by different MSCs. The subscriber administration is not performed by the exchanges. The mobile subscribers' current location determines which MSC is responsible for the mobile subscriber at that moment. Therefore, the PLMN contains a network component called Home Location Register (HLR) that administers the subscriber's data. The HLR is a data base where the mobile subscribers are created, deleted, and barred by the operator. It contains all the permanent subscriber identities, as well as the services that a mobile subscriber is authorized to use. The VLR contains the most current data of all mobile subscribers currently located within the MSCs area served by the VLR. The formation of working data (stored in VLR) from the permanent data (stored in HLR) reduces congestion to the HLR.

THE NETWORK ELEMENT AUC

This is the network element that protects the network from unauthorized users. Authentication means ensuring that an entity is truly the one it alleges to be. Subscriber authentication is performed at each registration and at each call set-up attempt (mobile originating or terminating). For an MS to access the network the VLR uses authentication parameters, called triples, that are generated regularly by the Authentication Center (AUC). The triples consist of RAND (Random Number) SRE (Signed Response) and K_c(Cipher Key). The network element AUC is associated with the HLR. The VLR requests the AUC to provide a copy of the triples for authentication. On completion of the exercise the VLR sends back to the AUC a new SRE and continues with the call processing with reference to the results of the authentication process.

THE NETWORK ELEMENT EIR

The network element Equipment Identification Register (EIR) is a data base that stores the International Mobile equipment identity (IMEI) for all the registered Mobile Equipment (ME). The IMEI uniquely identifies all registered ME.

This database has three parts which are maintained according to the behavior of the ME in the network. For the ME with no known problem are put in the white register. The ME which have minor problems e.g. failure to exactly synchronize to the channel are put in the grey register for further observation. The ME which have major problems e.g. reported stolen, suffers critically to lack of adherence to the network requirements are recorded in the black register. MEs' in the black register are not allowed to use the network.

BASE STATION SUBSYSTEM (BSS)

The network elements of the base station subsystem comprises of

- Base Station Controller (BSC)
- Base Transceiver Station (BTS)
- Transcoder and Rate Adapter Unit (TRAU).

BASE STATION SUBSYSTEM ELEMENT BSC.

The BSC as its name implies is responsible of controlling a group of BTS's. The number of BTS under a given BSC is determined by the BTS's capacities. Even in case of very low BTS capacities the maximum number per BSC is 16. The BSC carries out the intelligent functions in the BSS. The BSC assigns traffic channel connections from the NSS to the BTS.

BASE STATION SUBSYSTEM ELEMENT BTS

The Base Transceiver Station comprises of the radio transmission and reception equipment, including the antennas, and also the signaling processing cards specific to the radio interface. The BTS contains one or more transceivers (TRX) and serves up to three cells.

THE TRANSCODER AND RATE ADAPTION UNIT (TRAU)

The ISDN bit rate for coded voice is 64 Kb/s. This bit rate is very high to be used in the air-interface. The TRAU is the equipment used to code, decode and adapt to the required rate depending on the direction of the signal. The two main functions of the TRAU are the transcoder (TC) for speech coding/compression and rate adapter (RA) for data adaptation.

2.4.2 GSM Technology

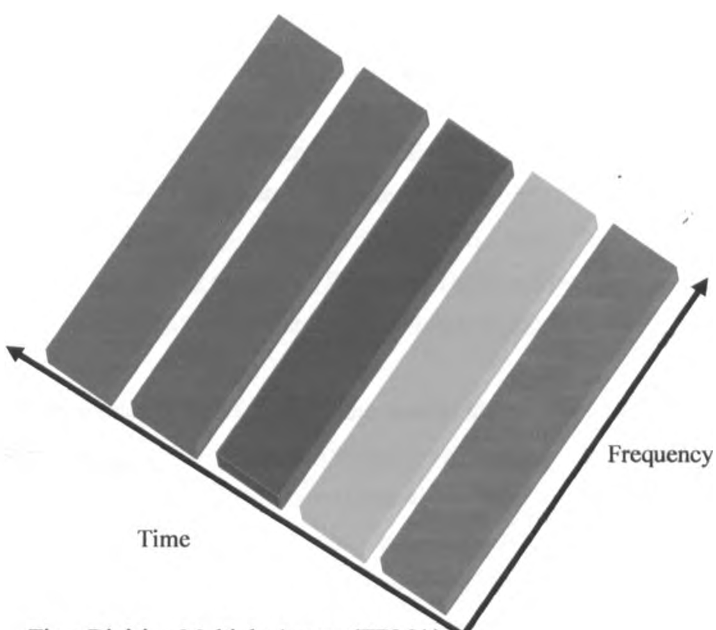


Figure 2. 11 Time Division Multiple Access (TDMA)

One of the most important requirements of the new GSM technology was that the new Standard should employ Time Division Multiple Access (TDMA) technology. This technology ensures that subscribers share the channel on time bases as shown in figure 2.11

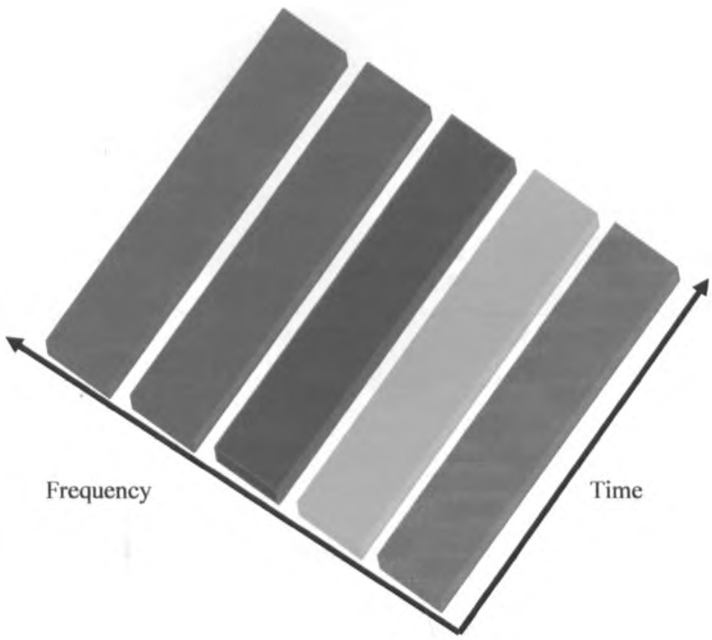


Figure 2. 12 Frequency Division Multiple Access (FDMA)

This ensured the support of major corporate players like Nokia, Ericsson and Siemens, and the flexibility of having access to a broad range of suppliers and the potential to get product faster into the marketplace (siemens, 2000)

As stated earlier GSM was destined to employ digital rather than analog technology and operate in the 900 MHz frequency band. Most GSM systems operate in the 900 MHz and 1.8 GHz frequency bands, except in North America where they operate in the 1.9 GHz band. To increase capacity through frequency reuse the new technology was to use Frequency Division Multiple Access (FDMA). FDMA divides the whole frequency band into smaller frequency bands as shown in figure 2.12.

This meant that GSM divides up the radio spectrum bandwidth by using a combination of Time- and Frequency Division Multiple Access (TDMA/FDMA) schemes on its 25 MHz wide frequency spectrum, dividing it into 124 carrier frequencies (spaced 200 KHz apart). In FDMA the frequency is divided into small bands figure 2.13. Each frequency is then divided into eight time slots using TDMA, and one or more carrier frequencies are assigned to each base station.

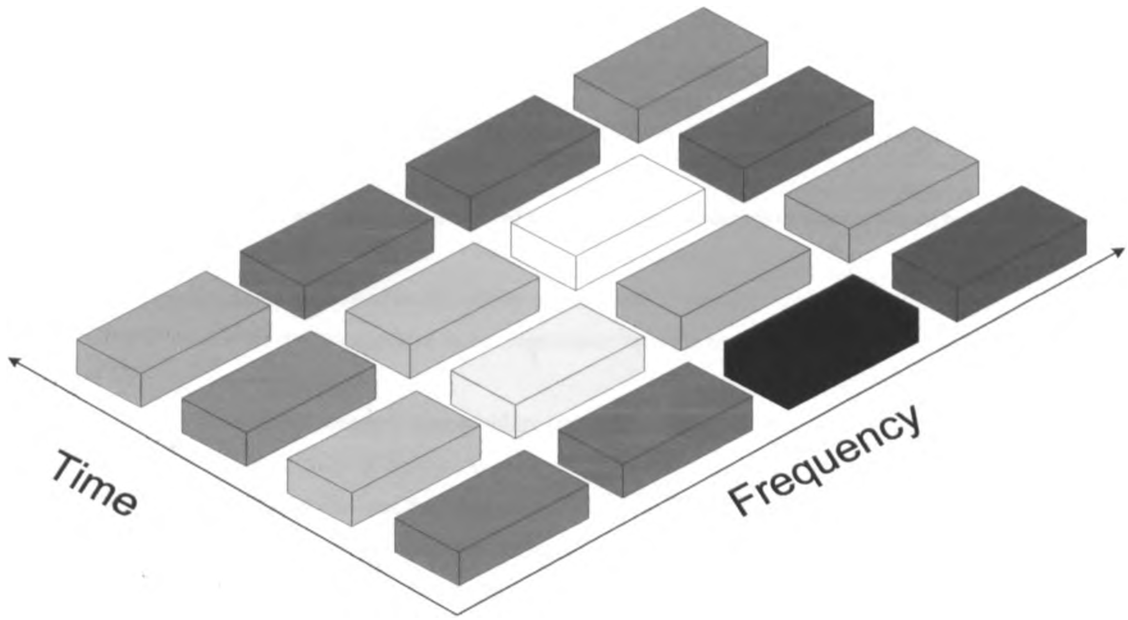


Figure 2.13 TDMA and FDMA multiple access system

Table 2. 1 Frequency allocation in GSM and extended GSM

GSM Frequency Bands		Channels	
System (Band)	Uplink (MHz)	Downlink (MHz)	No of Channels (ARFCN)
GSM900 (P-GSM)	890 - 915	935 - 960	124
E-GSM (Extended)	880 - 915	925 - 960	174
GSM-R (Railway)	876 - 915	921 - 960	145

The fundamental unit of time in this TDMA scheme is called a 'burst period' and it lasts 15/26 ms (or approx. 0.577 ms). Therefore the eight 'time slots' are actually 'burst periods', which are grouped into a TDMA frame, which subsequently form the basic unit for the definition of logical channels. One physical channel is one burst period per TDMA frame. The development of standards and systems spans well beyond the technical realm and often into the political field; this is best exemplified by what happened with GSM.

2.5 Quality of Service (QoS)

International Telecommunication Union- Telecommunication(ITU-T -94) has given two definitions of QoS:

1. The collective effect of service performance which determines the degree of satisfaction of a user of the service. where

   Network Performance: Is defined as- the ability of a network or network portion to provide the functions related to communication between users.

   and

2. User domain: throughput, accuracy, dependability (reliability, availability), ...(ITU-T, 2005)

In line with these definitions Quality of Service is generalized to mean the quantification used for evaluating the performance, reliability and usability of a telecommunications service. Many factors affect the quality of service of a mobile network. It is correct to look at QoS mainly from the customer's point of view, that is, QoS as judged by the user. There are standard metrics of measure of QoS that can be used to rate the QoS from the users perspective. These metrics are:

- The coverage,
- Accessibility (includes GoS), and the
- Audio quality

In coverage the strength of the signal is measured using test equipment and this can be used to estimate the size of the cell. Accessibility is about determining the ability of the network to handle successfully, calls from mobile-to-fixed networks and from mobile-to-mobile networks. The audio quality considers monitoring a successful call for a period of time for the clarity of the communication channel. All these indicators are used by the telecommunications industry to rate the quality of service of a network.

As expected Mobility adds complication to the QoS mechanisms. There are several reasons, some of the main ones being:

- A phone call or other session may be interrupted after a handoff, if the new base station is overloaded. Unpredictable handoffs make it impossible to give an absolute QoS guarantee during a session initiation phase.
- The pricing structure is often based on per-minute or per-megabyte fee rather than flat rate, and may be different for different content services.

A crucial part of QoS in mobile communications is grade of service, involving outage probability (the probability that the mobile station is outside the service coverage area, or affected by co-channel interference, i.e. crosstalk) blocking probability (the probability that the required level of QoS can not be offered) and scheduling starvation. These performance measures are affected by mechanisms such as mobility management, radio resource management, admission control, fair scheduling, channel-dependent scheduling etc

2.5.1 Factors affecting QoS

Many factors affect the quality of service of a mobile network. It is correct to look at QoS mainly from the customer's point of view, that is, QoS as judged by the user. There are standard metrics of QoS to the user that can be measured to rate the QoS. These metrics are: the coverage, accessibility (includes GOS), and the audio quality. In coverage the strength of the signal is measured using test equipment and this can be used to estimate the size of the cell. Accessibility is about determining the ability of the network to handle successful calls from mobile-to-fixed networks and from mobile-to-mobile networks. The audio quality considers monitoring a successful call for a period of time for the clarity of the communication channel. All these indicators are used by the telecommunications industry to rate the quality of service of a network.

2.5.2 Measurement of QoS

The QoS in industry is also measured from the perspective of an expert (e.g. teletraffic engineer). This involves assessing the network to see if it delivers the quality that the network planner has been required to target (KPI). Certain tools and methods (protocol analyzers, drive tests and Operation and Maintenance measurements), are used for this QoS measurement:

- Protocol analyzers are connected to BTSs, BSCs, and MSCs for a period of time to check for problems in the cellular network. When a problem is discovered the staff can record it and it can be analyzed.
- Drive tests allow the mobile network to be tested through the use of a team of people who take the role of users and take the QoS measures discussed above to rate the QoS of the network. This test does not apply to the entire network, so it is always a statistical sample.
- In the Operation and Maintenance Centers (OMCs), counters are used in the system for various events which provide the network operator with information on the state and quality of the network.
- Finally, customer complaints are a vital source of feedback on the QoS, and must not be ignored.

2.5.3 Cellular audio quality

The audio quality of a cellular network depends on, among other factors, the modulation scheme (e.g. FSK, QPSK) in use, matching to the channel characteristics and the processing of the received signal at the receiver.

2.5.4 Cellular Grade of Service

In general, grade of service (GoS) is measured by looking at traffic-carried, traffic offered and calculating the traffic blocked and lost. The proportion of lost calls is the measure of GOS. For cellular circuit groups an acceptable GOS is 0.02. This means that two users of the circuit group out of a hundred will encounter a call refusal during the busy hour at the end of the planning period. The grade of service standard is thus the acceptable level of traffic that the network can loose. GOS is calculated from the Erlang-B formula, as a function of the number of channels required for the offered traffic intensity.

2.6 Network Planning and QoS.

Network planning entails provisioning for resources necessary for establishing, managing and termination of communication sessions. In wireless networks there is the initial planning process and subsequent planning processes as determined from the data collected from the network management system. The first planning is the major determinant of the network capacity to handle the communication requirements. This is because the network coverage if not well designed and planned even future refinements becomes impossible to implement. The most popular planning tool uses the Erlang B formula which applies to lossy systems, such as telephone systems on both fixed and mobile networks, which do not provide traffic buffering, and are not intended to do so.

The goal of Erlang's traffic theory is to determine exactly how many service-providing elements should be provided in order to satisfy users, without wasteful over-provisioning. To do this, a target is set for the grade of service (GoS) or quality of service (QoS). For example, in a system where there is no queuing, the GoS may be that no more than 1 call in 100 is blocked (i.e., rejected) due to all circuits being in use (a GoS of 0.01), which becomes the target probability of call blocking, P_b, when using the ErlangB formula.

According to International Telecommunication Union (ITU) the grade of service should range between 1 to 5%, an average value of 2% is taken as the bench mark for telecommunication regulators to ensure adequate and satisfactory service delivery. The 2% QoS is calculated using the formula below.

$$\text{Telephony Service Non - Accessibility}\,[\%] = \frac{\text{unsuccessful call attempts}}{\text{all call attempts}} \times 100\,\%$$

(Tabbane 2009)

The numerator is the total number of failed (new and handoff) call attempts and the denominator is the network total call attempts.

In any telecommunication network whether fixed or mobile the distribution of the network resources follows the population distribution and subscribers routine movement. Wireless systems apply the principle of frequency reuse in macro cell planning. This principle is adapted to boost network capacity. However there is a maximum capacity limit allowable due to the number of frequencies used per cell and the number of cells per cluster. The resulting scenario is that some regions end up having adequate coverage while others experience sporadic excess resource demand. It follows that the actual QoS which does not take into consideration the unaffected regions can be expressed as the ratio of the unsuccessful call attempts to the total call attempts in the affected regions. This is expressed in the formula below:

$$ActualTelephoney - QoS = \frac{Unsuccessful \quad Call\ Attempts}{Total \quad Call \quad Attempts \quad in \quad Affected \quad \mathrm{Re}gions} \times 100\%$$

This is the actual chance of being affected since for a subscriber to be affected must be within the regions which suffers from scarcity of resources.

The ITU formula results to a huge number of call attempts hence giving the operators a lee way to offer poor quality of service.

There are a number of previous studies that explore the determination of the effects of handover on quality of service for voice communication and its impact on the network capacity. The most relevant studies are the ones that bring out the probabilities of handoff dropping and call blocking as the key determining factors of the grade of service and by extension the quality of service.

In planning network capacity is normally arrived at by considering the handoff algorithm to be implemented. There exists a variety of algorithms with varying degree of effects on the network capacities.

There are two major categories of handovers. Handover implemented in the network design such as the one where all new calls are set-up in Micro-cells and soon handed over to a Macrocell. . In such a situation the effect of this handover on quality of service is minimal, since it is well catered for in planning and does not arise out of pressure in allocation of resources. The other type is where the handover is triggered due to channel deterioration and distance of the mobile subscriber from the base station. This is different from the handover that is network designed. In this type of handover, the quality of service to be offered normally depends on time and availability of resources. Thus such quality can only be determined through a survey.

This research does not match exactly other researches that have been done in the past. But it compares to a big extent with a number of theoretical research papers that chronologically identifies the same focus area, quantities to be determined and comes up with the necessary approximations for analysis as follows.

The network capacity is evaluated during Busy Day Busy Hour (BDBH), at which time it is expected to have a lot of handoff requests. So if planning is done with reservation of Handoff channels all the reserved channels will be utilized and the network result to operate at full capacity. Any more handover requests will result to forced termination. Hence upon establishing the extra handover requests got in a packed system that utilizes handover request reservation algorithms, we can get the forced termination probability. In the same set-up the number of calls originated in the same cell cannot exceed the limit provided for in the planning. Any extra request to set-up a call will be rejected. The proportion of the unsuccessful requests to set up a call to the total traffic will give the blocking probability. The combination of blocking probability and handover dropping probability is a measure of quality of service as this is the same as the Grade of Service (GoS). ITU recommends that this grade of service should not be worse than 2% of the total calls.

In network systems that do not put in place algorithms that separate handover channels from ordinary channels. All channels are allocated on basis of first come first served. The blocking and forced termination probabilities are evaluated out of the total traffic.

There are other systems that provide queuing for both handoff and new call requests with varying priorities. These systems give allowance for a very short time in the queue since voice communication is real time. Such algorithms are rarely implemented and are unlikely to be encountered.

There are a number of researches done to approximate the effects of handover on network capacity and quality of service. Most of these studies use approximate models of the networks to estimate formulae for analysis to determine the PHD and PCB.

2.7 Handover analysis through traffic prediction and approximation.

Mobile network is comprised of a given number of base stations laid out across the area of coverage. Each base station is capable of handling a limited number of simultaneous traffic before quality thresholds are breached. In the initial stages of operation of the Network there are no problems associated with connectivity since the Subscriber base requirements can be supported by the network. But as the network matures and the traffic level increases, new network solutions are required in order to meet the required grade of service (GoS). Such solutions in a GSM network are:

- New channels added to a cell (TRXs)
- Underlaid/overlaid cells
- Cell splitting(additional base stations)
- Micro-cells for 'hot-spots'.
- Dual-band operation (GSM 900&1800).

Darwood et al., (2000) focused on the reduction of the time taken to rectify a network problem to bring it back to an acceptable grade of service. This was done through traffic forecasting using a tool that is able to predict areas where additional capacity is required and implement the changes to the network, including the intelligent placement of a new base-station installation. The tool used is as shown below figure 2.14

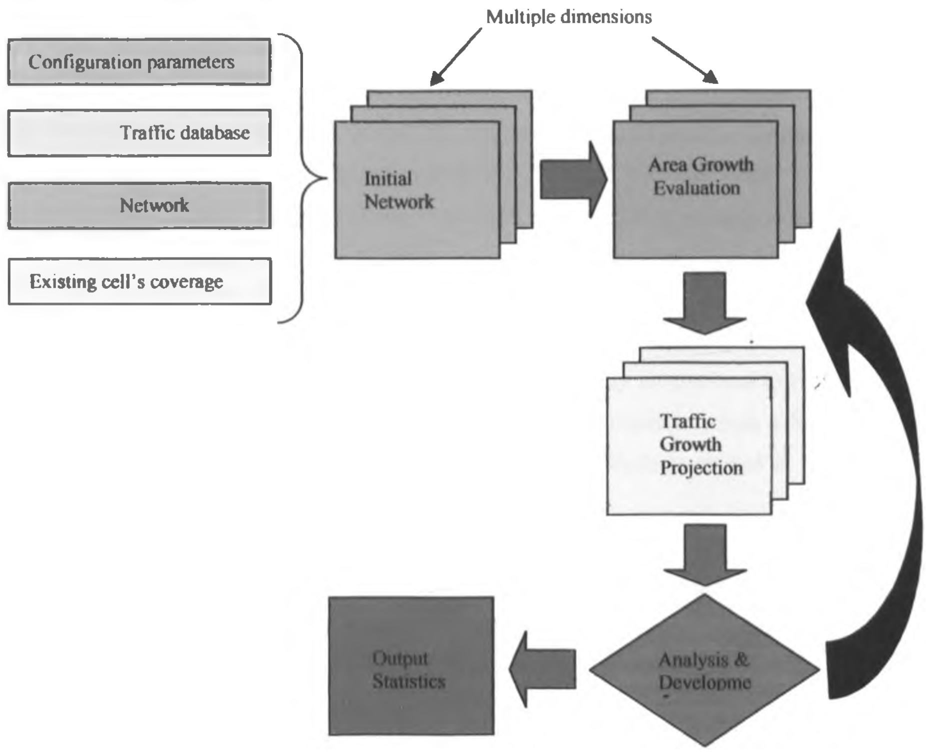


Figure 2. 14 Overview of Mobile Network Traffic Forecasting Tool (Adopted from mobile network traffic forecasting, Darwood et al, 2000)

Mobile network traffic forecasting helps in fore telling the capacity to be required in the near future, but it does not aid in establishing the effects of this extra requirements if it fails to be provided for. This tool attempts to solve the problem without assessing its impact if it was to occur. Further the tool uses new hardware to solve the detected problem of capacity. There are a myriad of problems in installing and activating of additional hardware. Some of them being financial and technical requirements, and the fact that during the none busy hour, idle capacity is further increased. The best solution is the one where attempt is made to solve the problem before it affects the system operation.

To concur with the current research the tool should predict the impact of extra capacity requirements basing it on the same hardware. The solution should be found on variation of quality without new installations and activation of new previously installed capacities. The suggested system should be dynamic such that during none pick hours the system switches back to high quality service. Where in this new model of solution the system should not be let to lower quality of service below the ITU stipulated standard.

2.8 Approximate analysis of handoff traffic in mobile Cellular Networks

In mobile communication the scarce radio resources are used to provide network coverage. As stated earlier in the introduction the area served by a given set of radio frequencies is called a cell. This cell can support a given number of subscribers depending on the number of frequencies allocated. To increase capacity for a given bandwidth the cell size requires to be small to allow for reuse of the same frequencies in a short distance away. As noted by Kwon (2000) in his paper titled "An approximate Analysis of Handoff Traffic in Mobile Cellular Networks", as the cell size becomes smaller, the impact of handoff traffic on quality of service (QoS) in mobile cellular networks becomes more and more significant. In this research paper it specifies three QoS performance measures namely: - the probability of call blocking (P_b), the probability of handoff dropping (P_d), and the probability of forced termination during a call (P_f). It is observed that P_f is almost directly proportional to P_d and therefore we scrutinize the analysis of P_b and P_d. This paper describes a model in which a Mobile terminal moves a long an arbitrary topology of cells. An approximate analysis is arrived at on making the following assumptions:-

- Each cell has the same capacity of channels.
- In each cell new calls are generated according to a Poisson process with a specified mean rate
- Spatial homogeneous traffic distribution
- Exponential call duration time with a mean
- Exponential call residence time with a mean.

An estimate of handoff call arrival rate into a cell is obtained assuming a trunk reservation call admission control (CAC) algorithm.

The expressions for the call blocking probability P_b and the handoff dropping probability are derived.

A graphical representation of these estimates for different Erlang load and cell resident times are as shown below figures 2.15 and 2.16

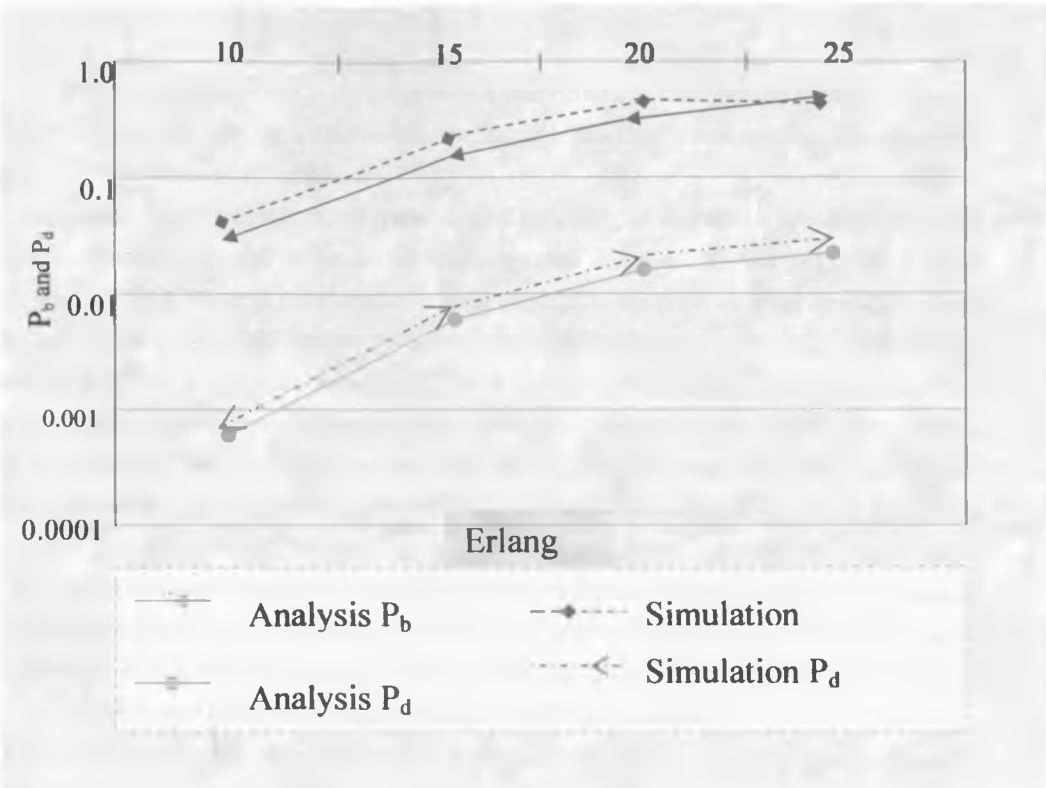


Figure 2. 15 Pb and Pd when C = 20 and t = 4 for different Erlang loading. (Adopted from An approximate Analysis of Handoff Traffic in Mobile cellular Networks, Kwon et al., 2000)

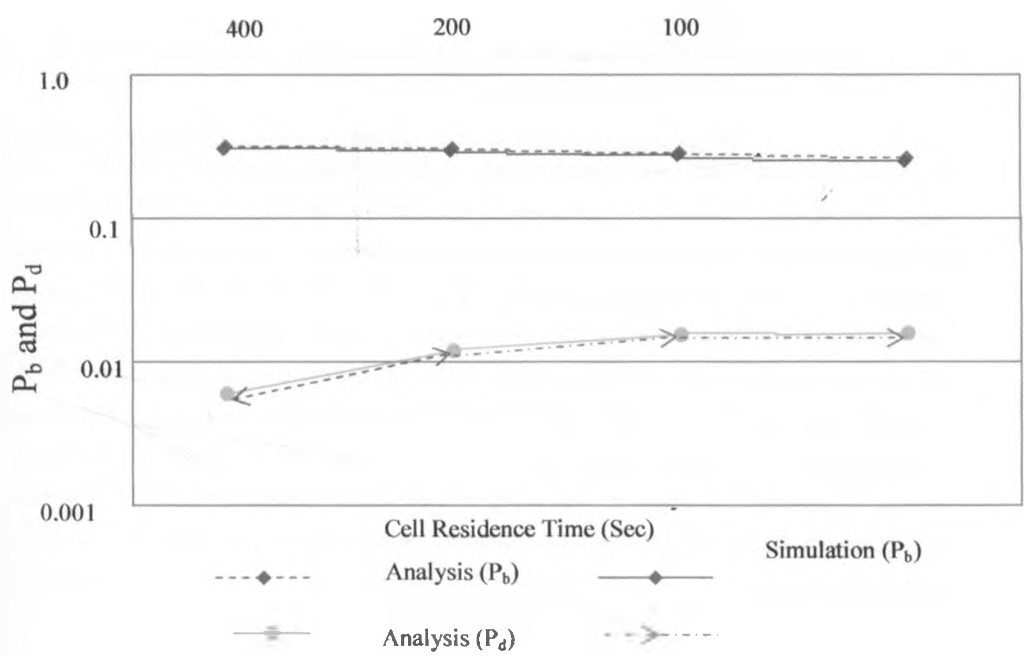


Figure 2. 16 Pb and Pd when C=20 and t=4 for different cell residence times. (Adopted from An Approximation Analysis of Handoff Traffic in Mobile cellular Networks, Kwon et al. 2000)

From graph of figure 2.15 it is evident that both P_b and P_d increase with increase in load as expected. Figure 2.16 reveals a peculiar scenario where the chance of blocking P_b decreases with decrease in time spent by MS in the cell(cell resident time CRT).

This research clearly indicates the effects of handoff on quality of service in a hypothetical scenario. With reference to the results got we can answer the question- does handoff affect the Quality of service of a network? The answer is yes as indicated in the graphs. But due to the estimates on traffic load and the cell resident times the impact of the handoff effect remains a very rough estimate. The unpredictability of direction and duration of a call in Mobile communication makes any estimates give a very vague picture of the true situation. This research gives an estimate of handoff effect which can be extrapolated to show the effects on both busy hour and non busy hour. The research should have gone a head and suggest a solution for handling the extra traffic load requirements caused by handoffs. It should also have provided the extent to which the facilities can lie idle if the network design was optimized to eradicate the network QoS degradation due to handoff. To an investor in any commercial entity the driving force is the average rate of return on the investment. In the case of telecommunication both busy hour and non busy hour have negative effects on average rate of return on the investment. Hence there require a workable average which ensures optimum productivity.

It is also difficult to rate the performance of a system which has been analyzed this way since the available data on performance combines these two metrics to come up with the well known GoS. But it is important to note that the metrics of P_b and P_d as used in this analysis are used by Network Operators in fixing the desired Key Performance Indicators (KPI). Hence this research is important for one to observe variation of these metrics as CRT and traffic intensity varies.

2.9 Handoff interference, performance and effects on voice quality in wireless cellular networks.

Horizontal and vertical Handoff and the use of Mean Opinion Score (MOS)

Networks that were initially designed for data communication have been enhanced for voice communication. These networks that are designed in conformity to IEEE802.11 standards utilize handheld WLAN-based devices. The terminal devices are constructed such that they can be used for both Data and Voice. WLANs networks are normally limited to a small radius where the access points can be accessed by the terminal devices. This makes the WLAN network appear like clusters or spots. In WLANS areas which are also covered by cellular mobile networks it is possible to use the free WLAN network to relieve the cellular network some of its load (voice) as the demand may dictate. In such a situation the cellular terminal device require to be dual band to be capable of handling the Wifi frequency and the cellular frequency ranges. When a mobile session is handed over from one network to another network where the two networks are technologically different the handoff is referred to as vertical handoff. One can then therefore refer to the handoff from one network to another network where the two networks use the same technology as horizontal handoff. In vertical handoff the effect of handoff can be measured through the fraction of the packet lost.

The importance of handoff as stated in the introduction is to facilitate continued connection of the mobile terminal to the network irrespective of the mobile terminals position or location. To fully maintain such a connection it is necessary to provide for vertical handoff since the mobile terminals trajectory might not be wholly covered by the same network. Hence handoff effects analysis is required This is further enhanced by the fact that due to the technological differences in networks that are optimized for data and the ones that are enhanced for voice, handoff schemes are required to handoff sessions among networks of diverse technology. Vertical handoffs are also seen as important requirement for Networks convergence.

The objective of vertical and horizontal handoffs is to provide a seamless mobility user experience, no matter whether the user is under cellular (GSM or CDMA) or WLAN coverage, ensuring service continuity for both, voice and data, when roving between GSM and WiFi areas. In a recent research Duran et al (2007) analyzed effects of handoff on voice quality for both vertical and horizontal handoffs. Since the two handoffs do not interfere or influence each other. The horizontal Handoff is more relevant to this study hence more attention is given to this part of the analysis.

For networks which are neither capacity limited nor coverage limited the effects of handoff cannot be established using our adopted metrics of CBP and HDP. The measure of handoff effects in such a case is the voice quality based on the E-model. This model considers packet loss due to handoff interruptions to be significantly high as compared to other losses caused by congestion and signal quality. Voice quality can be estimated using the procedure proposed in ITU-T G 107, calculating a rating factor R that is an additive combination of five factors as follows:

$$R = R_0 - I_S - I_d - I_e + A \quad \text{2.9(a)}$$

Where:

R_0 is the basic signal to noise ratio

I_S is the simultaneous impairment factor function of the SNR impairments associated with the switched circuit network paths.

I_d, is the delay impairment factor which includes all delay and echo effects

I_e is the equipment impairment factor which models impairment caused by low-bit-rate codecs: and the expectation factor

A is the advantage factor (Duran et al., 2007].

On making the assumption that network capacity and coverage are unlimited the factors R_0, I_S and A result to a constant. The factors I_e and I_d determine the value of R. The transmission rating factor can then be represented as

$$R = 93.35 - I_d - I_e \quad \text{2.9(b)}$$

ITU-T G.113 provides values for different codecs and for several values of packet losses. From such relationships it is possible to obtain the transmission rating factor R as a function of the packet loss for each of the voice codecs considered.

The behavior of I_e with packet loss for the typical voice codecs used in VoWLAN is as shown in figure 2.17 (Duran,et al., 2007). Although the R factor represents the quality of the transmission, the common way to represent the user perceived quality is the Mean Opinion Score (MOS). G.107 provides an expression to relate R with MOS which is represented as MOS_{CQE} (Conversational Quality Estimated). to distinguish it from the measured one. It is possible to relate handoff interval to the quality, according to 2.9(b) the higher the delay the lower the resulting quality.

The impact of handoff delay on quality for some codecs are shown in figure 2.18 (Duran et al., 2007).

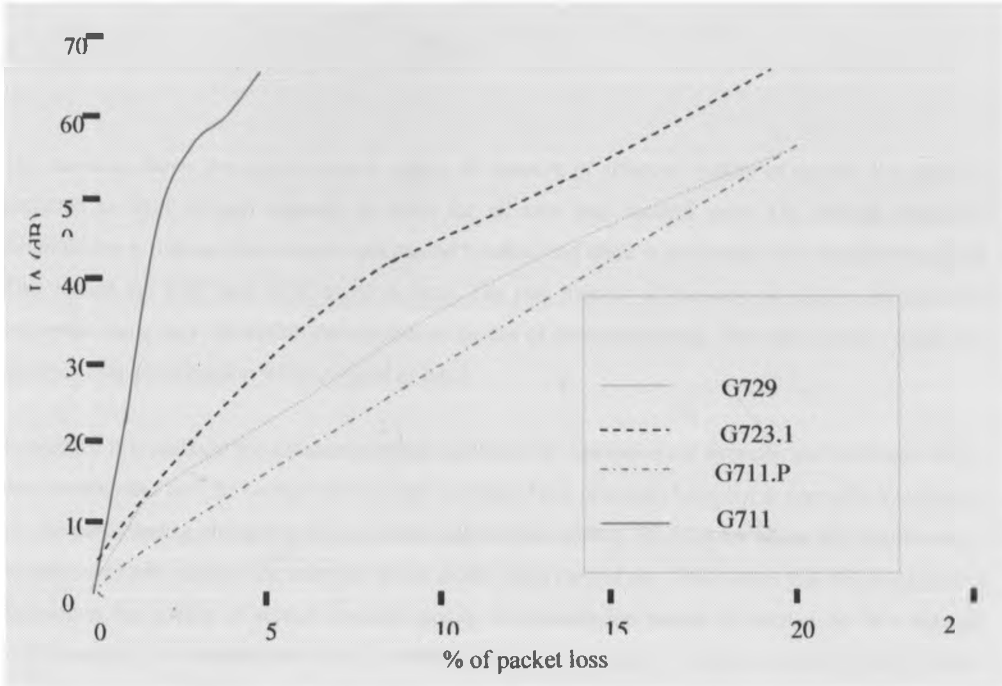


Figure 2. 17 Packet loss effects for different voice Codecs (Adopted from Effects of Handoff on Voice quality in wireless convergent networks, Duran et al., 2007)

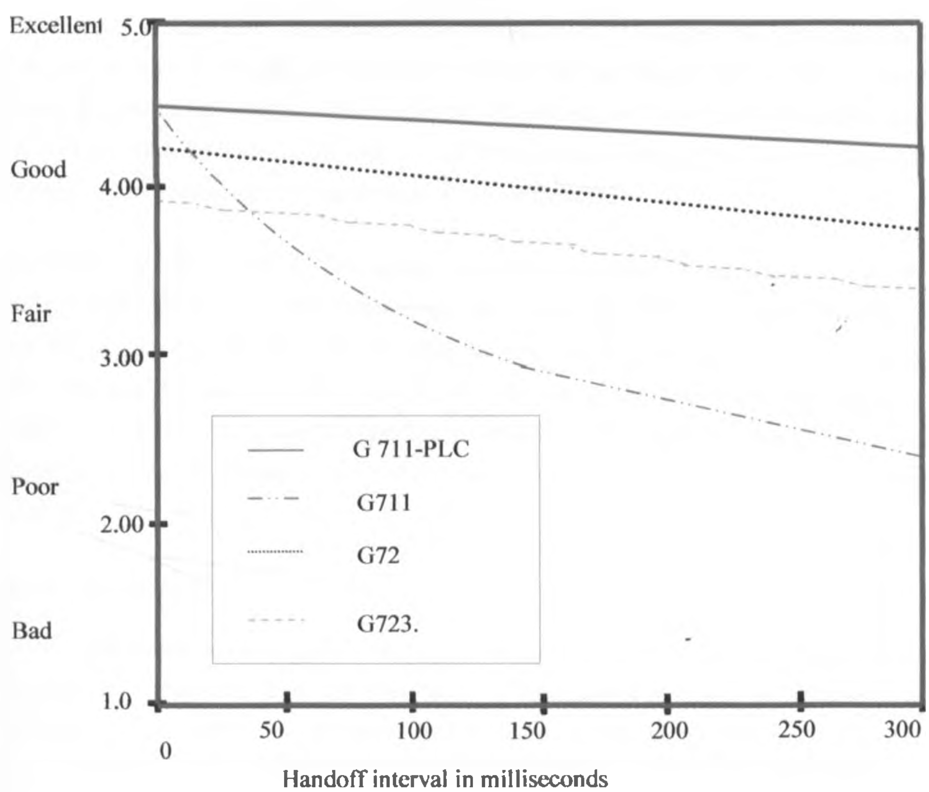


Figure 2. 18 Effects of handoff interval on the MOS performance (Adopted from Effects of Handoff on voice quality in wireless convergent networks, Duran et al., 2007)

The research shows the use of a lower metric of measure of effect of quality of service in a network assumed to have enough capacity to cater for all new and handoff calls. On making these two assumptions it follows that no new call can be blocked and there is no chance of a handoff dropping. This makes the CBP and HDP equal to zero. The two metrics of measure of quality are the most important since they determine the success or failure of communicating. The other metrics assess the quality of the transmission whether good or band.

In practice it is unlikely for a mature network to be free of limitations of capacity and coverage. Hence this research can only be carried out in a new network. New networks behavior is normally transitional, i.e. the performance changes as the networks subscription grows. So research where the results cannot be utilized to add value to the network is not worth being carried out. This means that this research that determines the quality of service through quality of transmission cannot be carried out in a network implemented in the normal prevailing conditions of resource scarcity (Radio frequency, space, license conditions etc). As noted earlier in the introduction there are limiting factors in the implementation, operation, management and maintenance of mobile network just like in any other business entity.

The analytical method drawn from the ITU-T guidelines used in this research to relate, the quality of service to equipment and delay impairment, quality rating factor R to the practical Mean Opinion Score (MOS) will be used to analyze the proposed framework. In our research the solution to the stated problems was the modification of codec to develop the conceptual framework. In the analysis of our framework we made the same assumption as made in this research. Hence this research is applicable in justifying the appropriateness of our proposed conceptual framework.

Handoff has a number of effects on wireless networks which have critical impact on the overall Network system performance. MS power output has classes, the device is normally directed on the power level to apply by the Base Station (BTS). Since Handoff algorithms are based on the power levels it happens that on the point of handing off, the MS is normally at the peak power output provided for in all the power level classes. The maximum power output encountered at the point of hand off contributes to interference or rather is another source of negative effects of handoff on network performance.

Handoff interference

Leu et al. (2008) published their research findings on the "Analysis of Handoff interference and outage along Arbitrary Trajectories in Cellular Networks". In this research there was the application of the handoff interference metric as an indicator of the effect of handoff on system performance. The handoff interference characterizes the additional interference noise caused by the handoff process. The Handoff noises emanate from the extra information required to be exchanged for efficient management of the call transfer and the fact that at the point of handoff the MS is normally at full power. The higher the amount of power used by MS the higher the interference caused by the power dissipated. In this research a presentation of the handoff interference and outage probability as metrics of measuring the handoff effects for an Ms moving along an arbitrary trajectory is analyzed. Outage probability is the fraction of time that the received power from the attached BTS falls below the required threshold. This is another handoff performance metric.

To characterize handoff performance for arbitrary trajectories in a cellular network, Alexe et al. (2008) approximated a general path by a piecewise linear path within a reduced geometric structure derived from the cellular network geometry. In this way a concise characterization of handoff performance over a wide range of mobile trajectories in the network geometry was obtained. This characterization provided a measure of the overall signaling load incurred by the handoff algorithm.

A recursive procedure for computing the mean handoff interference by using bivariate functions is used to compute the expected value of handoff interference corresponding to the communication link.

Analytical methods are used to draw analytical outage probability curves. The results show the larger the hysteresis level the more likely an outage event occurs. It is also observed that along a given trajectory between two base stations the outage probability first increases until around the midpoint between the two base stations and then decreases from this point. This is because the outage event happens more frequently around the midpoint between the two base stations, where the received signal strength is smaller.

This research serves to introduce a new handoff performance measure that characterizes handoff behaviour called handoff interference. It defines the maximum interference point along a trajectory at which the handoff margin is achieved and show that it generalizes to the concept of the crossover point. The mean number of handoffs and handoff margins are used to compute the overall signaling load due to handoffs in the network.

As stated earlier the Handoff performance metrics can be put into two major categories. The most important are the metrics that determine whether the call can be sustained or not. The other category gives an impression of the extent of the adverse effect on event that it impacts. The metrics of handoff interference and outage are in the second category. This means that their effects in a voice cellular network is not critical. The presence of interference cannot totally block a call from going on unless the interference is so high to render the communication unintelligible. The outage probability is a time based metric that must be reached to trigger handoff.

As it can be noted these two effects that are measurable using handoff interference and outage probability metrics cannot be eradicated but range from tolerable to intolerable levels.

This research reveals two more metrics of determining handoff effects on network performance. Though the effects cited in this research are not critical, it is important to note that the number of handoff effects and their corresponding measurements metrics have been increased. The effects of handoff on network performance now include interference and outage.

Zhang (2010) noted that a wireless system has two inherent challenges namely limited bandwidth and unreliable radio channel. These two limitations simultaneously serve as the fundamental constraints for the capacity improvement and quality of service improvement in wireless networks. It is further noted that Handoff is an indispensable operation in wireless networks to guarantee continuous, effective, and resilient services during a mobile station mobility. This paper also identifies Handoff counting, handoff rate, and handoff probability as important metrics to characterize the handoff performance. Handoff counting is the number of handoff operations during an active call connection. Handoff rate specifies the expected number of handoff operations during an active call, or equivalently, the average handoff counting. Handoff probability refers to the probability that an MS will perform a handoff before call completion. The fading channel is time varying, unreliable and erroneous. Extensively degraded signal may lead to physical link breakdown, and hence the forced termination of an active call. As a result, similar to the limited bandwidth , the fading channel also plays an equally important role on handoff performance.

The impact of the fading channel on the handoff metrics are compared in the presence and absence of Rayleigh fading.

Zhang (2010) did research and developed the results of handoff counting, handoff rate and handoff probability to demonstrate the explicit relationship between the handoff metrics and the physical layer. These three metrics are used to indicate performance when the handoff is already performed as can be deduced from the title "Handoff performance". Another fact is that like most of the research involving handoff there is a lot of assumption and approximations e.g. Rayleigh signal and device power approximations

With reference to Signal –Interference-Ratio (SIR) threshold a call can either progress or be discontinued. The Rayleigh fading channel is the main contributor of the interference and hence the main determinant of the SIR. In case of a handoff the quality of the communication depends on the amount of the interference. The worst extreme is when the interference is so intense to warrant the dropping of the call. In such a case the faded channel brings a limitation equivalent to capacity limitation. Hence the investigation of Handoff performance in Wireless Mobile Networks with unreliable Fading Channels is similar to establishing one of the effects of handoff on network capacity. This is directly meeting one of the objectives of our research though from an approximated analytical approach.

CHAPTER 3 PROPOSED SOLUTION

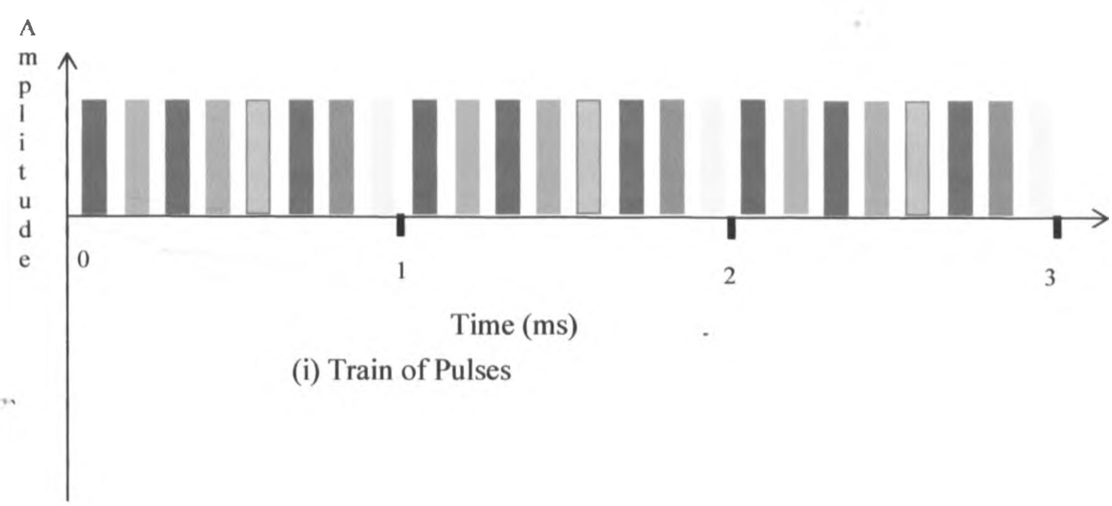
3.1 Introduction

The cellular concept was a major break through in solving the problem of spectral congestion and user capacity. It offered very high capacity in a limited spectrum allocation without any major technological changes. This concept has been used to boost capacity to the limit of the smallest cells possible called pico cells. In regions where the network has been reengineered to the limit of the picocell there is no possibility of further capacity increase through spectrum subdivision and reuse. There exists other methods that can be used to further increase spectrum utilization (Sesia et al., 2009). These methods include use of more advanced modulation scheme and access methods (e.g. Orthogonal Frequency Division Multiple Access) and use of lower bit rate per Subscriber.

Voice or speech is the basic input into the mobile communication system. Voice being analog in nature requires to be translated into digital format for it to be transmitted using a digital system. The process of converting an analog signal into a digital signal is comprised of three major processes namely Sampling, Quantization and Coding (Connor, 1981)

The three processes are performed as indicated in Figure 3.1 considering a single frequecy analog input.

Sampling is the multiplication of the analog signal by a train of pulses to produce an image of the analog signal in terms of pulses that are analog signal shaped. The sampling theorem states that to adequately represent an analog signal using a train of pulses sampling has to be done at a rate that is at least double the maximum frquency of the abase band. In speech the highest signal is taken to be 4000KHz or rather the base band is first band limited to a maximum frequeny of 4Khz. This gives rise to a sampling rate of 8000 samples per Second. Figure 3.1 (i) shows the sampling pulses generated at a rate of 8 samples per miliseconds which is equal to 8000 pulses per seconds.



(i) Train of Pulses

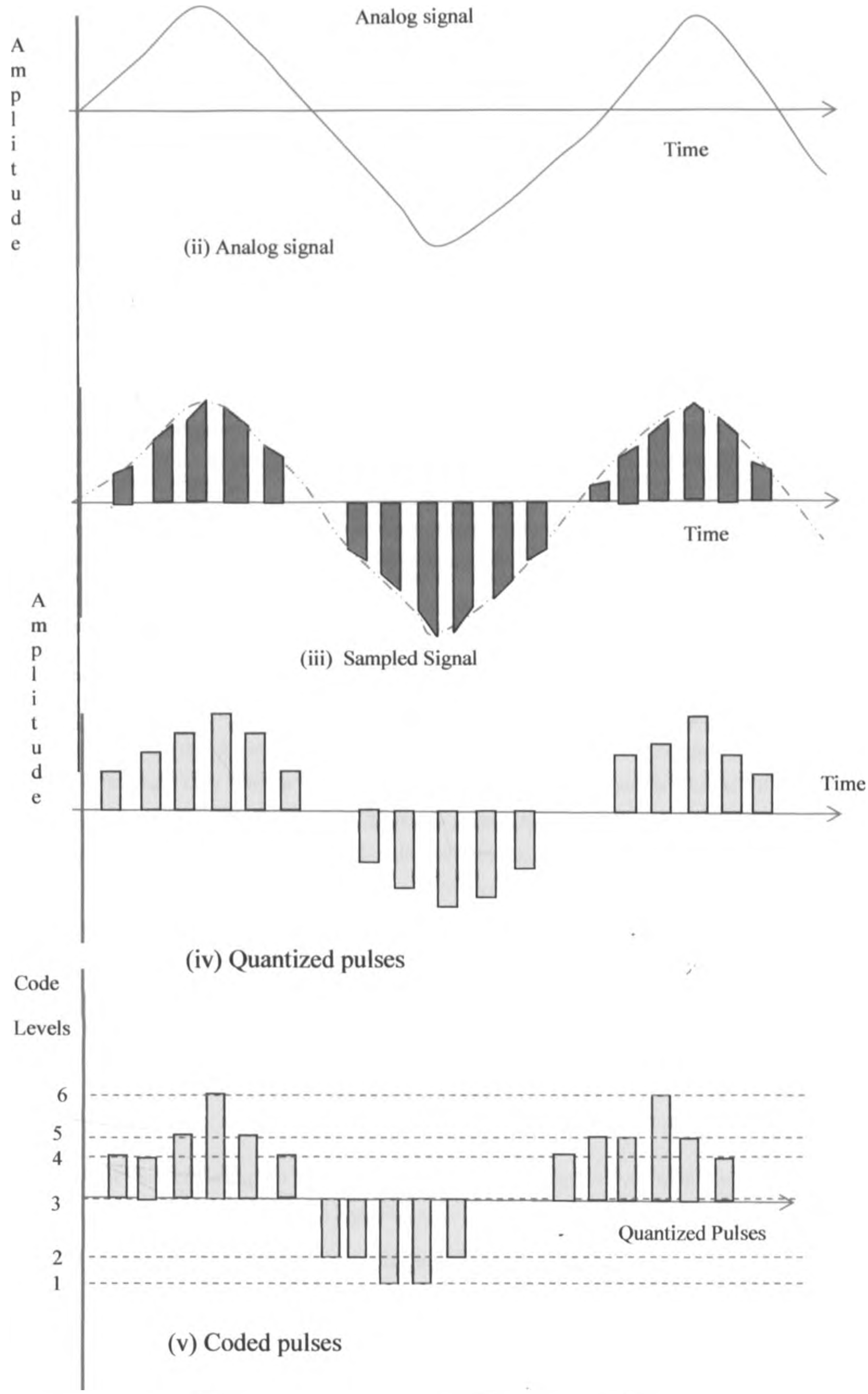


Figure 3. 1 Digitization of an analog signal

The sampled pulses are rounded off to the nearest quantised level in the quantiser and the quantised samples are converted into groups according to the binary code in the encoder. The process of approximation is refered to as Quantization. Each quantised level is then converted into a binary number in a process refered to as Coding. Each quantized level in ISDN is represented using an eight bit code word. This results to a bit rate of 8000X8 bits per Second per source or per speech channel. The 64Kbits/s is the ISDN standard used in fixed telephones for speech data (Conor, 1981).

In GSM the 8000 samples are coded using 13 bit words resulting to a speech data stream of 104kbit/s. This data stream is then compressed to 13kbit/s(FR). This is the full data rate for speech with 5.6 as the coresponding half rate TCH (TCH/2 or TCH/H).

The reverse of digitization or coding is refered to as decoding and is done by the receiver. Since most of the modern devices are meant to serve as both Transmitters and Receivers (Transceivers) the same device is constructed such that in a foreward direction it codes and in the reverse direction it decodes the information. The device that does the coding and decoding is called a CODEC which is the short for COding and DECoding. Codecs have like the network they are used in undergone a lot of evolution.

3.2 GSM Channels

GSM defines two sets of channels the Physical and Logical Chaneels. The Physical Channels are the bearer that is to mean that they are meant for transportation of the Logical Channels. Physical Channels on the air –interface uses time division multiple access where one Radio Frequency Channel (RFC) consists of eight TDMA Channels. A physical Channel is defined by a specific carier (RFC) in the uplink band, the corresponding carrier in the downlink and by the timeslot number in the TDMA frame. A Physical channel can function as a traffic channel(for transmission of speech and information) or as asignaling channel (Siemens, 2001).

Logical Channels are the contents of the physical channels that is to say that logical channels constitute the physical channel load. Logical channels are divided into two categories i.e. the Traffic Channels and the signaling (control) channels. Traffic channels are used for transmission of user payload data (speech, fax or data)

3.3 GSM Codecs

Codec performance has been improved as the overall network technology evolved from low bit rate low capacity to the present high capacity and high bit rate.

In the 2nd generation GSM System a TCH may either be fully used (full-rate TCH i.e. TCH/F) or be split into two half-rate channels (half-rate TCH i.e.TCH/H), which can be allocated to two different subscribers (Elberspacher et al., 2001). This splitting of the traffic channel results to double the capacity. The higher rate channels are designated Bm channel (mobile B channel) and the lower rate Lm channel (lower-rate mobile channel) in line with the Integrated System Digital Network (ISDN) terminology. A Bm channel is a TCH for the transmission of bit streams of either 13Kbits/s of digitally coded speech. Lm channels are TCH channels with less transmission bandwidth than Bm channels and transport speech signals of half the bit rate (TCH/H) of 5. 6 Kbit/s.

3.3.1 Half rate Codec

The need for higher capacity systems emerged as soon as GSM networks became the most widely deployed standard in the late 1990s. The reason for improved bandwidth utilization is to increase the network capacity and the spectral efficiency (i.e. traffic carried per cell area and frequency band). Capacity was expanded through the use of half rate codecs. Under good channel conditions, this codec achieves, in spite of the half bit rate, almost the same speech quality as the full rate codec.

3.3.2 Enhanced Full-rate Codec

This is a full rate codec with a net bit rate of 12.2Kbits/s. But it achieves speech quality clearly superior to the previously used full-rate codec. It achieves better clarity through the additional error detection on the most significant bits (Elberspacher, 2001)

3.3.3 Adaptive Multi-Rate (AMR) codec

Adaptive Multi Rate (AMR) is the fourth speech codec defined for the GSM system. The goal when specifying the AMR codec was to combine the benefits of the EFR and HR codes in order to achieve an improved standard of voice quality and greater capacity. AMR achieves this goal by dynamically adapting its bit-rate allocation between speech and channel coding, thereby optimizing speech quality in various radio channel conditions. Depending on the conditions, AMR dynamically uses either the GSM full rate traffic channel with a gross bit rate of 22.8 kbps or the GSM half rate traffic channel with a gross bit rate of 11.4 kbps. A part of this bit rate is used for speech coded bits and a part for error control. To be more precise, AMR has two principles of adoptability: channel mode adaptation and codec mode adaptation.

Channel mode adaptation dynamically selects the type of traffic channel that a connection should be assigned to, which is either a full-rate (TCH/F) or a half-rate traffic channel (TCH/H). The basic idea being to adapt a user's gross bit rate in order to optimize the usage of radio resources. If the traffic load in a cell is high, those connections using a TCH/F (gross bit rate 22.8kbit/s and having good channel quality should be switched to a TCH/H (11.4kbit/s). On the other hand, if the load is low, the speech quality of several TCH/H connections can be improved by switching them to a TCH/F.

Codec mode adaptation is to adapt the coding rate (i.e. the trade-off between the level of error protection versus the source bit rate) according to the current channel conditions. When the radio channel is bad, the encoder operates at low source bit rates at its input and uses more bits for forward error protection.

3.4 Advanced Adaptive Multi-Rate Codec (AAMR)

Ideally the channels(TCH) can be split into any number, but the increase in capacity through logical channel sharing (splitting) comes with a cost of reduced QoS. Hence there is need to have controlled channel sharing which does not lead to many channels with unnecessarily very low QoS.

The low bit rate solution is equivalent to the sharing of the logical channels. This is one of the solutions free of further spectrum or physical channel considerations.

In our solution to the problem as explained in the problem statement, we propose the use of an Advanced Adaptive Multi-Rate Codec capable of dynamically splitting the logical channels to enable multiple sharing as demand increases. The proposed AAMR is designed such that it switches to the Channel mode adaptation dynamically and selects the type of traffic channel that a connetion should be assigned to depending on the prevailing traffic load. The bit-rate of the new channel to be allocated is based on the percentage of the remaining channels and the rate at which request for the channels are received.

The AAMR codec is also designed to dynamically adapt to the codec mode. Though with limited bits due to increased capacity, the codec is capable of adjusting the proportion of protection bits to cater for the adverse channel effects.

3.4.1 Advanced Adaptive Multi-Rate Codec (AAMR) performance optimization

In most of the telecommunication equipment designs there are no specific values that are calculated to a stipulated accuracy. GSM is itself a set of standards that were agreed upon by a consortium of National standard bodies from European countries. One of the standards in GSM is the use of 156.25 bit periods per time slot. There is no design formula that was used to arrive at this value. But the use of this value is said to result to adequate capacity, range of transmission and considerable ease in equipment fabrication (Siemens, 2000). The guiding factor here is the balancing of the requirements visa viz the equipment availability i.e. cost. Equally in our modification of the Codec we optimize on the trade off between the GoS and Capacity.

The Codec design parameters are based on mean call duration d Seconds. The expected responce is such that when half the cell capacity is engaged. The codec assesses the rate (r) of arrival of requests for TCH expressed as a percent of the available capacity per second. If the rate of TCH requests is equal or more than the set value and the cell is at least 50% loaded the AAMR switches to channel mode. It is also designed to function through out in codec mode. The modelling equation for adaptation to channel mode is delived as follows:

Consider a cell of available capacity (AV. CP) x and whose TCH requests arrive at a rate of r%.Where r is expressed as a percentage of the available capacity. It follws that if we start our analysis when the cell load reaches 50%. Assuming that all the r% requests come at the end of each seconds, then the number of the engaged channels(load) during the first one seconds is CP_1 given as

$$CP_1 = \frac{x}{2} \qquad \text{.......3.4.1(a)}$$

At the end of the first one second the cell load which is the second(2^{nd}) second load is got as the sum of the previously occupied channels less the released(cleared) channels plus the new requests. The resulting 2^{nd} second load CP_2 is given as

$$CP_2 = \frac{x}{2}\left(\frac{d-1}{d}\right) + rx \qquad \text{.......3.4.1(b)}$$

At the end of this one second 1/d of the occupied channels will be released and another new set of requests got, this results to the loading shown in 3.4.1(c) during the third seconds

$$CP_3 = \frac{x}{2}\left(\frac{d-1}{d}\right)^2 + rx\left\{\frac{d-1}{d} + 1\right\} \quad \text{.......... 3.4.1(c)}$$

Similarly CP_4 is given as

$$CP_4 = \frac{x}{2}\left(\frac{d-1}{d}\right)^3 + rx\left\{\left(\frac{d-1}{d}\right)^2 + \left(\frac{d-1}{d}\right) + 1\right\} \quad \text{.......... 3.4.1(d)}$$

From equation 3.4.1(a) through 3.4.1(d), it follows that the cell load during the t^{th} second is given as

$$CP_t = \frac{x}{2}\left(\frac{d-1}{d}\right)^{t-1} + drx\left\{1 - \left(\frac{d-1}{d}\right)^{t-1}\right\} \quad \text{.......... 3.4.1(e)}$$

[For t = 1, 2, 3, 4, _, _, _]

Equation 3.4.1(e) gives the cell loading CP at time t seconds where the rate of new requests for TCHs arrives at a rate of r% per second, the mean call duration (CD) is d-seconds and the cell available capacity is x(TCH).

For d= 40s it follows that the t^{th} second load is given as

$$CP_t = \frac{x}{2}\left(\frac{39}{40}\right)^{t-1} + 40rx\left\{1 - \left(\frac{39}{40}\right)^{t-1}\right\} \quad \text{.......... 3.4.1(f)}$$

Tables 3.1 and 3.2 are generated using equation 4.3.1(f). The cell capacities are chosen for a high (CP=100) and a low (CP=30) capacity cells respectively.

From these tables as expected if the rate of requests for TCH is lower than the rate at which the engaged channels are being cleared then the cell's channel load reduces with time. The converse is also true i. e. when the rate of TCH requests is higher than the rate of release of the occuppied channels. The cell load continues increasing with time. Since the overshoot of demand results from unexpected random requirements for resources. With good updated planning the rate of requests per seconds (denoted here as r) rarely goes above 7%. The best rate to use then is 8% to ensure optimization of quality and capacity. From the tabulated data we find that during the eighth seconds that is t = 8 the cell load is in both cases equal or above the the cell design capacity. To get rid of unnecessary blocking and dropping of calls the AAMR Codec is designed such that on detecting that the cell load is 50% and the rate of requests for TCH is 8% or more. Then it automatically adapts to the channel mode and allocates new speech channels at Half-Rate. On reaching 75% of the old capacity, if the rate of requests is equal to or higher than 8% then subsequent new speech channel allocations are to be done at quarter-Rate i.e half of half-rate (FR/4).

Table 3. 1 Cell channel occupancy for different rates of requests (cell capacity = 100)

CELL CAPACITY X =100										
t^{th} Second	Number of Channels occupied									
	Rate									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	51.00	53.00	53.00	54.00	55.00	56.00	57.00	58.00	59.00	60.00
2	50.73	52.70	54.68	56.65	58.63	60.60	62.58	64.55	66.53	68.50
3	50.46	53.38	56.31	59.23	62.16	65.09	68.01	70.94	73.86	76.79
4	50.20	54.05	57.90	61.75	65.61	69.46	73.31	77.16	81.02	84.87
5	49.94	54.70	59.45	64.21	68.97	73.72	78.48	83.23	87.99	92.75
6	49.69	55.33	60.97	66.60	72.24	77.88	83.52	89.15	94.79	100.43
7	49.45	55.95	62.44	68.94	75.44	81.93	88.43	94.92	101.42	107.92
8	49.21	56.55	63.88	71.22	78.55	85.88	93.22	100.55	107.88	115.22
9	48.98	57.13	65.28	73.43	81.59	89.74	97.89	106.04	114.19	122.34
10	48.76	57.71	66.65	75.60	84.55	93.49	102.44	111.39	120.33	129.28
11	48.54	58.26	67.99	77.71	87.43	97.16	106.88	116.60	126.32	136.05
12	48.33	58.81	69.29	79.77	90.25	100.73	111.21	121.69	132.17	142.65
13	48.12	59.34	70.55	81.77	92.99	104.21	115.43	126.64	137.86	149.08
14	47.92	59.85	71.79	83.73	95.67	107.60	119.54	131.48	143.42	155.35
15	47.72	60.36	73.00	85.63	98.27	110.91	123.55	136.19	148.83	161.47
16	47.52	60.85	74.17	87.49	100.82	114.14	127.46	140.79	154.11	167.43
17	47.34	61.33	75.32	89.31	103.30	117.29	131.28	145.27	159.26	173.25
18	47.15	61.79	76.43	91.07	105.71	120.35	134.99	149.64	164,28	178.92
19	46.97	62.25	77.52	92.80	108.07	123.35	138.62	153.89	169.17	184.44
20	46.80	62.69	78.58	94.48	110.37	126.26	142.15	158.05	173.94	189.83
21	46.63	63.12	79.62	96.12	112.61	129.11	145.60	162.10	178.59	195.09
22	46.46	63.55	80.63	97.71	114.80	131.88	148.96	166.04	183.13	200.21
23	46.30	63.96	81.61	99.27	116.93	134.58	152.24	169.89	187.55	205.20
24	46.14	64.36	82.57	100.79	119.00	137.22	155.43	173.65	191.86	210.07
25	45.99	64.75	83.51	102.27	121.03	139.79	158.54	177.30	196.06	214.82
26	45.84	65.13	84.42	103.71	123.00	142.29	161.58	180.87	200.16	219.45
27	45.70	65.50	85.31	105.12	124.93	144.73	164.54	184.35	204.16	223.97
28	45.55	65.87	86.18	106.49	126.80	147.12	167.43	187.74	208.05	228.37
29	45.41	66.22	87.02	107.83	128.63	149.44	170.24	191.05	211.85	232.66
30	45.28	66.56	87.85	109.13	130.42	151.70	172.99	194.27	215.56	236.84

Table 3. 2 Cell occupancy for different rates of requests (cell capacity = 30)

CELL CAPACITY X =30										
t^{th} Second	Number of Channels occupied Rate									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00
2	15.22	15.81	16.40	17.00	17.59	18.18	18.77	19.37	19.96	20.55
3	15.14	16.01	16.89	17.77	18.65	19.53	20.40	21.28	22.16	23.04
4	15.06	16.21	17.37	18.53	19.68	20.84	21.99	23.15	24.30	25.46
5	14.98	16.41	17.84	19.26	20.69	22.12	23.54	24.97	26.40	27.82
6	14.91	16.60	18.29	19.98	21.67	23.36	25.05	26.75	28.44	30.13
7	14.83	16.78	18.73	20.68	22.63	24.58	26.53	28.48	30.43	32.38
8	14.76	16.96	19.16	21.36	23.56	25.76	27.97	30.17	32.37	34.57
9	14.69	17.14	19.59	22.03	24.48	26.92	29.37	31.81	34.26	36.70
10	14.63	17.31	20.00	22.68	25.36	28.05	30.73	33.42	36.10	38.78
11	14.56	17.48	20.40	23.31	26.23	29.15	32.06	34.98	37.90	40.81
12	14.50	17.64	20.79	23.93	27.07	30.22	33.36	36.51	39.65	42.79
13	14.44	17.80	21.17	24.53	27.90	31.26	34.63	37.99	41.36	44.72
14	14.37	17.96	21.54	25.12	28.70	32.28	35.86	39.44	43.02	46.61
15	14.32	18.11	21.90	25.69	29.48	33.27	37.07	40.86	44.65	48.44
16	14.26	18.25	22.25	26.25	30.25	34.24	38.24	42.24	46.23	50.23
17	14.20	18.40	22.59	26.79	30.99	35.19	39.38	43.58	47.78	51.97
18	14.15	18.54	22.93	27.32	31.71	36.11	40.50	44.89	49.28	53.67
19	14.09	18.67	23.26	27.84	32.42	37.00	41.59	46.17	50.75	55.33
20	14.04	18.81	23.58	28.34	33.11	37.88	42.65	47.41	52.18	56.95
21	13.99	18.94	23.89	28.83	33.78	38.73	43.68	48.63	53.58	58.53
22	13.94	19.06	24.19	29.31	34.44	39.56	44.69	49.81	54.94	60.06
23	13.89	19.19	24.48	29.78	35.08	40.37	45.67	50.97	56.26	61.56
24	13.84	19.31	24.77	30.24	35.70	41.16	46.63	52.09	57.56	63.02
25	13.80	19.43	25.05	30.68	36.31	41.94	47.56	53.19	58.82	64.45
26	13.75	19.54	25.33	31.11	36.90	42.69	48.47	54.26	60.05	65.84
27	13.71	19.65	25.59	31.54	37.48	43.42	49.36	55.30	61.25	67.19
28	13.67	19.76	25.85	31.95	38.04	44.13	50.23	56.32	62.42	68.51
29	13.62	19.87	26.11	32.35	38.59	44.83	51.07	57.31	63.56	69.80
30	13.58	19.97	26.35	32.74	39.13	45.51	51.90	58.28	64.67	71.05

3.4.2 AAMR Codec Performance

This model solution results to a network that is not capacity limited. Hence the use of the GoS as the metric of determining the model systems performance is not applicable. The suitability of this system can be assessed through the use of the ITU-T equation relating the specification of the network hardware codec and the audio QoS as determined using Likert-type Scale. For a network that is not capacity limited nor coverage limited the rating R is determined using equation 3.4.2(a) below.

$R = 93.35 - I_d - I_e$ ....3.4.2(a)

Where

I_d, is the delay impairment factor which includes all delay and echo effects

I_e is the equipment impairment factor which models impairment caused by low-bit-rate codecs, and the expectation factor.

For an AMR used at full rate the factors I_d and I_e take their default values. Since the new codec that is the AAMR is assumed to operate in the same environment as its unmodified type (AMR). Then the factor I_d can be assumed to be the same for the two Codes i.e. $I_d = 0$. Equation 3.4.2(a) reduces to

$R = 93.5 - I_e$ ....3.4.2(b)

We can regard the shared bandwidth to contribute to lost bits with the following probabilities:

- At half rate probability of 50%
- At Quarter rate Probability of 75%

From the computational model for use in transmission planning Recommendation ITU-T g.107 I_e becomes $I_{e\text{-}eff}$ in a situation where there is a probability of packet loss, with a packet-loss probability P_{pl}, $I_{e\text{-}eff}$ is calculated using the equation:

$$I_{e-eff} = I_e + (95 - I_e)\frac{P_{pl}}{\frac{P_{pl}}{BurstR} + Bpl} \quad \text{.......................................3.4.2(c)}$$

I_e is taken to be the default value of 0(zero) which corresponds to the value for unmodified AMR. The factor Burst Ratio (BurstR) is not changed by design and hence it as well retains the default value applicable to AMR of 1(one).

The packet-loss robustness Factor Bpl is defined as a codec-specific value. Its value is not bound to change since the actual bit-rate does not change. As a result its value is taken to be the default value of 4.3. On substituting these values equation 3.4.2(c) reduces to

$$I_{e-eff} = 95\left(\frac{P_{pl}}{P_{pl} + 4.3}\right) \quad \text{.......................................3.4.2(d)}$$

When operating at quarter rate $I_{e\ eff(HR/2)} = 95\left(\frac{0.75}{0.75 + 4.3}\right) = 95 \times 0.1485 = 14.1$

When operating at half rate $I_{e-eff(HR)} = 95\left(\frac{0.5}{0.5 + 4.3}\right) = 95 \times 0.1042 = 9.9$

The resulting values of R for the three different rates are

$R_{FR} = 93.5$, $R_{FR/2} = 93.5 - 9.9 = 83.5$ and $R_{FR/4} = 93.5 - 14.1 = 79.4$

There are three categories of services available from this device:

- Full rate
- Half rate
- Quarter rate

The best service is offered when 50% of the channels is availed at Full-rate, 25% at half -rate and 25% at quarter rate. All the percentages being expressed out of the old capacity before sharing is effected This results to a new capacity which is 200% of the old capacity. The R value is calculated and indicated against the new percentage after sharing.

This implies that 25% (FR) will have an		R = 93.5
25% (FR/2)	"	R = 83.5
50% (FR/4)	"	R =79.4

The resultant value of R is $0.25\times 93.5+0.25\times 83.5+0.5\times 79.4=83.95$

From recommendation ITU-T G.107 of 2009 the R factor is related to the MOS_{CQE} for values of R ranging from 0 to 100 as

$$MOS_{CQE}=1+0.035R+R(R-600(100-R)7\times 10^{-6} \qquad \text{...........3.4.2(e)}$$

The resulting value of MOS_{CQE} is 3.94

The other extreme is when all the channels that would have been allocated at full-rate happen to have been relinquished and reallocated at quarter rate. This gives rise to 25% of the channels being allocated at half rate and the remaining 75% at Quarter rate. The resulting capacity is 350%.

This implies that 14.28% (HR) will have an		R = 83.5
85.72% (HR/2)	"	R = 79.4

The average value of R = 79.96 which corresponds to a MOS_{CQE} of 3.84

This indicates that the AAMR would operate between the range of MOS_{CQE} of 3.84 and 3.94. If we take the worst performance then the AAMR Codec would be rated as FAIR on the Good or Better (GoB) scale i.e. the biggest percentage of users would be satisfied (ITU-T G. 107, 2009).

This model solution is capable of reducing congestion by dynamically increasing the cell capacity and trading off the bit rate and hence reducing the QoS. The advantages of such a solution is its adaptability to the load demand and minimal network modification requirements. When deployed this modified Codec can be used to achieve any value of Grade of service by adjusting the load trigger level and the rate of increase of the new requests r.

It is not possible for demand to overshoot 350% of the planned capacity in a moderately well planned network. This means that our solution qualifies to solve all the networks Busy Hour congestion problems as observed from increased rates of HO dropping and call blocking.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Research design

This is an academic research whose main objective was to gain a thorough understanding of the handoff algorithms implemented by the three leading mobile operators in Kenya and their effects on network capacity and quality of service. The methodology used was interviews to determine the type of handoff algorithms and surveys to collect numerical data for analysis to determine the quality of service offered.

The data was obtained from the Telecommunication Operators (TO) Network Management System. The source of the data is reliable since it was an excerpt from the programmed network management logs. Both types of data were obtained from the TOs employees, this means that the data is actually secondary data (secondary Data means data that are already available i.e. they refer to the data which have already been collected by someone else (Kothari, 2007)) .Data suitability and adequacy was ensured as the sources were statistically suitable representation of all the regions studied.

The design of the research therefore was a combination of descriptive survey and case study. The findings of our research concurred with our expectation of congestion in the network during the Busy Hour period. Out of the past experience in using the available GSM networks it was evident that a solution is required to mitigate on the problem of BH congestion in the Networks. As a result of this observation a solution was conceptualized and its performance analyzed along the collected data final analysis

4.2 Target population

The target population for this research was in two categories. First part required information from the network planners on the planned network capacity and the type of the deployed handoff algorithms. The second category was the staff in Operation and Maintenance Center (OMC) in charge of the Telecommunication Management Network (TMN) monitoring and data log consoles for availing data captured by the TMN system. The data required was a fraction of a few entries in a spread sheet that is recorded and stored as a company requirement for company use for Network management and optimization.

Telecommunication Operator One provided us with the required data as requested and from the heavily loaded cells within the four big towns as follows: Kisumu-5 Cells, Mombasa-5 Cells, Nairobi-10 Cells and Nakuru-6 Cells. Telecommunication Operators Two and Three gave out data for all the cells within the four Towns.

4.3 Sampling technique

Telecommunications Operators are known to deploy the same Handoff algorithm in the entire Network. Therefore there was no sampling required to get the information on the implemented types of handoff algorithms. However to collect data for analysis to determine the handoff effects on capacity and quality of service, requires identification of busy cells in busy neighborhood. Consequently purpose sampling was used to get the cells that experience congestion and whose neighborhood is comprised of other heavily loaded cells.

The ITU guide line on determination of the Quality of Service (QoS) and specifically Grade of Service (GoS) does not take into consideration the size of the population to be studied. It states that any group of circuits should offer at worst 2% GoS. Sample sizes (number of cells) in the three sets of data were taken to be adequate and no formula was used to arrive at the specified numbers.

Since this research was concerned with the network response when the service demand was at the peak. We scheduled our investigation to be conducted for one hour for five days of the week. The one hour for the data collection was within 8.00Hr to 17.00Hr and the one with the most traffic that day identified as a busy hour (BH). Due to the expected changes in the required data within short periods of time. The data was required to be recorded within periods of two minutes. But due to Operators technical short falls the data was given as recorded over one hour periods.

4.4 Data Collection Methods

In order to acquire the required data, formal requests were made to the Telecommunication operators to provide the following information:

- Handoff algorithms implemented in the networks
- Cells that operate at over 100% planned capacity
- The number of new call setup requests
- The number of the net Handoff requests into the cells under observation.

4.4.1 Handoff performance data

The handoff algorithms implemented in the network was given as statements out of personal interviews with the network Engineers. This information was necessary to explain the determined network performance out of the analysis of QoS data collected.

4.4.2 Network Data

All telecommunication network operators have installed Telecommunication Management Network systems which collect and record on disks and tapes the network performance and condition data which includes such data as the one required for this research. The only other important exercise other than getting the permission to acquire the data was extraction of the required parts.

Identification of the cells was done on the basis of the amount of traffic load experienced by the cell. For Safaricom the heavily loaded cells were identified by the Network Engineer and their data forwarded as requested.

Orange and Airtel gave data for all the cells in the four towns for seven busy hours of the seven days in a week. The data was further scrutinized for the required number of cells for analysis.

Where one of the Company was found to have very low QoS. Data from other cells that do not experience congestion was also requested for analysis to mitigate against portraying the whole network as always under performing.

4.5 Data analysis

The explanatory notes captured through face to face cross examination of the Network Engineer/Manager and further clarification through Electronic Mails were summarized into a single statement. The summary statement indicates the type of Handoff algorithm (scheme) implemented in the network.

The network performance data collected was analyzed using statistics and probability methods. The data acquired was not in the most suitable form for analysis as the most ideal data for analysis is the one taken for a duration of one average call duration. The first process was to break the one hour duration data into the mean call duration data. The average call duration (CD) is stated as 38s, it follows that in one hour there are $\frac{60X60}{38} = 94.74$ Call Durations (CDs). Since calling is a stochastic event the network performance can be observed over a time equal to the CD. The CD turns out to be the reciprocal of the mean call duration in Erlangs. It also means that one TCH can service 94.74 calls in one hour. This is the maximum theoretical limit. According to telephone theory by Erlang the TCH loading depends on their total number and there is no direct simple relationship between TCH and the Erlang loading. However there exist tables called Erlang Tables (shown in appendix 3) that are used to get either the number of TCH or the Erlang load whichever is of interest.

To compare cell loading to determine the heavily loaded ones, we used the product AVCP X 94.74 to get the maximum requests that the cell can handle. When total request (TTLRQ) is referenced over AVCP X 94.74 the results is a perfect indication of the extent of the cell loading. The more positive equation 4.5(a) is the heavier is the traffic load.

$$TTLRQ - AVCP \times 94.74 \quad \text{......} 4.5(a)$$

The NCSR and the HOR are averaged over the CD. The QoS metric of PCB is determined using the simple probability formula that combines two independent events. Where an independent event is one in which the probability of the event happening does not affect the probability of another event happening (Bird, 2006).

That is the probability of blocking of a new call request (NCSRB) is.

$P(NCSRB) = \frac{NCSR}{TTLRQ}$ and the probability of access denial P (F) is $P(F) = \frac{TTRQ - AVCP}{TTRQ}$

The combination of these two Probabilities is the Probability of Call Blocking PCB which is determined as

$$PCB = \frac{NCSR}{TTLRQ}\left(\frac{TTLRQ - AVCP}{TTLRQ}\right) = \frac{NCSR(TTLRQ - AVCP)}{TTLRQ^2} \quad \text{..........4.5(b)}$$

Similarly Probability of Handoff Dropping (PHD) is expressed as

$$PHD = \frac{HOR(TTLRQ - AVCP)}{TTLRQ^2} \quad \text{...4.5(c)}$$

The effect of Handoff on capacity is got through subtracting the Handoff Requests (HOR) from available capacity (AVCP) this results to the Effective Capacity (EFFCP). That is

$$EFFCP = AVCP - HOR \quad \text{...4.5(d)}$$

Handoffs inherently affect capacity since even in a well planned network it is impossible to carter for all the anticipated HOs. Consequently irrespective of the planning tools used HOs always reduce the provisioned capacity. The effect of handoff on capacity is well presented using graphs as depicted in the following chapter.

CHAPTER 5: FINDINGS, ANALYSIS AND INTERPRETATIONS

5.1 Introduction

The purpose for going to the field to collect the data was to identify the HO algorithms used and determine their effect on quality of service through the two metrics of PCB and PHD. In this chapter, the research findings are presented following analysis and interpretation of the data we collected from the three Telecommunication Operators. Data was sourced and received from three Mobile telecommunication Companies. The three sources of data have been referred to as Telecommunication Operators One, Two and Three. The findings are mainly presented using tables, line graphs and column bar charts where statistical methods have been used to determine probabilities as described in methodology.

Numerical data analyses has been done using the network capacity stated and the hypothesized capacity from the model solution. The practical results are interpreted and comparison made with the theoretical results. The results have consistently indicated far much better performance of the model gadget as compared to the existing hardware in the network. This comparison in the whole of the data analysis and the determination of the MOS_{CQE} of the proposed Codec in methodology covers the required validation of device performance

5.1 Data Processing and Analysis

From Telecommunication Operator (TO) One the Busy Hour (BH) data obtained was for 10 cells in Nairobi, 5 each from Mombasa and Kisumu, and 6 from Nakuru resulting to a total of 26 cells. This data has been presented in its raw form just as received from the network operator. Due to the nature of results found from analysis of BH data another set of data covering the non Busy Hour period was requested and acquired. Therefore two sets of data from TO One have been analyzed.

Telecommunication Operator two gave data for all the cells taken for seven days for Kisumu, Mombasa, Nairobi and Nakuru. From the received lot twenty seven cells were identified for analysis.

Telecommunication Operator Three gave data for all High trafficking cells within Kisumu, Mombasa, Nairobi and Nakuru. The highest trafficking 26 cells were identified and their data has been analyzed

In all the three sources of data there were two categories of data, one the notes taken during personal interviews with the Network Engineer. From this data the first step in the analysis was the determination of the type of the HO algorithm, which has a lot of effect on the QoS metrics to be determined.

The other category of data was the numerical data indicating the traffic levels and the referenced cell capacities. In this case the data collected being secondary data did not exactly much the durations suitable for analysis as stated in our methodology. Hence the processing started by splitting the data to obtain averages that corresponds to the applicable call durations.
The broken down data into short call durations equal to the Telecommunications Operator average call duration was analyzed to determine metrics of QoS measurement PCB and PHD. The results of the analysis are presented in tables, bar charts and line graphs.

5.2 Data Presentation

This is the presentation of the data as sourced from the Operator. The first category of data collected as notes is presented as a statement of how the Handoff requests are processed by the respective Network. The numerical data is a true excerpt of the system record captured through the systems Telecommunications Management Network. This means that the collected data is reliable. It is also suitable since it was collected at the agreed time and in the correct units. The area of coverage as stated in the methodology does not matter as the standard used by ITU has no minimum so long as reference is made to a group of circuits connecting the area under study.
The explanatory notes have been captured through face to face cross examination of the Network Engineer/Manager and further clarification through Electronic Mails. It is also ascertained by the categories of the data given. This confirmed that the algorithms applied are as stated in the notes.

5.3 Analysis of Telecommunication Operator One Data

The Network offers no Priority to HandOff Request (HOR) calls over the New Call Setup Requests (NCSR). This means that after exchange of control information through signaling both type of calls compete for the same Traffic Channels (TCHs). So the type of HO algorithm used in the whole of the Safaricom Network is the one of zero Priority. The implementation of this HO scheme simplifies the analysis since the two categories of requests can be analyzed together as there is no special treatment given to any one of them.

There are two sets of Data obtained from Operator One . The first set of data corresponds to the busy hour period when as earlier suggested the Network is supposed to experience the heaviest amount of Traffic Load. On analysis of this set of data it revealed a serious over stretch of the network resources over the BH period. To establish how the network performed outside the BH period. Another set of data was collected. On second analysis of the non busy hour data it has ascertained that the network performs within the expected range of performance index.

Tabulation, analysis and findings of the two sets of data are presented in this section.

5.3.1 Analysis of BH data from Telecommunication Operator One

To determine the network BH prevailing probabilities of call blocking and handoff dropping the raw data is organized further, and then analyzed in phases. The first phase of the analysis is to get the average data to represent the demand per cell in each town. The resulting data is a better indication of the network demand in the respective cell per call duration. The resulting averaged data has been used to determine the QoS metrics of PCB and PHD.

Each town result is presented using bar charts for ease of comparison. As far as the research is concerned even a single town is enough to give an indication of the Network quality of service with reference to the ITU guidelines.

Further analysis is done to combine all the individual town data to have one presentation of the four towns while having taken the individual town demand into consideration. In this final presentation is the average for the four towns which is an adequate representation of the whole Network.

In the determination of the towns QoS we presented results got using the network available capacity at Full Rate (FR) and another column of results that are got on implementation of the model solution that increases capacity to varying bit rates (XR).

Due to the simplicity of the HO algorithm used, GoS is got as a direct sum of PCB and PHD. This important QoS metric has been quoted for the whole network at the end of all the analysis.

The raw BH data is comprised of three tables the first table (Table 5.1) contains the specification of the cells under study, the second one (Table 5.2) is a tabulation of the busy hour handoff requests (HOR) while the third one (Table 5.3) is the corresponding BH new call setup requests (NCSR).

Table 5. 1 Operator One cell specification and capacity

CI	Town	Cell Capacity(CP)	CI	Town	Cell Capacity(CP)
70	Nairobi	39	15740	Kisumu	26
300	Nairobi	68	20120	Mombasa	53
1386	Nairobi	137	20141	Mombasa	69
3512	Nairobi	29	20151	Mombasa	69
5032	Nairobi	42	20152	Mombasa	53
5811	Nairobi	38	20232	Mombasa	54
7231	Nairobi	44	30001	Nakuru	69
7311	Nairobi	32	30610	Nakuru	53
10760	Nairobi	58	30770	Nakuru	72
13202	Nairobi	85	40380	Kisumu	26
13252	Nakuru	75	42541	Kisumu	22
13970	Nakuru	78	42581	Kisumu	24
13972	Nakuru	63	42592	Kisumu	25

Table 5.1 contains the network cell identifier CI(Cell Identity), the town where the cell is located and the cell TCH capacities. In this research the number of TCH is defined as the available capacity. This is not always the case since the TCH cannot be engaged throughout. But since we are focusing on the network at a time when there exist a high random frequency of calling, then it is possible to incorporate the negligible small time between calls into the mean Call Duration (CD).

The translation of TCH capacity to the expected Erlang load is done through the use of the Erlang tables. As an indicator of the relationship between TCH and Erlang load, from the Erlang table given in appendix 3, 44 TCH can carry a maximum of 34.7 Erlangs at 2% Grade of service. This type of analysis is best suited in cases of fixed line telephone analysis where collision effects are more pronounced.

Table 5. 2 Operator One Busy Hour Handoff request data

CI	Date	BH Handover Attempts	CI	Date	BH Handover Attempts	CI	Date	BH Handover Attempts
70	12/3/2010	747	10760	12/9/2010	878	20152	12/8/2010	4033
70	12/6/2010	802	13202	12/3/2010	235	20152	12/9/2010	3864
70	12/7/2010	752	13202	12/6/2010	217	20232	12/3/2010	3219
70	12/8/2010	679	13202	12/7/2010	208	20232	12/6/2010	3222
70	12/9/2010	696	13202	12/8/2010	224	20232	12/7/2010	3111
300	12/3/2010	848	13202	12/9/2010	178	20232	12/8/2010	3484
300	12/6/2010	850	13252	12/3/2010	284	20232	12/9/2010	3120
300	12/7/2010	784	13252	12/6/2010	273	30001	12/3/2010	123
300	12/8/2010	807	13252	12/7/2010	250	30001	12/6/2010	155
300	12/9/2010	768	13252	12/8/2010	252	30001	12/7/2010	137
1386	12/3/2010	7056	13252	12/9/2010	304	30001	12/8/2010	142
1386	12/6/2010	6905	13970	12/3/2010	283	30001	12/9/2010	117
1386	12/7/2010	6568	13970	12/6/2010	272	30610	12/3/2010	478
1386	12/8/2010	7057	13970	12/7/2010	247	30610	12/6/2010	439
1386	12/9/2010	6432	13970	12/8/2010	241	30610	12/7/2010	509
3512	12/3/2010	588	13970	12/9/2010	295	30610	12/8/2010	433
3512	12/6/2010	468	13972	12/3/2010	229	30610	12/9/2010	406
3512	12/7/2010	433	13972	12/6/2010	172	30770	12/3/2010	709
3512	12/8/2010	512	13972	12/7/2010	185	30770	12/6/2010	502
3512	12/9/2010	467	13972	12/8/2010	183	30770	12/7/2010	652
5032	12/3/2010	649	13972	12/9/2010	136	30770	12/8/2010	583
5032	12/6/2010	728	15740	12/3/2010	679	30770	12/9/2010	637
5032	12/7/2010	686	15740	12/6/2010	731	40380	12/3/2010	3213
5032	12/8/2010	611	15740	12/7/2010	953	40380	12/6/2010	542
5032	12/9/2010	604	15740	12/8/2010	852	40380	12/7/2010	707
5811	12/3/2010	868	15740	12/9/2010	644	40380	12/8/2010	628
5811	12/6/2010	990	20120	12/3/2010	4257	40380	12/9/2010	685
5811	12/7/2010	1044	20120	12/6/2010	5173	42541	12/3/2010	2792
5811	12/8/2010	1091	20120	12/7/2010	5048	42541	12/6/2010	2733
5811	12/9/2010	961	20120	12/8/2010	4704	42541	12/7/2010	2865
7231	12/3/2010	1062	20120	12/9/2010	4370	42541	12/8/2010	2763
7231	12/6/2010	705	20141	12/3/2010	5838	42541	12/9/2010	2843
7231	12/7/2010	770	20141	12/6/2010	5816	42581	12/3/2010	5175
7231	12/8/2010	843	20141	12/7/2010	6001	42581	12/6/2010	5103
7231	12/9/2010	974	20141	12/8/2010	5774	42581	12/7/2010	5128
7311	12/3/2010	1163	20141	12/9/2010	5722	42581	12/8/2010	4871
7311	12/6/2010	923	20151	12/3/2010	7165	42581	12/9/2010	5148
7311	12/7/2010	920	20151	12/6/2010	7890	42592	12/3/2010	6562
7311	12/8/2010	846	20151	12/7/2010	7875	42592	12/6/2010	3082
7311	12/9/2010	917	20151	12/8/2010	7829	42592	12/7/2010	3080
10760	12/3/2010	1160	20151	12/9/2010	7925	42592	12/8/2010	3102
10760	12/6/2010	757	20152	12/3/2010	15031	42592	12/9/2010	2993
10760	12/7/2010	929	20152	12/6/2010	4085			
10760	12/8/2010	1100	20152	12/7/2010	4019			

Table 5. 3 Operator One Busy Hour New Call Setup data

CI	DATE	Number of CallSetups	CI	DATE	Number of CallSetups	CI	DATE	Number of CallSetups
70	12/3/2010	9865	10760	12/9/2010	8515	20152	12/8/2010	4887
70	12/6/2010	10260	13202	12/3/2010	8800	20152	12/9/2010	4998
70	12/7/2010	8998	13202	12/6/2010	8519	20232	12/3/2010	6066
70	12/8/2010	9336	13202	12/7/2010	9291	20232	12/6/2010	6119
70	12/9/2010	10257	13202	12/8/2010	8932	20232	12/7/2010	4934
300	12/3/2010	9607	13202	12/9/2010	9285	20232	12/8/2010	6215
300	12/6/2010	9238	13252	12/3/2010	7883	20232	12/9/2010	5992
300	12/7/2010	8019	13252	12/6/2010	8396	30001	12/3/2010	8586
300	12/8/2010	8164	13252	12/7/2010	8038	30001	12/6/2010	8543
300	12/9/2010	7765	13252	12/8/2010	8088	30001	12/7/2010	8530
1386	12/3/2010	16250	13252	12/9/2010	7906	30001	12/8/2010	8585
1386	12/6/2010	17061	13970	12/3/2010	8296	30001	12/9/2010	8435
1386	12/7/2010	16396	13970	12/6/2010	8751	30610	12/3/2010	4182
1386	12/8/2010	16630	13970	12/7/2010	8645	30610	12/6/2010	3837
1386	12/9/2010	15783	13970	12/8/2010	8640	30610	12/7/2010	3809
3512	12/3/2010	7542	13970	12/9/2010	8638	30610	12/8/2010	3913
3512	12/6/2010	7735	13972	12/3/2010	6675	30610	12/9/2010	3882
3512	12/7/2010	6959	13972	12/6/2010	6674	30770	12/3/2010	7057
3512	12/8/2010	7107	13972	12/7/2010	6519	30770	12/6/2010	6229
3512	12/9/2010	7353	13972	12/8/2010	7981	30770	12/7/2010	6270
5032	12/3/2010	5481	13972	12/9/2010	6815	30770	12/8/2010	6263
5032	12/6/2010	5169	15740	12/3/2010	3512	30770	12/9/2010	6155
5032	12/7/2010	4494	15740	12/6/2010	3844	40380	12/3/2010	3105
5032	12/8/2010	5144	15740	12/7/2010	3623	40380	12/6/2010	3076
5032	12/9/2010	7943	15740	12/8/2010	3740	40380	12/7/2010	3323
5811	12/3/2010	7319	15740	12/9/2010	3666	40380	12/8/2010	2862
5811	12/6/2010	9604	20120	12/3/2010	5485	40380	12/9/2010	3186
5811	12/7/2010	5554	20120	12/6/2010	6269	42541	12/3/2010	1961
5811	12/8/2010	5862	20120	12/7/2010	6457	42541	12/6/2010	1936
5811	12/9/2010	9140	20120	12/8/2010	5750	42541	12/7/2010	1720
7231	12/3/2010	4110	20120	12/9/2010	5594	42541	12/8/2010	1701
7231	12/6/2010	4311	20141	12/3/2010	7020	42541	12/9/2010	1811
7231	12/7/2010	4251	20141	12/6/2010	7216	42581	12/3/2010	2299
7231	12/8/2010	3902	20141	12/7/2010	7174	42581	12/6/2010	2391
7231	12/9/2010	4208	20141	12/8/2010	7024	42581	12/7/2010	2189
7311	12/3/2010	3839	20141	12/9/2010	7240	42581	12/8/2010	2363
7311	12/6/2010	3754	20151	12/3/2010	4998	42581	12/9/2010	2375
7311	12/7/2010	3565	20151	12/6/2010	5425	42592	12/3/2010	2323
7311	12/8/2010	3002	20151	12/7/2010	5310	42592	12/6/2010	2543
7311	12/9/2010	3557	20151	12/8/2010	5215	42592	12/7/2010	2328
10760	12/3/2010	8190	20151	12/9/2010	5172	42592	12/8/2010	2599
10760	12/6/2010	8944	20152	12/3/2010	4564	42592	12/9/2010	2379
10760	12/7/2010	7982	20152	12/6/2010	5120			
10760	12/8/2010	7936	20152	12/7/2010	5055			

5.3.2 Basic Analysis of Operator One Data

The data given in the tables 5.1, 5.2 and 5.3 is matched and the requests split into the average requests over 38s and 2min call durations. The first phase of analysis is the basic analysis where the 26 cells are analyzed separately and individual cell average determined.

All the basic data analysis has been done and is presented in appendix 2. Table A2.1 presents the basic analysis of Operator One data for Nairobi Town.

In further analysis the cell averaged data has been used which is a better representative of the network demand over the busy hour in each town. The last part of table A2.1 presents a summary of the four towns averages which was derived in this section and used in the final data analysis.

5.3.3 Analysis of Operator One data to determine PCB and PHD

This phase of analysis is comprised of the analysis of the town averages to determine the PCB and PHD and to graphically present the effect of HO on network capacity. The following is the secondary analysis of the four towns' averaged data as contained in the basic analyses table A2.1 in appendix 2.

Nairobi Town

Table 5. 4 Secondary analysis of Operator One BH data for Nairobi Town

ANALYSIS OF OPERATOR ONE BH AVERAGED DATA FOR NAIROBI TOWN														
CELL DETAILS			AVER RQ/HR		38 SECONDS AVERAGE REQUEST ANALYSIS									
	CI	CP	NCSR	HOR	AVER NCS	AVER HOR	TTL RQ.	NCSR /TTL RQ	HOR/ TTL RQ	HOR /CP	PCB	PHD	PCB (XR)	PHD (XR)
1	70	39	9743	735	103	7.8	111	93.0%	7.0%	19.8%	60.1%	4.5%	0.9%	0.1%
2	300	68	8559	811	90	8.6	99	91.3%	8.7%	12.6%	28.5%	2.7%	3.4%	0.3%
3	1386	137	16424	6804	173	71.8	245	70.7%	29.3%	52.4%	31.2%	12.9%	3.5%	1.5%
4	3512	29	7339	494	77	5.2	83	93.7%	6.3%	18.0%	60.8%	4.1%	1.7%	0.1%
5	5032	42	5646	656	60	6.9	67	89.6%	10.4%	16.5%	33.0%	3.8%	4.7%	0.6%
6	5811	38	7496	991	79	10.5	90	88.3%	11.7%	27.5%	50.9%	6.7%	2.2%	0.3%
7	7231	44	4156	871	44	9.2	53	82.7%	17.3%	20.9%	14.1%	3.0%	0.4%	0.1%
8	7311	32	3543	954	37	10.1	47	78.8%	21.2%	31.5%	25.7%	6.9%	4.4%	1.2%
9	10760	58	8313	965	88	10.2	98	89.6%	10.4%	17.6%	36.5%	4.2%	4.7%	0.5%
10	13202	85	8965	212	95	2.2	97	97.7%	2.3%	2.6%	12.0%	0.3%	3.4%	0.1%
	AVE	57	8019	1349	85	14.2	99	85.6%	14.4%	24.9%	36.1%	6.1%	1.4%	0.2%

The analyzed Nairobi BH data shows that the chance of a request to be blocked (PCB) is 36.1% and the chance of dropping a call (PHD) is 6.1%.

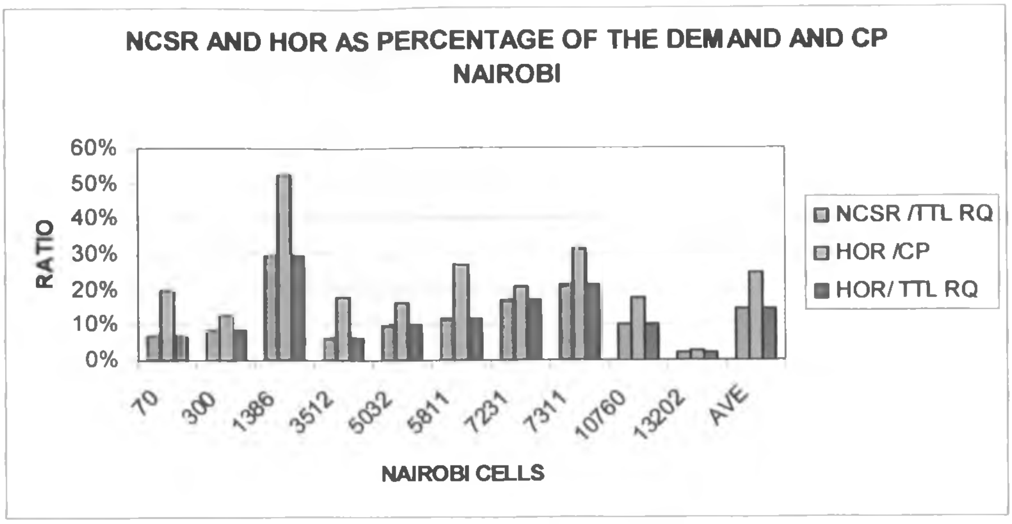


Figure 5. 1 Ratios of NCSR and HOR to demand and available capacity for TO One-Nairobi Town

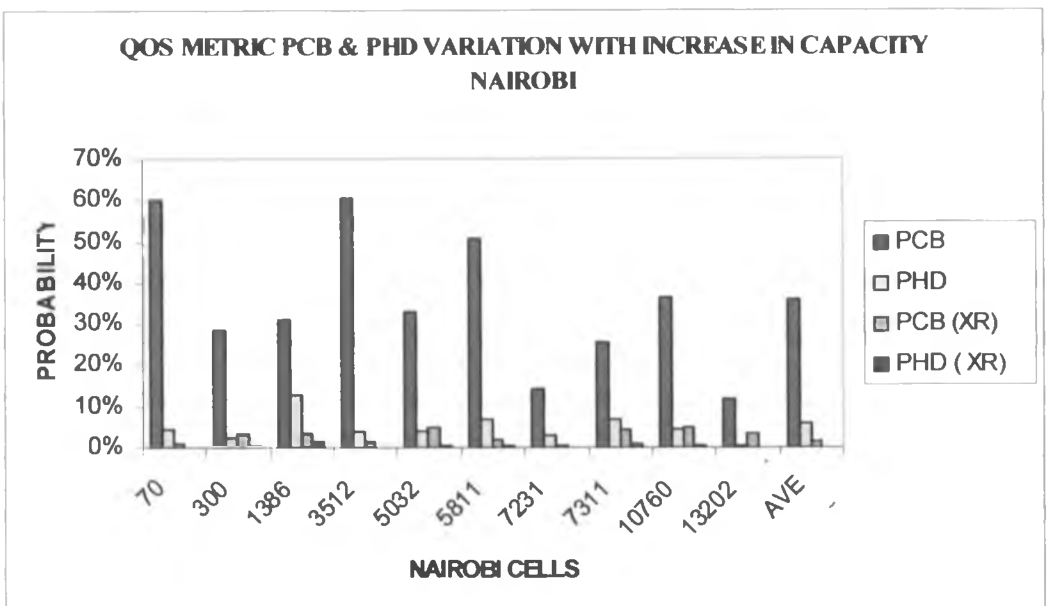


Figure 5. 2 PCB and PHD at FR and XR Capacities for TO One-Nairobi Town

The HOR demands a 24.9% of the available capacity while these requests constitute 14.4% of the total demand. The QoS value in this case far much surpasses the recommended standard. This is attributed to the Handoff share of 25% of the available capacity while in the network planning the resources (TCH) could not have been approximated to an adequate level of accuracy . On implementation of the proposed AAMR Codec to mitigate on this revealed network inefficiencies, the resulting PCB and PHD would be 1.4% and 0.2% respectively. Hence the proposed solution would bring the QoS values to 1.6% which is within the recommended range.

Nakuru

The table below shows Secondary analysis of the averaged data for Nakuru town as drawn from Table A2.1 in appendix 2

Table 5. 5 Secondary analysis of Operator One BH data for Nakuru Town

SECONDARY ANALYSIS OF OPERATOR ONE BH AVERAGED DATA FOR NAKURU TOWN														
CELL SPECIFICATION			AVERAGE REQUEST ANALYSIS WITH REFERENCE TO 38S CALL DURATION											
	CI	CP	AVER NCSR/ HR	AVER-HO/ HR	AVER NCS	AVER-HOR	TTL RQ	NCSR / TTL RQ	HOR /TTL RQ	HOR / CP	PCB	PHD	PCB (XR)	PHD (XR)
1	13252	75	8062	273	85.1	2.88	88	96.7%	3.3%	3.8%	14.3%	0.5%	1.9%	0.1%
2	13970	78	8594	268	90.7	2.82	93.5	97.0%	3.0%	3.6%	16.1%	0.5%	4.0%	0.1%
3	13972	63	6933	181	73.2	1.91	75.1	97.5%	2.5%	3.0%	15.7%	0.4%	3.4%	0.1%
4	30001	69	8536	135	90.1	1.42	91.5	98.4%	1.6%	2.1%	24.2%	0.4%	2.0%	0.0%
5	30610	53	3925	453	41.4	4.78	46.2	89.7%	10.3%	9.0%	0.0%	0.0%	2.0%	0.2%
6	30770	72	6395	617	67.5	6.51	74	91.2%	8.8%	9.0%	2.5%	0.2%	2.5%	0.2%
	AV	68	7074.0	321	74.67	3.39	78.1	95.7%	4.3%	5.0%	11.9%	0.5%	1.9%	0.1%

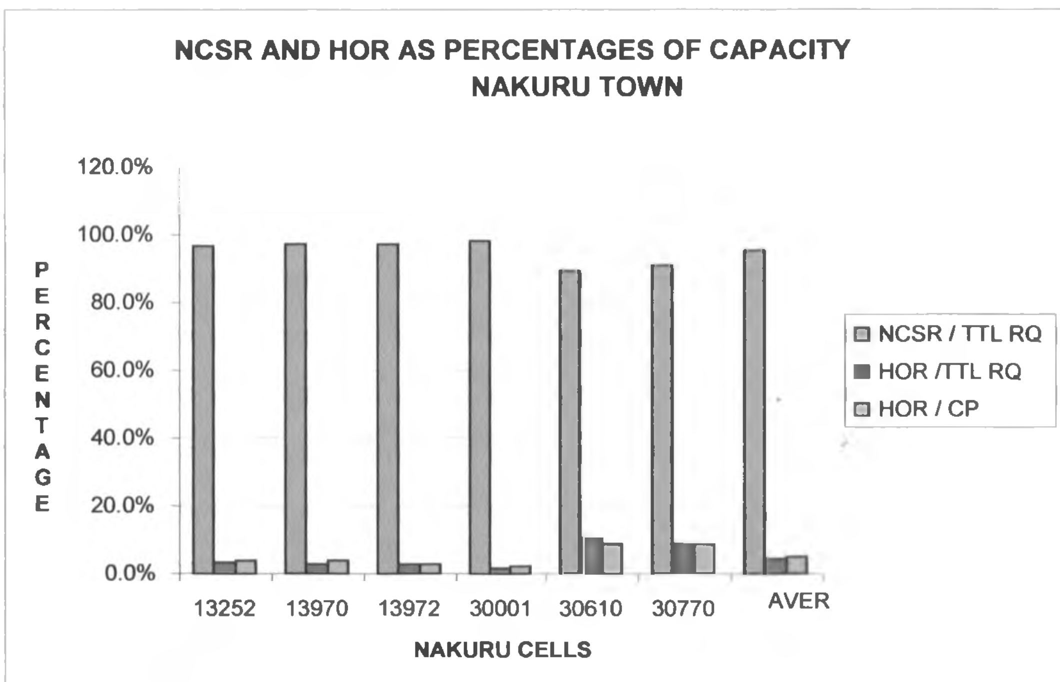


Figure 5. 3 Ratios of NCSR and HOR to demand and available capacity for TO One-Nakuru Town

This analysis shows that in Nakuru Mobile Subscribers are almost stationary during busy hour and if they ever move they do so within radius of the cells. As a result the HO calls demand a very small percentage of capacity which has been shown to be equal to 4.3%. The 0.5% PHD is equally small as the number of requests is also small. The PCB is 11.9% which is high but does not necessarily require our proposed solution since the effect of HO in this town is minimal.

The ratio of NCSR to the TTLRQ in Nakuru town has been found to be 96%. This translates to Handoff requirements of only 4% of the total Capacity. The indication here is that the majority of the users are normally on limited mobility.

If the mobile network has to be maintained then the best solution for this area would be the use of smaller higher frequency cells i.e. 1800Mhz series. Alternatively the whole of the area can be reengineered with a different value of K (the number of cells in a cluster).

It also shows that a majority of the users can be satisfied with a fixed wireless system. If some of the subscribers can be offloaded to a different network then the existing resources would adequately serve the truly mobile customers.

The proposed solution is most suited where there exists a large proportion of mobile users (users with frequent HOR). This means MS that move while connected (not attached) to the network. However, the results indicate that if the proposed AAMR was deployed it would improve the QoS values to 1.9% (PCB) and 0.1%(PHD). The final results obtainable with the new device would be within the required range.

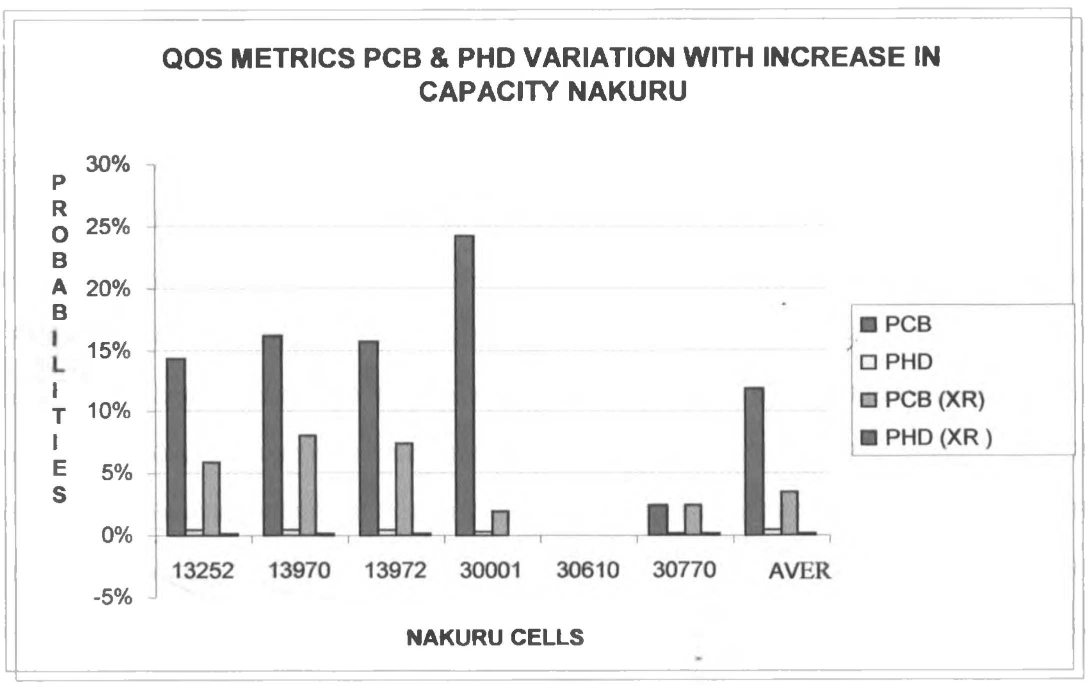


Figure 5. 4 PCB and PHD at FR and XR capacities for TO One-Nakuru Town

Kisumu Town

Table 5. 6 Secondary analysis of Operator One BH data for Kisumu Town

ANALYSIS OF AVERAGED DATA FOR KISUMU														
CELL SPECIFICATION			AV. NCS/ HR	AV-HO/ HR	AVERAGE REQUEST ANALYSIS OVER 38S CALL DURATION									
	CI	CP			AV NCS	AV-HOR	TTL RQ	NCSR /TTL RQ	HOR/ TTL RQ	HOR/ CP	PCB	PHD	PCB (XR)	PHD (XR)
17	15740	26	3677	771.8	38.81	8.147	46.96	82.7%	17.3%	31.3%	36.9%	7.7%	0.1%	0.1%
18	40380	26	3110.4	1155	32.83	12.19	45.02	72.9%	27.1%	46.9%	30.8%	11.4%	0.5%	0.5%
19	42541	22	1825.8	2799	19.27	29.55	48.82	39.5%	60.5%	134.3%	21.7%	33.2%	0.5%	0.5%
20	42581	24	2323.4	5085	24.52	53.67	78.2	31.4%	68.6%	223.6%	21.7%	47.6%	1.2%	1.2%
21	42592	25	2434.4	3764	25.7	39.73	65.42	39.3%	60.7%	158.9%	24.3%	37.5%	0.4%	0.4%
	AV	24.6	2674.2	2715	28.23	28.7	56.88	49.6%	50.4%	116.5%	28.2%	28.6%	0.3%	0.3%

In Kisumu Town the requests are almost equal meaning that the available capacity is supposed to be shared almost equally between the Handoff and New call setup. But the HOR is marginally bigger than the NCSR which presents a rare scenario in a mobile network. The calculated PCB is 28.2% and PHD is 28.6%. The Handoff has been shown to demand 50% of the available capacity hence resulting to an effective capacity of only 50%.

The final average data for Kisumu portrays a scenario direct opposite of the observation made in Nakuru. The mobility in this area is high hence it requires an efficient system for provisioning and management of the required resources.

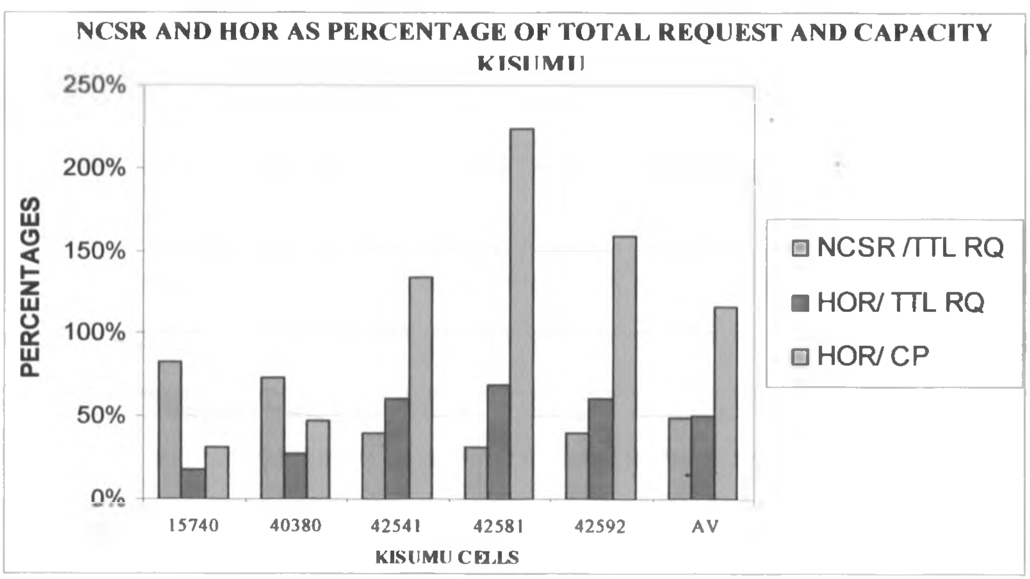


Figure 5. 5 Ratios of NCSR and HOR to demand and available capacity for TO One-Kisumu Town

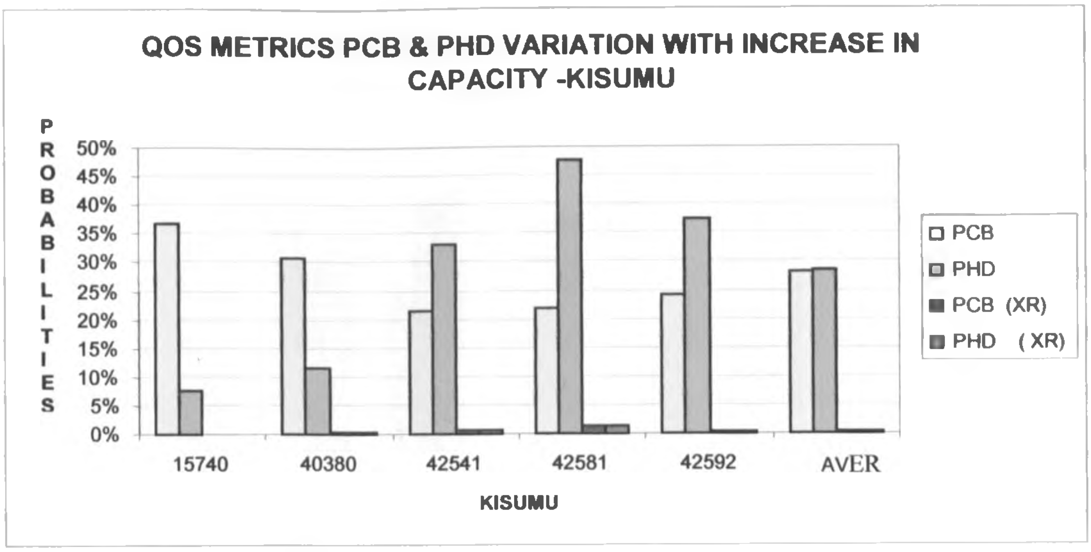


Figure 5. 6 PCB and PHD at FR and XR capacities for TO One-Kisumu Town

In this case where there exist almost an equal number of demand requests. Our new device is the best suited to solve the resulting problem of congestion. From the analysis in table 5.6 the new values of PCB and PHD at the rate XR available on deployment of the proposed Hardware are 0.3% each. This is a big improvement from their initial values of 28% got using the ordinary hardware.

Mombasa Town

The averaged data for Mombasa has also been drawn from Table A2.1 and analysis done like in the other previous three cases.

Table 5. 7 Secondary analysis of Operator One BH data for Mombasa Town

SECONDARY ANALYSIS OF OPERATOR ONE BH AVERAGED DATA FOR MOMBASA TOWN															
CELL SPECIFICATION			AV RQ/HR		AV. RQ ANALYSIS WITH REFERENCE TO 38S CALL DURATION										
	CI	CP	NCSR	HOR	AV NCSR	AV-HOR	TTL RQ	NCSR/ TTL RQ	HOR/ TTL RQ	HOR/CP AT XR	PCB	PHD	PCB (XR)	PHD (XR)
22	20120	53	5911	4710	62.4	49.7	112	55.7%	44.3%	44.7%	29.3%	23.4%	0.4%	0.3%
23	20141	69	7135	5830	75.3	61.5	137	55.0%	45.0%	46.9%	27.3%	22.3%	2.3%	1.9%
24	20151	69	5224	7737	55.1	81.7	137	40.3%	59.7%	62.3%	20.0%	29.6%	1.7%	2.5%
25	20152	53	4925	6206	52	65.5	117	44.2%	55.8%	56.2%	24.3%	30.6%	0.3%	0.4%
26	20232	54	5865	3231	61.9	34.1	96	64.5%	35.5%	37.2%	28.2%	15.5%	2.8%	1.6%
	AV	60	5812	5543	61.3	58.5	120	51.2%	48.8%	49.1%	25.7%	24.5%	0.3%	0.3%

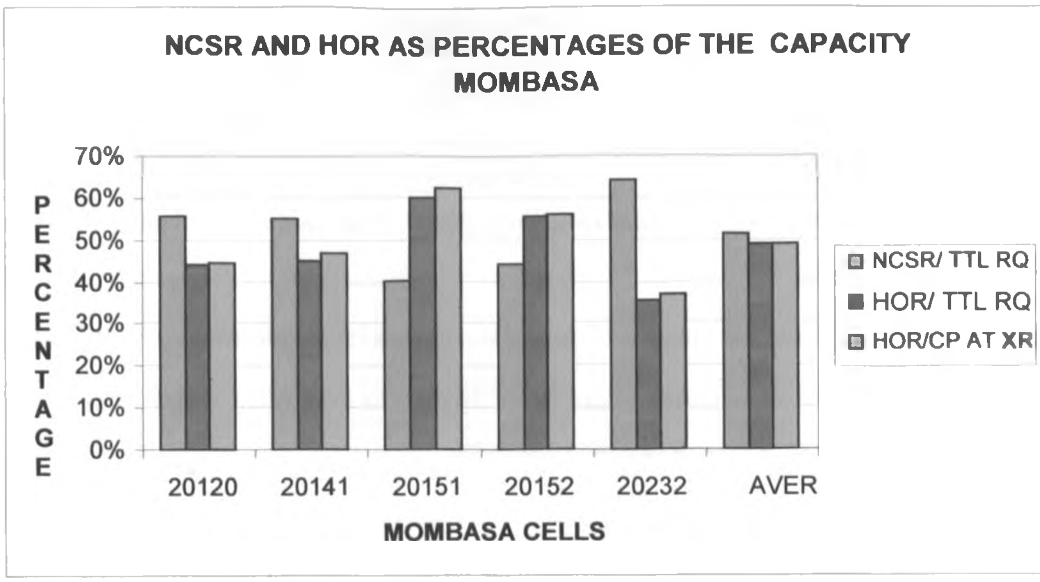


Figure 5. 7 Ratios of NCSR and HOR to demand and available capacity for TO One-Mombasa Town

This shows that in Mombasa the number of handoff requests i.e. at 48%of the total requests is almost equal to the number of new call requests at 52% to TTLRQ. The overall effect is that there is an almost equal chance of call blocking and handoff dropping which have been determined to be 25.7% and 24.5 % respectively. On deployment of the proposed AAMR Codec the new metrics of PCB and PHD would take new values of 0.3% each.

There is a lot of similarity between the problem and solution in Kisumu and Mombasa because they have almost equal ratios of the two requests to the total requests.

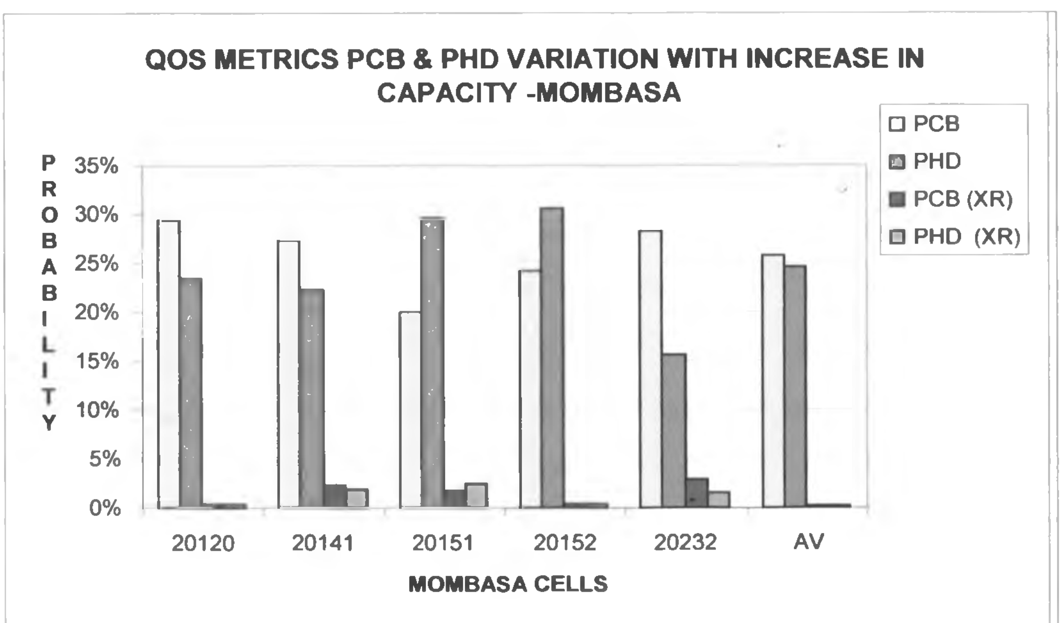


Figure 5. 8 PCB and PHD at FR and XR capacities for TO One-Mombasa Town

5.3.4 Final analysis of Operator one data to determine the Network GoS.

Though all the data collected does not represent a group of circuits. The average of the averages from the four different towns as presented in the last rows of the previous tables (Table 5. 4 to 5.7) is further analyzed to determine the Network overall PCB, PHD and QoS. The results indicated better performance than the one got in the Nairobi case which was found to be the worst among the four towns under study. This is how the better performing areas mask the impact of the under performing regions.

Table 5. 8 Final analysis of Operator One BH data to determine the Network GoS

FINAL DATA ANALYSIS FROM THE FIRST TELECOMMUNICATION OPERATOR														
AREA	FR AVCP	EFF CP	AVER RQ/ HR		REQUESTS ANALYSIS WITH RESFERENCE TO 38S CD									
					AVERAGE		TTL RQ	NCSR/ TTL RQ	HOR/ TTL RQ	HOR/CC FR	PCB	PHD	PCB (XR)	PHD (XR)
			NCSR	HOR	NCSR	HOR								
NRB	57	42.8	8019	1349	84.6	14.2	98.9	85.6%	14.4%	25%	36%	6.1%	1.7%	0.29%
NKU	68	64.6	7074	321	74.7	3.4	78.1	95.7%	4.3%	5.0%	12%	0.6%	4.0%	0.18%
KSM	25	-3.7	2674	2715	28.2	28.7	56.9	49.6%	50.4%	115%	28%	28%	1.6%	1.67%
MSA	60	1.5	5812	5543	61.3	58.5	119.9	51.2%	48.8%	98%	26%	24%	2.5%	2.39%
AVER.	53	26.3	5895	2482	62.2	26.2	88.4	70.4%	29.6%	50%	29%	12%	1.4%	0.60%
OVERALL GRADE OF SERVICE														41%
OVERALL NEW GRADE OF SERVICE														**2.0%**

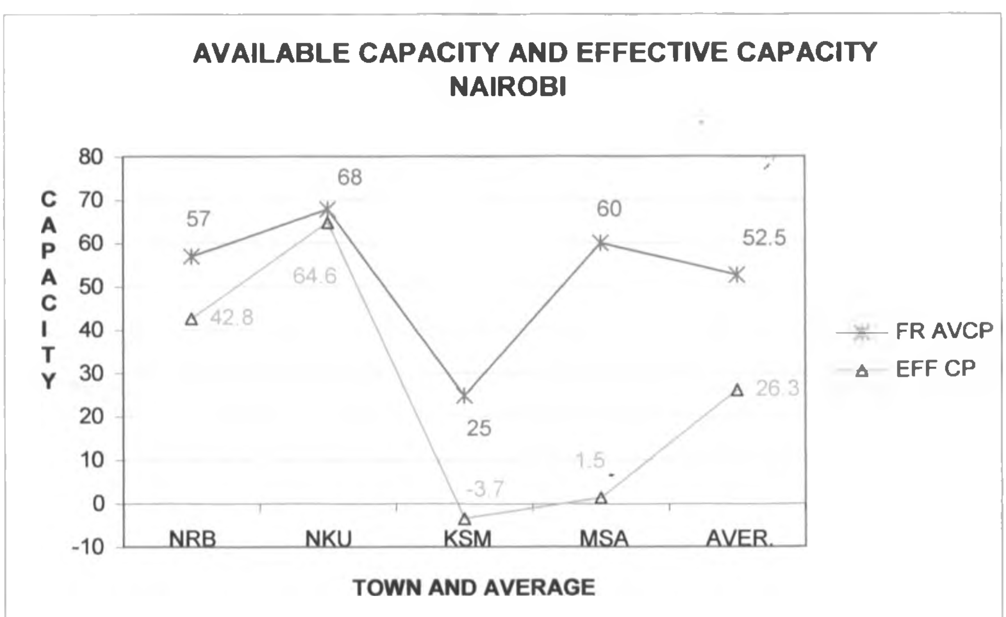


Figure 5. 9 Available and Effective capacities for Operator One Network

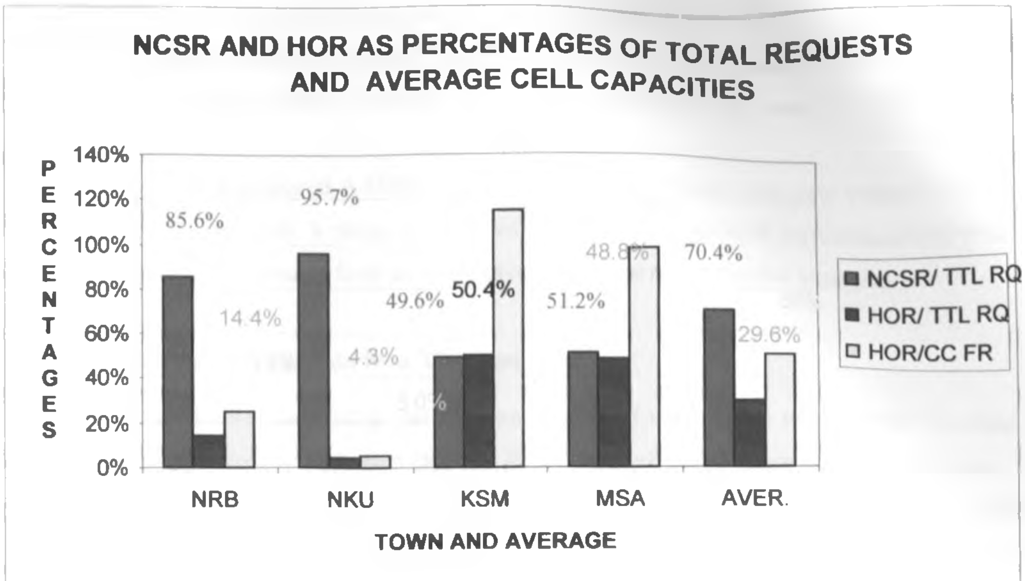


Figure 5. 10 Ratios of NCSR and HOR to demand and available capacity for BH Operator One Network

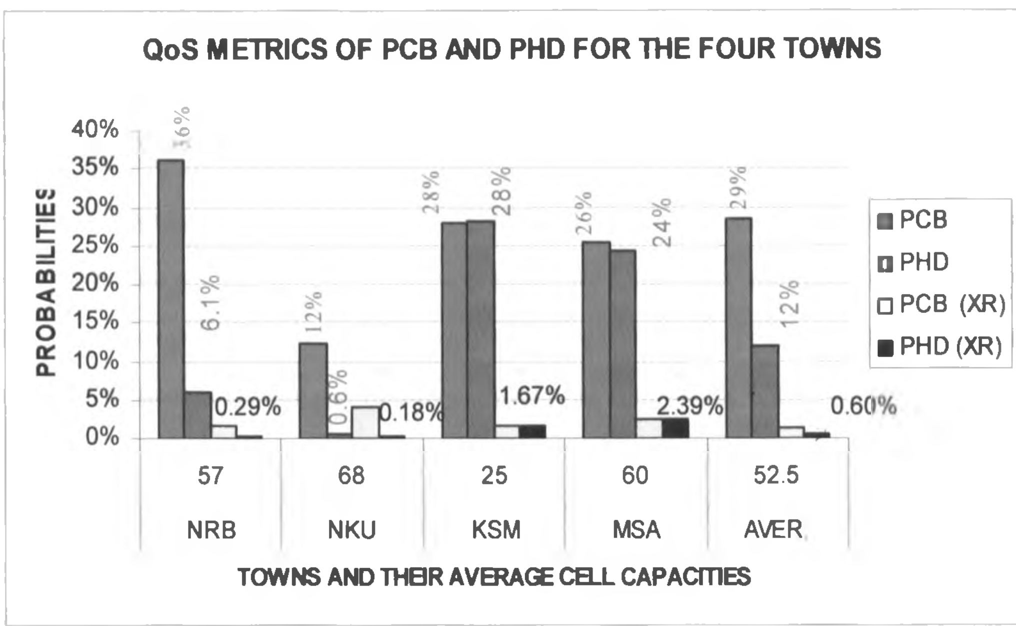


Figure 5. 11 PCB and PHD at FR and XR capacities for Operator One Network

The results indicate that handoff constitutes 30% of the total demand and hence this reduced the available capacity to an effective capacity that is 50% of the available capacity. So if handoff was to be given total priority over new calls the Network would result to new calls being serviced by 50% of the planned capacity.

The overall values of PCB and PHD have resulted to 29% and 12% respectively. These values give rise to a GoS of 41.

From this analysis of the final averaged data it shows that though HO has not been given any priority over New Call setup. Available Network capacity does not meet the prevailing demand of which HO constitutes 30%. This is a clear indication that the low GoS of 41% has resulted out of the effect of handoff on Capacity.

On application of the proposed AAMR device, PCB and PHD would take new values of 1.4% and 0.6% respectively, and GoS a value of 2%. This is a significant network performance improvement making the performance change from an intolerable state to the recommended standard.

5.3.5 Analysis of non BH data from Operator One

The bad state of affairs observed in the analyses of the BH data can be misconstrued to create an impression that the Telecommunication Operator One's Network performance is always very poor.

As a result of trying to allay fears that an operators market can be affected by our research findings which have revealed serious flaws in the network performance. We requested for the non busy hour data for analysis

The non BH data is analyzed in a similar way to the BH data. The data was taken from cells selected randomly and data recorded for duration of one hour for 60 days. The basic analysis of this data is contained in Table A2.3 in appendix 2.

This non BH data has resulted into almost the expected values of QoS. Since values of the two Metrics that is PCB and PHD have ranged between 0 and 2, there has been no need of suggesting any mitigation factors since the network seems to be managing the existing load. If the device (AAMR) was deployed to the network it would maintain all the channels at full rate and hence create zero change in GoS.

5.3.6 Final analysis of Operator One non BH data

Table 5. 9 Final analysis of the Non BH data for Operator One

NON BUSY HOUR (BH) DATA ANALYSIS

AREA	AVER NTCHD	AVER NCB	AVER NCS	AVER NHO	TTL TCH ALL.	QoS Metrics		HO/ AV. CP	HO /NCS RQ
						PCB	PHD		
NRB	11.9	6.3	1377.1	1068.1	2445.2	0.46%	1.11%	43.68%	77.56%
NKU	6.0	5.8	760.5	888.0	1648.4	0.76%	0.68%	53.87%	116.77%
MSA	10.1	14.1	823.4	231.3	1054.7	1.71%	4.35%	21.93%	28.09%
KSM	15.2	41.7	1571.0	1093.5	2664.4	2.65%	1.39%	41.04%	69.61%
AVER.	10.8	17.0	1133.0	820.2	1953.2	1.47%	1.30%	41.99%	72.39%
OVERALL GRADE OF SERVICE							**1.42%**		

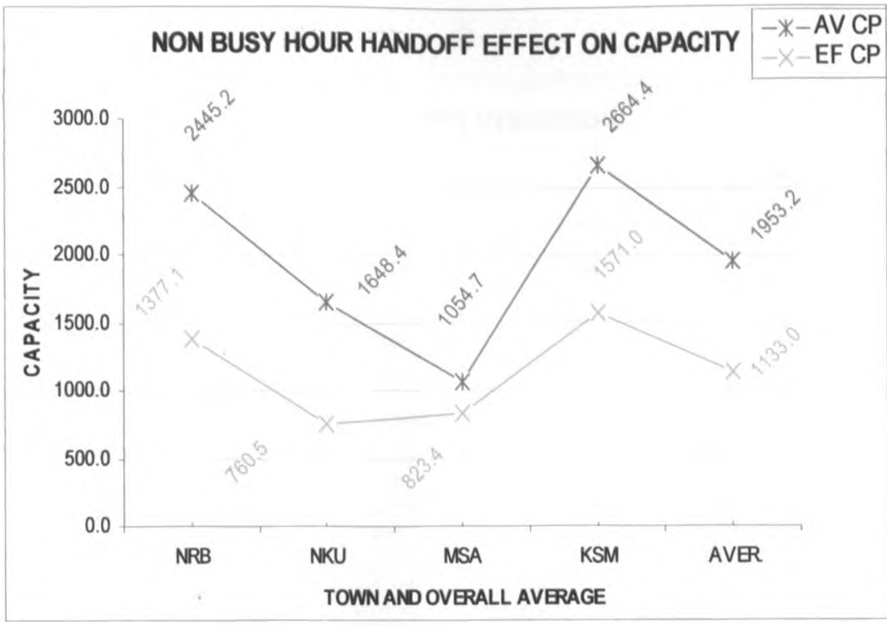


Figure 5. 12 Variation of Available and Effective Capacities for Operator One during Non BH time

Handoff has contributed to the highest percentage of traffic as compared to the new calls. The situation is extreme in Nakuru (HO 116% of the NCS) where we found that during busy hour the percentage of HO was ranging about 3%. This means that except in Nairobi in the other towns there is a lot of movement outside the busy hour. And in Nairobi movement is there during busy hour. In all the four towns non of them seems to suffer from the problem of heavy overload. Hence there are no mitigation factors to be addressed.

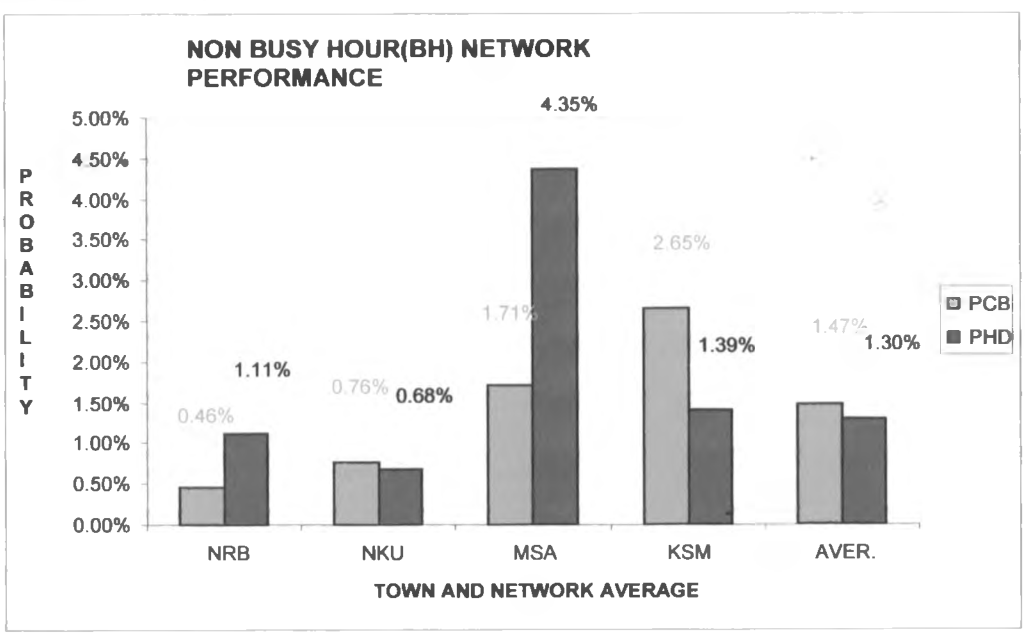


Figure 5. 13 Non BH QoS metrics of PCB and PHD for Operator One Network

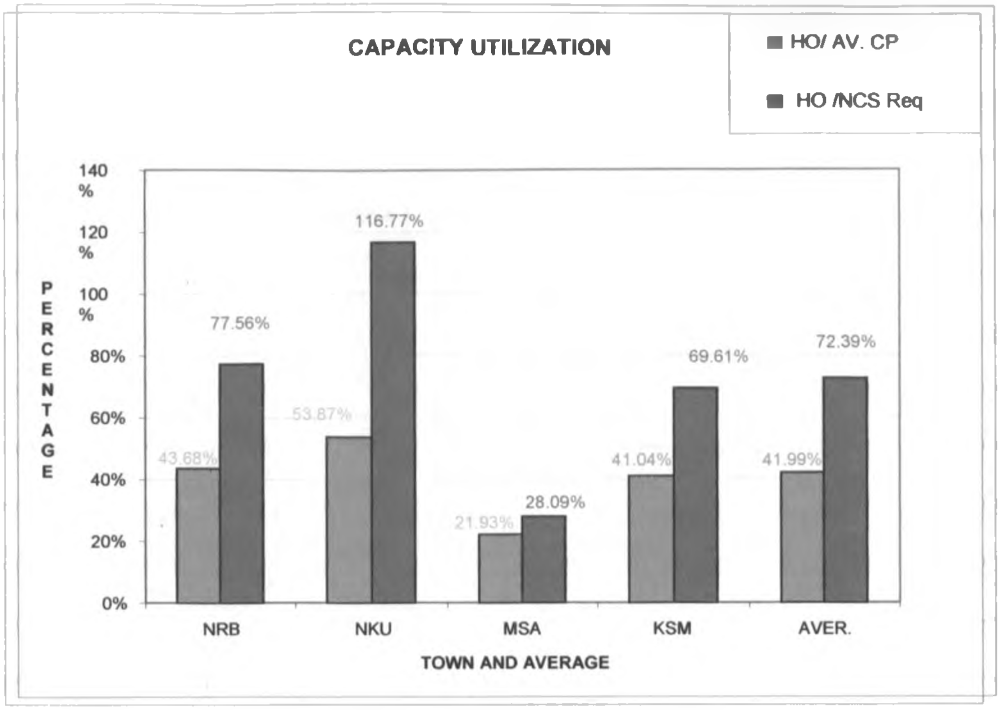


Figure 5. 14 Non BH Ratios of HOR to available capacity and NCSR for Operator One

Analysis for the non Busy Hour (non peak hour) data was consolidated together that is the basic and the second level of analysis to be able to indicate the prevailing level of QoS. As stated earlier QoS can be established for any duration of time and for any group of circuits.

The result of this analysis is that the network performs as expected outside the BH time. The average GoS of 1.42% is actually better than the stated upper limit value of 2%.

But this does not mean that in the two towns of Kisumu and Mombasa where the performance has resulted to GoS of 2.13% and 2.3% respectively should not be investigated further. The overshoot is not marginal for all practical purposes. Possible causes of low GoS in these two towns is the effect of water on signal propagation and the resulting difficult in positioning of the base stations.

One way of improving the GoS in the two affected towns would be conversion of some of the SDCCH to TCH channels. Such a network configuration would establish a different equilibrium point at a better GoS.

5.4 Analysis of Telecommunication Operator two data

Telecommunication Operator (TO) Two gave data for all the sites referred to by the names of the four towns we quoted. All the data for the high trafficking cells in Kisumu, Mombasa, Nakuru and Nairobi was given for seven days ranging from 6^{th} February to 12^{th} February, 2011.

This data has been filtered to get the cells with the most traffic per TCH. Ten cells were identified in Nairobi, five in Kisumu, seven in Nakuru and six in Mombasa. The analysis has been carried out following the same formulae as for the Operator One data. In the cases where calculated values result to negatives or depict a situation of very low loading the graphs are not drawn since all the data labels would have ended up clouding at zero mark.

Nairobi Town

Table 5. 10 Secondary analysis of Operator Two BH data for Nairobi Town

CELL DETAILS		AVERAGE FOR SEVEN ENTRIES					QoS Metrics		GoS	HO_EFF_CP
AREA	CI	TFCL	CC	NCSR	HOR	TTLR	PCB	PHD		
NRB	041NBAD	111.4	10554	4491	5926	10417	0.0%	0.0%	0.0%	4628
NRB	041NBBD	75.7	7172	4117	3711	7828	4.4%	4.0%	8.4%	3461
NRB	042NBAD	146.5	13879	7219	3242	10462	0.0%	0.0%	0%	10637
NRB	043NBB	181	17147	15712	2303	18014	4.2%	0.6%	4.8%	14845
NRB	048NBAD	88.3	8365	2971	2078	5049	0.0%	0.0%	0%	6288
NRB	048NBBD	75.3	7134	3015	2052	5067	0.0%	0.0%	0%	5081
NRB	049NBCD	74.6	7067	3657	3458	7115	0.3%	0.3%	1%	3609
NRB	103NBAD	77.2	7314	4460	1099	5559	0.0%	0.0%	0%	6214
NRB	108NBA	174.3	16513	17249	2216	19466	13.4%	1.7%	15%	14296
NRB	379NBBD	100.7	9540	4256	4381	8637	0.0%	0.0%	0%	5159
NRB	AVER	110.5	10468	6715	3047	9761	0.0%	0.0%	0.0%	7422

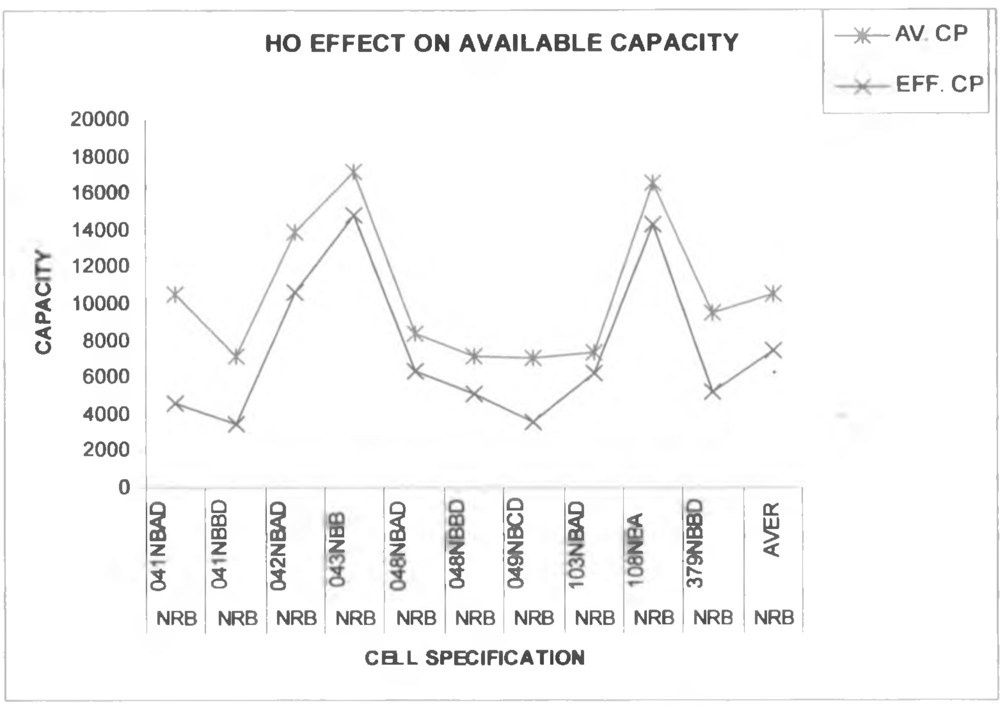


Figure 5. 15 Available and Effective capacities of TO Two data for Nairobi Town

The analysis does not reveal network overload. Hence there is practically no problem to be solved.

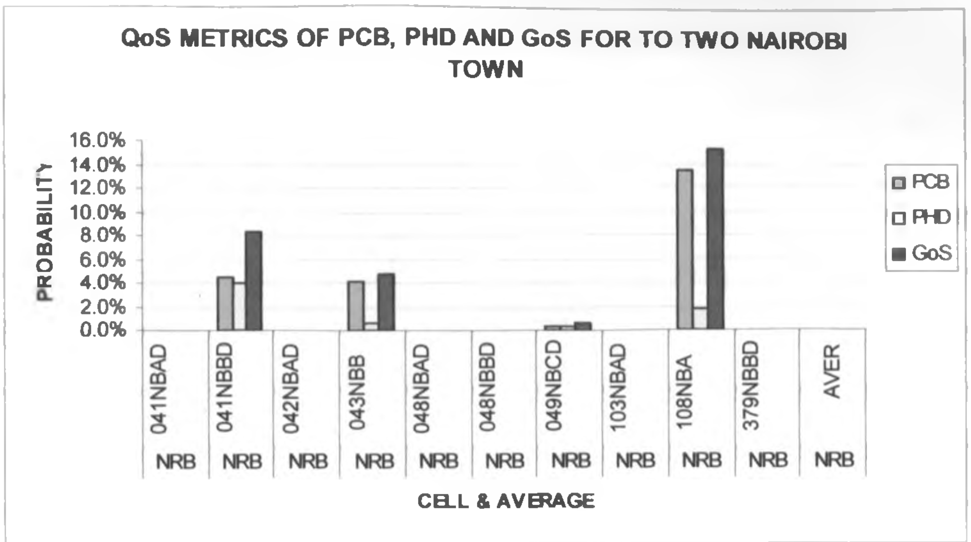


Figure 5. 16 QoS Metrics of PCB and PHD for TO Two Nairobi Town

Nakuru Town

The averaged data for the six cells and the secondary analyses are given in table 5.11.
As indicated earlier the network seems to be having a very light load. Despite the fact that the observation was made during the BH period the QoS got per individual cells do not warrant further investigations.

Table 5. 11 Secondary analyses of Operator Two BH data for Nakuru Town

CELL DETAILS							QoS Metrics		GoS	HO_EFF_CP
AREA	CI	TFCL	CC	NCSR	HOR	TTLR	PCB	PHD		
NJORO	500NKC	53	5031	1764	337	2101	-117%	-22.4%	-139.5%	4694
CHEPSIR	552NKB	41	3898	4983	799	5781	28.1%	4.5%	32.6%	3099
ELDRAV	562NKC	41	3915	3155	246	3401	-14.0%	-1.1%	-15.1%	3669
MOLTWN	576NKC	37	3465	2724	519	3242	-5.8%	-1.1%	-6.9%	2946
LITEIN	584NKC	69	6494	6422	1195	7617	12.4%	2.3%	14.7%	5299
KRCHCLG	670KCBD	43	4116	1154	2330	3484	-6.0%	-12.1%	-18.1%	1786
NKU	AVER	47	4486	3367	904	4271	-4.0%	-1.1%	-5.0%	3582

Kisumu Town

Table 5. 12 Secondary analysis of Operator Two BH data for Kisumu Town

CELL DETAILS		AVERAGE FOR SEVEN ENTRIES					QoS Metrics		GoS	HO_EFF_CP
AREA	CI	TFCL	CC	NCSR	HOR	TTLR	PCB	PHD		
SIAYA	103KSB	70	6660	5262	637	5899	-11.5%	-1.4%	-12.9%	6023
UGUNJA	106KSA	75	7145	6373	1330	7704	6.0%	1.3%	7.3%	5814
BSA LWR	138BSA	77	7269	6286	1332	7618	3.8%	0.8%	4.6%	5937
KEUMBU	304KSB	66	6217	4091	943	5034	-19.1%	-4.4%	-23.5%	5274
IGEMEBE	315KSA	62	5847	4817	228	5045	-15.2%	-0.7%	-15.9%	5619
KISUMU	AVER	70	6628	5366	894	6260	-5.0%	-0.8%	-5.9%	5734

Mombasa Town

Table 5. 13 Secondary analyses of Operator Two BH data for Mombasa

CELL DETAILS		AVERAGE FOR THE EIGHT ENTRIES					QoS Metrics		GoS	HO_EFF_CP
AREA	CI	TFCL	CC	NCSR	HOR	TTLR	PCB	PHD		
MSA	004MSA	186.0875	17629	10925	5947	16872	-2.9%	-1.6%	-4.5%	11683
MSA	008MSB	239.325	22673	14351	8820	23171	1.3%	0.8%	2.1%	13853
MSA	203MSA	457.3875	43331	40285	1635	41919	-3.2%	-0.1%	-3.4%	41697
MSA	406MLC	372.45	35285	25378	6246	31623	-9.3%	-2.3%	-11.6%	29039
MSA	005MSA	379.3125	35935	26057	9829	35885	-0.1%	0.0%	-0.1%	26106
MSA	AVER	327	30971	23399	6495	29894	-2.8%	-0.8%	-3.6%	24476

Kisumu and Mombasa like the other two cases of Nairobi and Nakuru the networks are able to carry the BH load. Hence there is no further analysis that is necessary in the case of Telecommunication Operator Two.

5.5 Analyses of Telecommunication Operator Three Data

The TO Three had not identified the top most heavily loaded cells as per the request. Hence the first step was to identify the right cells for analyses. The identified cells have been analyzed for averages in Table A2.12 and A2.13 in appendix 2.

The resulting average for the four towns are as stipulated in the following four tables starting with Table 5.14

Nairobi Town

This is the only town that has load that is nearly optimum. The analysis has shown that the overall town load can be managed with the deployed equipments. Hence in the analysis we have not used our proposed solution.

Table 5. 14 Secondary analysis of Operator Three BH data for Nairobi

ANALYSIS OF THE AVERAGED DATA FOR OPERATOR THREE- NAIROBI REGION										
CELL SPECIFICATION		LOAD	ATTEMPTS		TTL		EFF. CP	QoS ANALYSIS		
CI	CP(TCH)	ERLANG	NCSR	HOR	ATMPT	AV CP		PCB	PHD	GoS
NBI2261	28	28.72	1720	970.4	2690.4	2652.6	1682.2	0.9%	0.5%	1.4%
NBI0521	27	26.438	1889.6	732.8	2622.4	2557.9	1825.1	1.8%	0.7%	2.5%
NBI0082	26	21.444	1987.2	853.2	2490.4	2463.2	1610.0	0.9%	0.4%	1.1%
NBI2071	26	22.62	1796	780.6	2576.6	2463.2	1682.6	3.1%	1.3%	4.4%
NBI0673	29	24.682	1464.4	1310	2774	2747.4	1437.8	0.5%	0.5%	1.0%
NBI1201	27	23.21	1637.6	1056	2693.6	2557.9	1501.9	3.1%	2.0%	5.0%
NBI0911	29	29.79	1885.4	1229	3114.4	2747.4	1518.4	7.1%	4.7%	11.8%
NBI2503	28	28.454	1641.4	1075	2716	2652.6	1578.0	1.4%	0.9%	2.3%
NBI3371	28	26.446	1965.2	860.2	2825.4	2652.6	1792.4	4.3%	1.9%	6.1%
NBI2312	28	27.42	1799	967.2	2766.2	2652.6	1685.4	2.7%	1.4%	4.1%
AVER	28	25.9224	1778.58	983.4	2726.94	2614.7	1631	2.7%	1.5%	4.1%

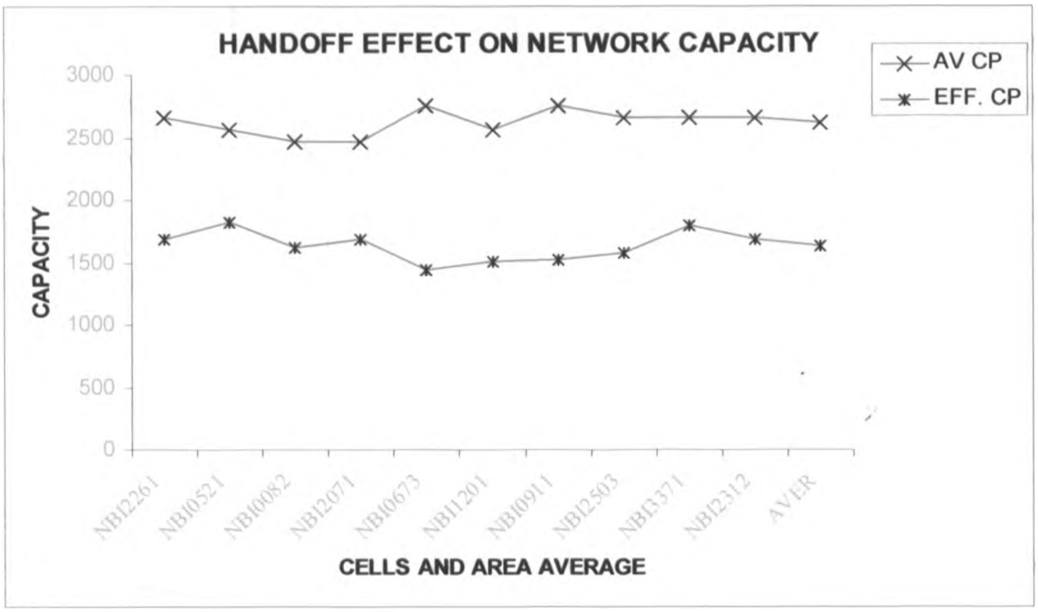


Figure 5. 17 Available and Effective capacities for Operator Three-Nairobi Town

The individual cell indicate light load. The GoS value of 4.1% is not very far from the recommended value. The curves also suggest some consistency in the traffic. It is the poor performance of three out of the ten cells that have made the final value overshoot the required standard. Greatest contributor to the this poor performance is the cell ID NBI 3371.Since more than half of the cells have acceptable GoS, resource redistribution is recommended as a solution to reduce the overloading of a small section of the network.

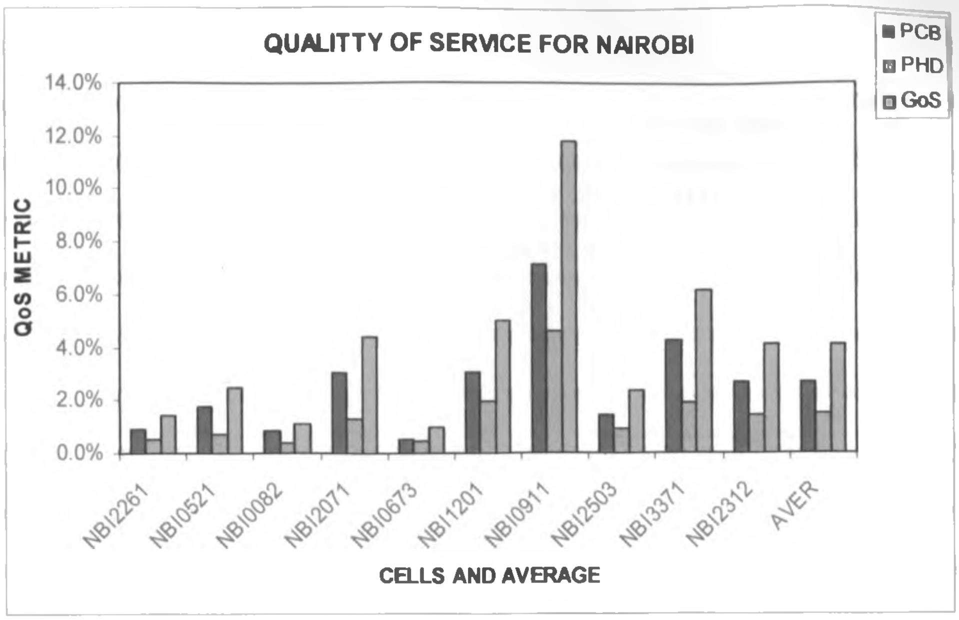


Figure 5.18 PCB, PHD and GoS for TO Three- Nairobi Town

Kisumu, Nakuru and Mombasa Towns

The average data for these three other towns resulted to negative values as contained in Tables 5.15, 5.16 and 5.17. This means that the network was not subjected to excess load even during the high demand busy hour time. The very big and negative values of GoS for Nakuru: -88.1%, Mombasa: -46.9% and Kisumu: -132.5% cannot be used to combine with the Nairobi value of 4.1%, as this would result to the concealment of the Nairobi poor GoS.

Table 5. 15 Operator Three Secondary BH Data analysis for Nakuru Town.

OPERATOR THREE -NAKURU SECONDARY DATA ANALYSIS									
CELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
NRU0691	29	23.98	459.8	495.4	955.2	2747.4	-90.3%	-11.8%	-187.6%
NRU0053	29	24.74	1773	442.4	2215.4	2747.4	-19.2%	-3.1%	-24.0%
NRU0693	29	23.06	840	294	1134	2747.4	-105.4%	-6.3%	-142.3%
NRU0041	28	25.22	1691.8	372.4	2064.2	2652.6	-23.4%	-3.1%	-28.5%
NRU0723	30	32.72	489.6	393.6	883.2	2842.1	-123.0%	-9.6%	-221.8%
NRU0043	44	38	1254.8	505.6	1760.4	4168.4	-97.5%	-7.0%	-136.8%
Town Aver	32	28.7	1209.8	401.6	1611.4	3031.6	-66.2%	-6.2%	-88.1%

Table 5. 16 Operator Three Secondary BH Data analysis for Mombasa Town

OPERATOR THREE -MOMBASA SECONDARY DATA ANALYSIS									
CELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
KFI0033	45	29.22	1265	297	1562	4263.2	-140.1%	-4.4%	-172.9%
KFI0031	45	30.64	1934	342.8	2276.8	4263.2	-74.1%	-3.8%	-87.2%
MSA0191	29	29.06	2089.6	477	2566.6	2747.4	-5.7%	-1.1%	-7.0%
MSA0491	28	27.58	733.2	459.8	1193	2652.6	-75.2%	-9.5%	-122.4%
MSA0131	36	28.32	1338.6	468.8	1807.4	3410.5	-65.7%	-6.5%	-88.7%
MSA0021	43	31.36	2203.2	956.8	3160	4073.7	-20.2%	-5.3%	-28.9%
MSA0302	45	30.58	2229	717.6	2946.6	4263.2	-33.8%	-5.2%	-44.7%
Town Aver	36.2	29.38	1718.7	616	2334.7	3429.5	-34.5%	-5.7%	-46.9%

Table 5. 17 Operator Three Secondary BH Data Analysis for Kisumu Town

OPERATOR THREE -KISUMU SECONDARY DATA ANALYSIS									
CELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
KMU0101	29	7.22	266.2	580.2	846.4	2747.4	-70.6%	-14.6%	-224.6%
NYD0093	13	7.14	423.2	155.4	578.6	1231.6	-82.5%	-6.7%	-112.9%
KMU0191	20	5.36	185.2	69.2	254.4	1894.7	-469.4%	-3.2%	-644.8%
KMU0103	29	6.8	294	292.6	586.6	2747.4	-184.6%	-8.4%	-368.4%
NYD0032	29	6.68	405.4	195.6	601	2747.4	-240.9%	-5.6%	-357.1%
NYD0091	13	5.36	335.4	293	628.4	1231.6	-51.2%	-11.7%	-96.0%
Town Aver	13	6.268	328.6	201.16	529.8	1231.6	-82.2%	-9.3%	-132.5%

Since the research has not revealed any problem to warrant further investigations there is no further analysis performed on Operator Three data. The Nairobi slight overload should be addressed independently and as earlier suggested through resource redistribution.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Telecommunication Operators are licensed and supervised by the National Communication Regulatory Authorities. The communication standards bodies set the relevant standards and regulations with reference to the ITU recommendations. The subscribers who are Customers to the TOs do not get to know the licensing requirements on the QoS to be offered by the Service Providers. Although the quality thresholds are available majority of the Customers either do not know or take that these references are of no use to them.

Some of the technical requirements quoted in the licenses are Quality of Service standards specifically the requirement on the GoS. The standard GoS is normally administered through the two factors of Network unavailability (call blocking) and forced termination (call dropping).

The problems of call blocking and call dropping have become so prevalent these days. This is why we decided to carry out a practical determination of the gravity of these two problems.

The main purpose of this study was to determine the Quality of Service being offered by the leading Mobile Telecommunication Operators and compare with the internationally recommended value. This objective was met through the successful achievements of the following:

- Identification of the Handoff schemes implemented by the three leading GSM network operators in Kenya and evaluation of their performance by determination of the effect of catering/provisioning for Handoff calls on network capacity.
- Determination of the effect of Handoff calls on the network Quality of Service using the probability of handoff call dropping, probability of call blocking and the probability of failure of allocation of traffic channel (GoS) metrics of measurement.
- Development of a suitable conceptual Handoff and network configuration framework that optimizes the network capacity and Quality of service.

Based on the presented results this study achieved its objectives and the following conclusions have been drawn.

6.2 Handoff Schemes identification and effect on network performance.

The handoff schemes determine the number or fraction of the available TCH that is provisioned for handoff. As the total number of TCH equal to the available capacity, it means that the employed scheme determines the resulting effective capacity.

The network operator decides on the scheme to employ through the identification of suitable Key performance Indicators (KPI). The three Operators stated that the schemes in use within their Networks were the Zero Priority Schemes (ZPS). That is the Handoff algorithms in use by the three TOs are the same. The ZPS means a scheduling algorithm that ensures that the new calls and the handoff calls are given equal chances of acquiring new TCH. The effect on performance is that new calls are blocked only if there are no free TCH. The overall effect is that the GoS got with Zero priority schemes is the best that can be obtained. Any other algorithm serves to satisfy a section of the Subscribers and worsens the GoS. So the employed HO scheme has no direct effect on the networks GoS.

6.3 Determination of network Quality of Service

Quality of Service is one of the Networks measures of performance. For rolled out networks then, it is only fair to comment on the QoS after it is practically determined. In the literature review a number of studies to determine the network QoS were discussed. All of the highlighted studies and practically all of the published network performance research findings are theoretical. The problem is the fact that the studies rely on modeling of the networks under investigation. It was argued that non of those methods would be appropriate for application to a live or existing Network.

It is also noted that the previous researches do not focus on the time the Networks are likely to offer lower quality than the standard stipulated in the Key Performance Indicators (KPI). Under normal circumstances the BH is the time when the network load is at the peak. This is the same time that the Network underperforms. It was also noted that since it is not feasible for outsiders(researchers) to conduct research on a live system. There are no research findings on BH available determined from real Networks. The research that are conducted by the TOs tend to generalize so that the network weakness is not clearly brought out. Whereas it is recommended that the Network consistently meets the stipulated level of GoS very little attention has been paid to the BH period.

In this study on analysis of the data collected, it has shown that during Busy Hour, both Telecommunication Operators Two and Three offer GoS that is better than the upper limit of 2% expected in the worst case scenario. In these two cases the networks overall GoS has not been analyzed beyond the secondary analysis. This is because for TO Two the four towns GoS results of Nairobi:0%, Nakuru:-5%, Mombasa:-3.6% and Kisumu: -5.9% got from the secondary data analysis, confirms that the network is under utilized and hence the overall GoS is 0%. For TO Three the GoS results got for the four towns were Nairobi: 4.1%, Nakuru: -88.1%, Mombasa: -46.9% and Kisumu: -132.5%. The Network indicated some light overload in Nairobi. Combination of the Nairobi small positive GoS with the big Negative values of Nakuru, Mombasa and Kisumu would result to a negative value for the whole Network. This indicates that Operator Three has no overload problem, the revealed low GoS value within Nairobi can be solved through resource redistribution.

The BH GoS for Operator One found in this research was 41%. This value is too big as compared to the set maximum allowable value of 2%. As a result of this extremely high GoS a second set of data (non BH) was collected. The non BH data revealed a GoS of 1.42%. In the secondary analysis of the BH data we have used both Full rate Available Capacity and X-rate the conceptualized rate capacity from the model solution. It has been demonstrated that in the new X-rate codec can improve the Operator one GoS from 41% to the maximum allowed 2%. There is provision for more improvement of GoS to even lower values less than 2%, but such configurations would result to unoccupied low bit-rate channels.

The conceptual solution designed was based on network expansion through modification of the network hardware codec.

6.4 Network Capacity expansion

The problem of congestion means that the network is unable to service the demand at that time of observation. This comes as a result of all the available resources being engaged. In case of a congested network the major observation by the network users is high rate of call drops and call blocking. The solution to this problem has been achieved through capacity expansion.

The proposed solution is a modification of a network device the Codec that is capable of accommodating higher number of subscribers than the number the network is planned for. This new device is capable of making subscribers share a TCH (during high demand time) which would under optimum loading be meant for a single user.

The designed Advanced Adaptive Multi-Rate Codec (AARM) is triggered by the network load level and the rate of increase of the cell load as generalized using equation 3.4.1(e). The rate of change of the network load to trigger the codec to start splitting channels was determined using equation 3.4.1(f) that was derived using the network average call duration time d of 40s, optimization of the timing t and the rate of request r% . The two trigger factors of load level and rate of requests-r% can be varied and the resulting action can as well be more refined to achieve any desired accuracy and corresponding KPI.

The AAMR system can allocate one TCH to one, two or four subscribers. It is however noble to have it adapt to any denomination of rate. But due to the symmetry of the GSM digital frame used to transmit the payload data. Odd number and fractional sharing of TCH would result to a technical problem due to synchronization and delay jitter.

The parallel analysis of Operator One BH data using the Available full rate capacity and the modeled X-rate capacity has shown great improvement of the GoS (from 41% to 2%). This shows that Network Capacity Expansion is the solution to BH congestion. A lot of care has been taken to cause minimal changes to the network to minimize on the costs and time to implement the changes.

6.5 Recommendations

There are no publications of research by mobile TO to reveal their operational Qos values. This is a strong indicator that Mobile TOs do not always adhere to the set standard of QoS.

Since anybody else would only be in a position to conduct theoretical research. It should therefore be the responsibility of the regulator to measure the Mobile Networks Qos. This can be done by ensuring that the Regulator has access or can intercept all the TMNs Network Management information. This can serve to increase the Qos offered, since the Operator would have no control of when the assessment is conducted.

The research has shown that during Busy Hour the performance of the network with a big number of customers deteriorates to a level below the minimum stipulated by ITU. The network performance during other times has also been established to be within the recommended range.

As the performance declines to below standard for only a short time. It is strongly recommended to the Mobile Operators to deploy hardware that can dynamically adapt to the changing and unpredictable traffic load. The existing AMR was designed to reduce the impact of this problem. But later on Planners planned the network with its extended capacity under consideration and hence the increased capacity could not be used to cater for unprecedented load overshoots.

This is where the AAMR comes in handy. Its capability to adapt to three different rates and the resulting acceptable performance (MOS), makes it indispensable.

We therefore recommend its deployment to reduce this problem of periodic congestion.

6.6 Further Research Work

In this research, it was established that for mature highly subscribed Networks there is congestion during the Busy Hour period. It would be desirable to have the subscribers acquire and use the services to their satisfaction, at all times. This would require a lot of network resources, which can be incorporated into the network at the time their requirements arises. Any new equipment (or new resources) would call for major network re-planning.

The resulting problem can be solved through capacity expansion using the existing resources. There exists a number of ways through which the network existing capacity can be expanded at minimum change in the network major components and protocols. The modification of the AMR codec used as a solution in this study is one of the appropriate expansion methods. The other method is the improvement of the spectral efficiency through a better modulation scheme that can allow a single 200 KHz channel to be used by more than 8 Subscribers. Further research is recommended in this line.

We also recommend research on new network hardware that can enable any intermediate level of sharing of traffic channels. The Network hardware device that can be used to facilitate splitting of channels to any fraction of user payload other than the existing fractions of powers of two, for example enabling odd number of (three, five e.t.c.) subscribers share a single channel as opposed to the existing level of sharing by even number (two, four e.t.c.) of Subscribers.

There is a wide field of research that is relevant to the identified problem. But such research should be limited to the sections of the network where a big fraction of the network existing hardware would continue being usable without major alterations or changes in the protocols applied.

Appendix 1 References

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Appendix 2 Data Analysis

Table A2.1 Basic analysis of Operator One Busy Hour data

BASIC ANALYSIS OF OPERATOR ONE BUSY HOUR DATA FOR NAIROBI TOWN															
CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP		CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP	
CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S	CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S
70	39	12/3	19	9865	747	104.1	7.89	5811	38	12/3	20	7319	868	77.26	9.16
70	39	12/6	19	10260	802	108.3	8.47	5811	38	12/6	20	9604	990	101.4	10.45
70	39	12/7	19	8998	752	95.0	7.94	5811	38	12/7	19	5554	1044	58.63	11.02
70	39	12/8	19	9336	679	98.5	7.17	5811	38	12/8	20	5862	1091	61.88	11.52
70	39	12/9	19	10257	696	108.3	7.35	5811	38	12/9	20	9140	961	96.48	10.14
CELL AVERAGE				9743	735.2	102.8	7.76	CELL AVERAGE				7495.8	991	79.12	10.46
300	68	12/3	19	9607	848	101.4	8.95	7231	44	12/3	10	4110	1062	43.38	11.21
300	68	12/6	19	9238	850	97.51	8.97	7231	44	12/6	9	4311	705	45.51	7.44
300	68	12/7	19	8019	784	84.65	8.28	7231	44	12/7	9	4251	770	44.87	8.13
300	68	12/8	19	8164	807	86.18	8.52	7231	44	12/8	9	3902	843	41.19	8.90
300	68	12/9	19	7765	768	81.96	8.11	7231	44	12/9	12	4208	974	44.42	10.28
CELL AVERAGE				8559	811.4	90.34	8.56	CELL AVERAGE				4156.4	871	43.87	9.19
1386	137	12/3	19	16250	7056	171.5	74.48	7311	32	12/3	10	3839	1163	40.52	12.28
1386	137	12/6	19	17061	6905	180.1	72.89	7311	32	12/6	9	3754	923	39.63	9.74
1386	137	12/7	19	16396	6568	173.1	69.33	7311	32	12/7	10	3565	920	37.63	9.71
1386	137	12/8	20	16630	7057	175.5	74.49	7311	32	12/8	14	3002	846	31.69	8.93
1386	137	12/9	20	15783	6432	166.6	67.89	7311	32	12/9	10	3557	917	37.55	9.68
CELL AVERAGE				16424	6804	173.4	71.82	CELL AVERAGE				3543.4	953.8	37.40	10.07
3512	29	12/3	19	7542	588	79.61	6.21	10760	58	12/3	19	8190	1160	86.45	12.24
3512	29	12/6	19	7735	468	81.65	4.94	10760	58	12/6	19	8944	757	94.41	7.99
3512	29	12/7	19	6959	433	73.46	4.57	10760	58	12/7	19	7982	929	84.25	9.81
3512	29	12/8	19	7107	512	75.02	5.40	10760	58	12/8	19	7936	1100	83.77	11.61
3512	29	12/9	19	7353	467	77.62	4.93	10760	58	12/9	19	8515	878	89.88	9.27
CELL AVERAGE				7339	493.6	77.47	5.21	CELL AVERAGE				8313.4	964.8	87.75	10.18
5032	42	12/3	20	5481	649	57.86	6.85	13202	85	12/3	20	8800	235	92.89	2.48
5032	42	12/6	20	5169	728	54.56	7.68	13202	85	12/6	19	8519	217	89.92	2.29
5032	42	12/7	19	4494	686	47.44	7.24	13202	85	12/7	19	9291	208	98.07	2.20
5032	42	12/8	20	5144	611	54.30	6.45	13202	85	12/8	19	8932	224	94.28	2.36
5032	42	12/9	19	7943	604	83.84	6.38	13202	85	12/9	19	9285	178	98.01	1.88
CELL AVERAGE				5646	655.6	59.60	6.92	CELL AVERAGE				8965.4	212	94.63	2.24

BASIC ANALYSIS OF OPERATOR ONE BUSY HOUR DATA FOR NAKURU TOWN															
CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP		CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP	
CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S	CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S
13252	75	12/3	19	7883	284	83.21	3.00	30001	69	12/3	19	8586	123	90.63	1.30
13252	75	12/6	19	8396	273	88.62	2.88	30001	69	12/6	19	8543	155	90.18	1.64
13252	75	12/7	19	8038	250	84.85	2.64	30001	69	12/7	19	8530	137	90.04	1.45
13252	75	12/8	19	8088	252	85.37	2.66	30001	69	12/8	19	8585	142	90.62	1.50
13252	75	12/9	19	7906	304	83.45	3.21	30001	69	12/9	19	8435	117	89.04	1.24
CELL AVERAGE				8062	272.6	85.10	2.88	CELL AVERAGE				8535.8	135	90.10	1.42
13970	78	12/3	19	8296	283	87.57	2.99	30610	53	12/3	20	4182	478	44.14	5.05
13970	78	12/6	19	8751	272	92.37	2.87	30610	53	12/6	20	3837	439	40.50	4.63
13970	78	12/7	19	8645	247	91.25	2.61	30610	53	12/7	20	3809	509	40.21	5.37
13970	78	12/8	18	8640	241	91.20	2.54	30610	53	12/8	20	3913	433	41.30	4.57
13970	78	12/9	18	8638	295	91.18	3.11	30610	53	12/9	20	3882	406	40.98	4.29
CELL AVERAGE				8594	267.6	90.71	2.82	CELL AVERAGE				3924.6	453	41.43	4.78
13972	63	12/3	19	6675	229	70.46	2.42	30770	72	12/3	19	7057	709	74.49	7.48
13972	63	12/6	19	6674	172	70.45	1.82	30770	72	12/6	19	6229	502	65.75	5.30
13972	63	12/7	19	6519	185	68.81	1.95	30770	72	12/7	19	6270	652	66.18	6.88
13972	63	12/8	17	7981	183	84.24	1.93	30770	72	12/8	19	6263	583	66.11	6.15
13972	63	12/9	19	6815	136	71.94	1.44	30770	72	12/9	19	6155	637	64.97	6.72
CELL AVERAGE				6933	181	73.18	1.91	CELL AVERAGE				6394.8	617	67.50	6.51

BASIC ANALYSIS OF OPERATOR ONE BUSY HOUR DATA FOR MOMBASA TOWN															
CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP		CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP	
CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S	CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S
20120	53	12/3	16	5485	4257	57.90	44.94	20141	69	12/3	18	7020	5838	74.10	61.62
20120	53	12/6	12	6269	5173	66.17	54.60	20141	69	12/6	18	7216	5816	76.17	61.39
20120	53	12/7	14	6457	5048	68.16	53.28	20141	69	12/7	18	7174	6001	75.73	63.34
20120	53	12/8	13	5750	4704	60.69	49.65	20141	69	12/8	13	7024	5774	74.14	60.95
20120	53	12/9	13	5594	4370	59.05	46.13	20141	69	12/9	13	7240	5722	76.42	60.40
CELL AVERAGE				5911	4710	62.39	49.72	CELL AVERAGE				7134.8	5830	75.31	61.54

BASIC ANALYSIS OF OPERATOR ONE BUSY HOUR DATA FOR MOMBASA TOWN															
CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP		CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP	
CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S	CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S
20151	69	12/3	13	4998	7165	52.76	75.63	20232	54	12/3	21	6066	3219	64.03	33.98
20151	69	12/6	13	5425	7890	57.26	83.28	20232	54	12/6	21	6119	3222	64.59	34.01
20151	69	12/7	13	5310	7875	56.05	83.13	20232	54	12/7	22	4934	3111	52.08	32.84
20151	69	12/8	13	5215	7829	55.05	82.64	20232	54	12/8	21	6215	3484	65.60	36.78
20151	69	12/9	13	5172	7925	54.59	83.65	20232	54	12/9	21	5992	3120	63.25	32.93
CELL AVERAGE				5224	7737	55.14	81.67	CELL AVERAGE				5865.2	3231	61.91	34.11
20152	53	12/3	13	4564	15031	48.18	158.7								
20152	53	12/6	13	5120	4085	54.04	43.12								
20152	53	12/7	14	5055	4019	53.36	42.42								
20152	53	12/8	12	4887	4033	51.59	42.57								
20152	53	12/9	13	4998	3864	52.76	40.79								
CELL AVERAGE				4925	6206	51.98	65.51								

BASIC ANALYSIS OF OPERATOR ONE BUSY HOUR DATA FOR KISUMU TOWN															
CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP		CELL SPECIFICATION		DATE & TIME		REQUESTS		AVERAGE REQUESTS /CP	
CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S	CI	CC	DTE	HR	NCS	HO	NCS/38S	HO/38S
15740	26	12/3	21	3512	679	37.07	7.17	42581	24	12/3	21	2299	5175	24.27	54.63
15740	26	12/6	21	3844	731	40.58	7.72	42581	24	12/6	21	2391	5103	25.24	53.87
15740	26	12/7	20	3623	953	38.24	10.06	42581	24	12/7	22	2189	5128	23.11	54.13
15740	26	12/8	20	3740	852	39.48	8.99	42581	24	12/8	21	2363	4871	24.94	51.42
15740	26	12/9	21	3666	644	38.70	6.80	42581	24	12/9	21	2375	5148	25.07	54.34
CELL AVERAGE				3677	771.8	38.81	8.15	CELL AVERAGE				2323.4	5085	24.52	53.68
40380	26	12/3	21	3105	3213	32.78	33.92	42592	25	12/3	21	2323	6562	24.52	69.27
40380	26	12/6	21	3076	542	32.47	5.72	42592	25	12/6	21	2543	3082	26.84	32.53
40380	26	12/7	21	3323	707	35.08	7.46	42592	25	12/7	22	2328	3080	24.57	32.51
40380	26	12/8	21	2862	628	30.21	6.63	42592	25	12/8	21	2599	3102	27.43	32.74
40380	26	12/9	20	3186	685	33.63	7.23	42592	25	12/9	21	2379	2993	25.11	31.59
CELL AVERAGE				3110	1155	32.83	12.19	CELL AVERAGE				2434.4	3764	25.70	39.73
42541	22	12/3	21	1961	2792	20.70	29.47								
42541	22	12/6	21	1936	2733	20.44	28.85								
42541	22	12/7	21	1720	2865	18.16	30.24								
42541	22	12/8	21	1701	2763	17.96	29.17								
42541	22	12/9	21	1811	2843	19.12	30.01								
CELL AVERAGE				1826	2799	19.27	29.55								

Table A2.2 Operator One Town averages and the overall Network Average

ANALYSIS OF OPERATOR ONE BH AVERAGED DATA FOR NAIROBI TOWN														
CELL DETAILS			AVER RQ/HR		38 SECONDS AVERAGE REQUEST ANALYSIS									
	CI	CP	NCSR	HOR	AVER NCS	AVER HO	TTL RQ.	NCSR /TTL RQ	HOR/ TTL RQ	HOR /CP	PCB	PHD	PCB (XR)	PHD (XR)
1	70	39	9743	735	103	7.8	111	93.0%	7.0%	19.8%	60.1%	4.5%	0.9%	0.1%
2	300	68	8559	811	90	8.6	99	91.3%	8.7%	12.6%	28.5%	2.7%	3.4%	0.3%
3	1386	137	16424	6804	173	71.8	245	70.7%	29.3%	52.4%	31.2%	12.9%	3.5%	1.5%
4	3512	29	7339	494	77	5.2	83	93.7%	6.3%	18.0%	60.8%	4.1%	1.7%	0.1%
5	5032	42	5646	656	60	6.9	67	89.6%	10.4%	16.5%	33.0%	3.8%	4.7%	0.6%
6	5811	38	7496	991	79	10.5	90	88.3%	11.7%	27.5%	50.9%	6.7%	2.2%	0.3%
7	7231	44	4156	871	44	9.2	53	82.7%	17.3%	20.9%	14.1%	3.0%	0.4%	0.1%
8	7311	32	3543	954	37	10.1	47	78.8%	21.2%	31.5%	25.7%	6.9%	4.4%	1.2%
9	10760	58	8313	965	88	10.2	98	89.6%	10.4%	17.6%	36.5%	4.2%	4.7%	0.5%
10	13202	85	8965	212	95	2.2	97	97.7%	2.3%	2.6%	12.0%	0.3%	3.4%	0.1%
	AVER	57	8019	1349	85	14.2	99	85.6%	14.4%	24.9%	36.1%	6.1%	1.4%	0.2%

SECONDARY ANALYSIS OF OPERATOR ONE BH AVERAGED DATA FOR NAKURU TOWN														
CELL SPECIFICATION			AVERAGE REQUEST ANALYSIS WITH REFERENCE TO 38S CALL DURATION											
	CI	CP	AV. NCSR / HR	AV-HO/ HR	AV NCS	AV-HO R	TTL RQ	NCSR / TTL RQ	HOR /TTL RQ	HOR / CP	PCB	PHD	PCB (XR)	PHD (XR)
1	13252	75	8062	272.6	85.1	2.9	88	96.7%	3.3%	3.8%	14.3%	0.5%	1.9%	0.1%
2	13970	78	8594	267.6	90.7	2.8	93.5	97.0%	3.0%	3.6%	16.1%	0.5%	4.0%	0.1%
3	13972	63	6933	181	73.2	1.9	75.1	97.5%	2.5%	3.0%	15.7%	0.4%	3.4%	0.1%
4	30001	69	8536	134.8	90.1	1.4	91.5	98.4%	1.6%	2.1%	24.2%	0.4%	2.0%	0.0%
5	30610	53	3925	453	41.4	4.8	46.2	89.7%	10.3%	9.0%	0.0%	0.0%	2.0%	0.2%
6	30770	72	6395	616.6	67.5	6.5	74	91.2%	8.8%	9.0%	2.5%	0.2%	2.5%	0.2%
	AVER	68.3	7074.0	321	74.67	3.39	78.1	95.7%	4.3%	5.0%	11.9%	0.5%	1.9%	0.1%

ANALYSIS OF AVERAGED DATA FOR MOMBASA														
CELL SPECIFICATION			AV RQ/HR		AV. RQ ANALYSIS WITH REFERENCE TO 38S CALL DURATION									
	CI	CP	NCSR	HOR	AV NCSR	AV-HOR	TTL RQ	NCSR/TTL RQ	HOR/TTL RQ	HOR/CP AT XR	PCB	PHD	PCB (XR)	PHD (XR)
22	20120	53	5911	4710.4	62.4	49.7	112.1	55.7%	44.3%	44.7%	29.3%	23.4%	0.4%	0.3%
23	20141	69	7135	5830.2	75.3	61.5	136.9	55.0%	45.0%	46.9%	27.3%	22.3%	2.3%	1.9%
24	20151	69	5224	7736.8	55.1	81.7	136.8	40.3%	59.7%	62.3%	20.0%	29.6%	1.7%	2.5%
25	20152	53	4925	6206.4	52.0	65.5	117.5	44.2%	55.8%	56.2%	24.3%	30.6%	0.3%	0.4%
26	20232	54	5865	3231.2	61.9	34.1	96.0	64.5%	35.5%	37.2%	28.2%	15.5%	2.8%	1.6%
	AV	59.6	5812	5543	61.3	58.5	119.9	51.2%	48.8%	49.1%	25.7%	24.5%	0.3%	0.3%

ANALYSIS OF AVERAGED DATA FOR KISUMU														
CELL SPECIFICATION			AVERAGE REQUEST ANALYSIS WITH REFERENCE TO 38S CALL DURATION											
	CI	CP	AV. NCS/HR	AV-HO/HR	AV NCS	AV-HOR	TTL RQ	NCSR /TTL RQ	HOR/TTL RQ	HOR/CP	PCB	PHD	PCB (XR)	PHD (XR)
17	15740	26	3677	771.8	38.8	8.1	47	82.7%	17.3%	31.3%	36.9%	7.7%	0.1%	0.1%
18	40380	26	3110	1155	32.8	12	45	72.9%	27.1%	46.9%	30.8%	11.4%	0.5%	0.5%
19	42541	22	1826	2799.2	19.3	30	48.8	39.5%	60.5%	134.3%	21.7%	33.2%	0.5%	0.5%
20	42581	24	2323	5085	24.5	54	78.2	31.4%	68.6%	223.6%	21.7%	47.6%	1.2%	1.2%
21	42592	25	2434	3763.8	25.7	40	65.4	39.3%	60.7%	158.9%	24.3%	37.5%	0.4%	0.4%
	AV	24.6	2674.2	2715	28.2	28.7	56.9	49.6%	50.4%	116.5%	28.2%	28.6%	0.3%	0.3%

SUMMARY OF THE FOUR TOWNS DATA								
TOWN	NO/C	AV CP	TOTAL REQUESTS -		AVERAGE		AVERAGE/38S CP	
			NCSR	HOR	NCSR/HR	HOR/HR	NCSR	HO
NAIROBI	10	57	400928	67460	8018.56	1349.2	84.64	14.24
NAKURU	6	68	212221	9628	7074.03	320.9	74.67	3.39
KISUMU	5	25	66855	67874	2674.20	2715.0	28.23	28.66
MOMBASA	5	59.6	145299	138575	5811.96	5543.0	61.35	58.51
NETWORK	1	53.88	31742.4231	70884	5894.69	2482.0	62.22	26.20

Table A2.3 Basic analysis of Operator One non Busy Hour data for Nairobi Town

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/28	622	18	0	541	464	0.0%	3.9%	46.2%	11/13	622	12	0	533	494	0.0%	2.4%	48.1%
9/29	622	0	0	601	532	0.0%	0.0%	47.0%	11/14	622	0	0	491	449	0.0%	0.0%	47.8%
9/30	622	6	0	549	438	0.0%	1.4%	44.4%	11/15	622	0	0	541	434	0.0%	0.0%	44.5%
10/1	622	0	0	549	441	0.0%	0.0%	44.5%	11/16	622	0	0	476	417	0.0%	0.0%	46.7%
10/2	622	0	0	571	563	0.0%	0.0%	49.6%	11/17	622	0	0	510	523	0.0%	0.0%	50.6%
10/3	622	0	0	594	486	0.0%	0.0%	45.0%	11/18	622	0	0	511	519	0.0%	0.0%	50.4%
10/4	622	12	0	633	545	0.0%	2.2%	46.3%	11/19	622	0	0	524	525	0.0%	0.0%	50.0%
10/5	622	6	0	607	506	0.0%	1.2%	45.5%	11/20	622	0	0	562	442	0.0%	0.0%	44.0%
10/6	622	0	0	544	435	0.0%	0.0%	44.4%	11/21	622	0	0	585	568	0.0%	0.0%	49.3%
10/7	622	12	0	531	534	0.0%	2.2%	50.1%	11/22	622	0	0	537	462	0.0%	0.0%	46.2%
10/8	622	0	0	540	480	0.0%	0.0%	47.1%	11/23	622	0	0	488	410	0.0%	0.0%	45.7%
10/9	622	0	6	638	463	0.9%	0.0%	42.1%	11/24	622	6	0	529	493	0.0%	1.2%	48.2%
10/10	622	6	0	531	475	0.0%	1.3%	47.2%	11/25	622	6	0	526	471	0.0%	1.3%	47.2%
10/11	622	0	0	577	444	0.0%	0.0%	43.5%	11/26	622	12	6	553	506	1.1%	2.4%	47.8%
10/12	622	0	0	534	494	0.0%	0.0%	48.1%	11/27	622	0	0	604	594	0.0%	0.0%	49.6%
10/13	622	0	0	566	549	0.0%	0.0%	49.2%	11/28	622	0	6	521	425	1.2%	0.0%	44.9%
10/14	622	0	6	581	550	1.0%	0.0%	48.6%	11/29	622	6	0	626	610	0.0%	1.0%	49.4%
10/15	622	6	0	648	483	0.0%	1.2%	42.7%	11/30	622	0	6	539	449	1.1%	0.0%	45.4%
10/16	622	0	0	597	403	0.0%	0.0%	40.3%	12/1	622	6	0	600	515	0.0%	1.2%	46.2%
10/17	622	0	0	494	477	0.0%	0.0%	49.1%	12/2	622	0	0	626	628	0.0%	0.0%	50.1%
10/18	622	0	6	527	478	1.1%	0.0%	47.6%	12/3	622	0	0	626	639	0.0%	0.0%	50.5%
10/19	622	0	6	556	483	1.1%	0.0%	46.5%	12/4	622	0	0	628	465	0.0%	0.0%	42.5%
10/20	622	0	0	514	402	0.0%	0.0%	43.9%	12/5	622	6	0	522	533	0.0%	1.1%	50.5%
10/21	622	0	0	535	436	0.0%	0.0%	44.9%	12/6	622	6	0	630	554	0.0%	1.1%	46.8%
10/22	622	0	0	508	480	0.0%	0.0%	48.6%	12/7	622	6	0	592	450	0.0%	1.3%	43.2%
10/23	622	0	0	531	402	0.0%	0.0%	43.1%	12/8	622	6	0	635	470	0.0%	1.3%	42.5%
10/24	622	0	0	416	324	0.0%	0.0%	43.8%	12/9	622	0	0	597	495	0.0%	0.0%	45.3%
10/25	622	0	0	537	488	0.0%	0.0%	47.6%	12/10	622	12	0	700	371	0.0%	3.2%	34.6%
10/26	622	6	0	511	385	0.0%	1.6%	43.0%	12/11	622	12	0	638	547	0.0%	2.2%	46.2%
10/27	622	6	6	473	418	1.3%	1.4%	46.9%	12/12	622	6	0	570	582	0.0%	1.0%	50.5%
10/28	622	6	0	543	493	0.0%	1.2%	47.6%	12/13	622	0	0	610	417	0.0%	0.0%	40.6%
10/29	622	0	0	573	476	0.0%	0.0%	45.4%	12/14	622	12	6	694	642	0.9%	1.9%	48.1%
10/30	622	0	0	604	554	0.0%	0.0%	47.8%	12/15	622	0	0	577	515	0.0%	0.0%	47.2%
10/31	622	12	0	556	495	0.0%	2.4%	47.1%	12/16	622	0	0	546	397	0.0%	0.0%	42.1%
11/1	622	6	0	571	459	0.0%	1.3%	44.6%	12/17	622	0	0	584	495	0.0%	0.0%	45.9%
11/2	622	0	0	560	514	0.0%	0.0%	47.9%	12/18	622	0	0	708	542	0.0%	0.0%	43.4%
11/3	622	18	0	550	516	0.0%	3.5%	48.4%	12/19	622	0	18	732	673	2.5%	0.0%	47.9%
11/4	622	0	0	526	439	0.0%	0.0%	45.5%	12/20	622	0	0	622	502	0.0%	0.0%	44.7%
11/5	622	0	0	545	510	0.0%	0.0%	48.3%	12/21	622	6	0	619	530	0.0%	1.0%	46.0%
11/6	622	6	0	606	560	0.0%	1.1%	48.0%	12/22	622	6	0	560	435	0.0%	1.4%	43.7%
11/7	622	18	0	590	487	0.0%	3.7%	45.2%	12/23	622	6	0	563	576	0.0%	1.0%	50.6%
11/8	622	0	6	661	442	1.0%	0.0%	40.0%	12/24	622	6	0	513	454	0.0%	1.3%	46.9%
11/9	622	12	0	524	441	0.0%	2.7%	45.7%	12/25	622	6	0	418	392	0.0%	1.5%	48.4%
11/10	622	12	0	570	444	0.0%	2.7%	43.8%	12/26	622	0	0	344	278	0.0%	0.0%	44.7%
11/11	622	6	0	546	522	0.0%	1.1%	48.9%	12/27	622	0	0	387	306	0.0%	0.0%	44.2%
11/12	622	0	0	556	340	0.0%	0.0%	37.9%	12/28	622	18	0	428	397	0.0%	4.5%	48.1%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NT CH D	NB C	NCS	NHO	QoS Metrics		HO/ CP	Date	CI	NTC HD	NB C	NCS	NHO	QoS Metrics		HO/ CP
						PCB	PHD								PCB	PHD	
9/28	1790	52	0	3781	2848	0.0%	1.8%	43.0%	11/7	1790	0	0	629	724	0.0%	0.0%	53.5%
9/29	1790	56	0	3732	3024	0.0%	1.9%	44.8%	11/8	1790	76	56	4155	3806	1.3%	2.0%	47.8%
9/30	1790	24	0	3811	2979	0.0%	0.8%	43.9%	11/9	1790	52	8	4022	3717	0.2%	1.4%	48.0%
10/1	1790	44	8	4273	3714	0.2%	1.2%	46.5%	11/10	1790	56	20	4309	3550	0.5%	1.6%	45.2%
10/2	1790	12	0	2564	1970	0.0%	0.6%	43.4%	11/11	1790	48	0	3888	3363	0.0%	1.4%	46.4%
10/3	1790	4	0	667	592	0.0%	0.7%	47.0%	11/12	1790	68	20	4620	3711	0.4%	1.8%	44.5%
10/4	1790	48	0	4006	3372	0.0%	1.4%	45.7%	11/13	1790	4	0	2450	2153	0.0%	0.2%	46.8%
10/5	1790	72	0	3980	3426	0.0%	2.1%	46.3%	11/14	1790	12	0	540	585	0.0%	2.1%	52.0%
10/6	1790	32	0	4038	3362	0.0%	1.0%	45.4%	11/15	1790	8	0	4897	3318	0.0%	0.2%	40.4%
10/7	1790	20	0	3905	3209	0.0%	0.6%	45.1%	11/16	1790	112	0	3996	3102	0.0%	3.6%	43.7%
10/8	1790	176	48	4557	3679	1.1%	4.8%	44.7%	11/17	1790	40	0	4174	3443	0.0%	1.2%	45.2%
10/9	1790	76	0	2631	2086	0.0%	3.6%	44.2%	11/18	1790	32	0	3982	3318	0.0%	1.0%	45.5%
10/10	1790	0	0	575	587	0.0%	0.0%	50.5%	11/19	1790	116	0	3975	3463	0.0%	3.3%	46.6%
10/11	1790	192	0	3856	3048	0.0%	6.3%	44.1%	11/20	1790	88	0	2594	2048	0.0%	4.3%	44.1%
10/12	1790	44	0	3950	3135	0.0%	1.4%	44.2%	11/21	1790	0	0	622	722	0.0%	0.0%	53.7%
10/13	1790	36	0	3579	2956	0.0%	1.2%	45.2%	11/22	1790	40	0	3448	2990	0.0%	1.3%	46.4%
10/14	1790	48	0	3692	3018	0.0%	1.6%	45.0%	11/23	1790	168	0	3459	2886	0.0%	5.8%	45.5%
10/15	1790	28	0	4052	3357	0.0%	0.8%	45.3%	11/24	1790	88	0	3286	3374	0.0%	2.6%	50.7%
10/16	1790	8	0	2260	1919	0.0%	0.4%	45.9%	11/25	1790	28	0	3546	3426	0.0%	0.8%	49.1%
10/17	1790	0	0	557	450	0.0%	0.0%	44.7%	11/26	1790	36	0	3701	3763	0.0%	1.0%	50.4%
10/18	1790	12	0	3730	3089	0.0%	0.4%	45.3%	11/27	1790	12	0	2087	1942	0.0%	0.6%	48.2%
10/19	1790	24	0	3982	3534	0.0%	0.7%	47.0%	11/28	1790	4	0	518	889	0.0%	0.4%	63.2%
10/20	1790	4	0	933	994	0.0%	0.4%	51.6%	11/29	1790	12	4	3555	3672	0.1%	0.3%	50.8%
10/21	1790	80	4	3715	3359	0.1%	2.4%	47.5%	11/30	1790	32	0	4249	3681	0.0%	0.9%	46.4%
10/22	1790	56	0	3680	3588	0.0%	1.6%	49.4%	12/1	1790	60	0	3844	3816	0.0%	1.6%	49.8%
10/23	1790	40	0	2390	2383	0.0%	1.7%	49.9%	12/2	1790	44	0	3973	3714	0.0%	1.2%	48.3%
10/24	1790	0	0	550	698	0.0%	0.0%	55.9%	12/3	1790	68	0	4118	4082	0.0%	1.7%	49.8%
10/25	1790	12	0	3476	3529	0.0%	0.3%	50.4%	12/4	1790	12	0	2266	2192	0.0%	0.5%	49.2%
10/26	1790	108	0	3793	3584	0.0%	3.0%	48.6%	12/5	1790	4	0	530	663	0.0%	0.6%	55.6%
10/27	1790	244	0	3491	3294	0.0%	7.4%	48.5%	12/6	1790	32	0	3876	3854	0.0%	0.8%	49.9%
10/28	1790	224	0	3580	3417	0.0%	6.6%	48.8%	12/7	1790	40	0	3782	3705	0.0%	1.1%	49.5%
10/29	1790	24	0	3766	3822	0.0%	0.6%	50.4%	12/8	1790	36	0	3794	3745	0.0%	1.0%	49.7%
10/30	1790	4	0	2508	2285	0.0%	0.2%	47.7%	12/9	1790	36	4	3892	3791	0.1%	0.9%	49.3%
10/31	1790	4	0	580	626	0.0%	0.6%	51.9%	12/10	1790	36	0	4106	4109	0.0%	0.9%	50.0%
11/1	1790	56	0	3736	3531	0.0%	1.6%	48.6%	12/11	1790	0	0	2284	2147	0.0%	0.0%	48.5%
11/2	1790	28	0	3789	3798	0.0%	1.0%	50.0%	12/12	1790	4	0	512	632	0.0%	1%	55%
11/3	1790	172	776	4143	4662	19%	3.7%	52.9%	12/13	1790	20	0	979	1117	0.0%	1.8%	53.3%
11/4	1790	48	8	3833	3553	0.2%	1.4%	48.1%	12/14	1790	72	0	4130	3957	0.0%	1.8%	48.9%
11/5	1790	48	36	4065	3983	0.9%	1.2%	49.5%	12/15	1790	28	0	4052	3357	0.0%	1%	45%
11/6	1790	48	0	2598	2374	0.0%	2.0%	47.7%	12/16	1790	228	4	3976	4050	0.1%	5.6%	50.5%
12/17	1790	48	24	4137	4200	0.6%	1.1%	50.4%	11/1	4250	4	0	1537	1251	0.0%	0.3%	44.9%
12/18	1790	12	0	2170	1998	0.0%	0.6%	47.9%	11/2	4250	8	0	1514	1381	0.0%	0.6%	47.7%
12/19	1790	0	0	560	769	0.0%	0.0%	57.9%	11/3	4250	8	0	1557	1160	0.0%	0.7%	42.7%
12/20	1790	20	0	4051	3876	0.0%	0.5%	48.9%	11/4	4250	12	0	1393	1192	0.0%	1.0%	46.1%
12/21	1790	100	0	4097	3843	0.0%	2.6%	48.4%	11/5	4250	4	0	1389	1230	0.0%	0.3%	47.0%
12/22	1790	60	0	3907	3704	0.0%	1.6%	48.7%	11/6	4250	4	0	1251	1129	0.0%	0.4%	47.4%
12/23	1790	24	4	3742	3315	0.1%	0.7%	47.0%	11/7	4250	0	0	875	714	0.0%	0.0%	44.9%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
12/24	1790	16	0	3514	3157	0.0%	0.5%	47.3%	11/8	4250	4	0	1344	989	0.0%	0.4%	42.4%
12/25	1790	8	0	997	833	0.0%	1.0%	45.5%	11/9	4250	4	0	1427	1198	0.0%	0.3%	45.6%
12/26	1790	0	0	280	308	0.0%	0.0%	52.4%	11/10	4250	4	0	1317	1069	0.0%	0.4%	44.8%
12/27	1790	72	0	1150	1310	0.0%	5.5%	53.3%	11/11	4250	4	0	1354	1126	0.0%	0.4%	45.4%
12/28	1790	16	0	2121	1925	0.0%	0.8%	47.6%	11/12	4250	4	0	1301	1188	0.0%	0.3%	47.7%
9/28	4250	4	0	1277	970	0.0%	0.4%	43.2%	11/13	4250	8	0	1266	1074	0.0%	0.7%	45.9%
9/29	4250	28	0	1323	965	0.0%	2.9%	42.2%	11/14	4250	8	0	812	482	0.0%	1.7%	37.2%
9/30	4250	0	0	1299	1123	0.0%	0.0%	46.4%	11/15	4250	12	0	1494	1292	0.0%	0.9%	46.4%
10/1	4250	4	0	1284	990	0.0%	0.4%	43.5%	11/16	4250	4	0	1502	1349	0.0%	0.3%	47.3%
10/2	4250	8	0	1238	998	0.0%	0.8%	44.6%	11/17	4250	16	0	1368	1086	0.0%	1.5%	44.3%
10/3	4250	4	0	789	387	0.0%	1.0%	32.9%	11/18	4250	8	0	1474	1263	0.0%	0.6%	46.1%
10/4	4250	16	0	1383	1138	0.0%	1.4%	45.1%	11/19	4250	0	0	1393	1258	0.0%	0.0%	47.5%
10/5	4250	20	0	1489	1219	0.0%	1.6%	45.0%	11/20	4250	0	0	1342	995	0.0%	0.0%	42.6%
10/6	4250	4	0	1333	1123	0.0%	0.4%	45.7%	11/21	4250	0	0	920	529	0.0%	0.0%	36.5%
10/7	4250	0	0	1357	1095	0.0%	0.0%	44.7%	11/22	4250	4	0	1372	1239	0.0%	0.3%	47.5%
10/8	4250	0	0	1213	1002	0.0%	0.0%	45.2%	11/23	4250	0	0	1350	1192	0.0%	0.0%	46.9%
10/9	4250	4	0	1226	939	0.0%	0.4%	43.4%	11/24	4250	4	0	1506	1043	0.0%	0.4%	40.9%
10/10	4250	8	0	924	361	0.0%	2.2%	28.1%	11/25	4250	0	0	1356	1049	0.0%	0.0%	43.6%
10/11	4250	16	0	1315	966	0.0%	1.7%	42.3%	11/26	4250	8	4	1391	1157	0.3%	0.7%	45.4%
10/12	4250	12	0	1336	1117	0.0%	1.1%	45.5%	11/27	4250	12	4	1204	929	0.3%	1.3%	43.6%
10/13	4250	4	0	1293	992	0.0%	0.4%	43.4%	11/28	4250	4	0	734	324	0.0%	1.2%	30.6%
10/14	4250	0	0	1565	1032	0.0%	0.0%	39.7%	11/29	4250	4	0	1438	1275	0.0%	0.3%	47.0%
10/15	4250	4	0	1350	1139	0.0%	0.4%	45.8%	11/30	4250	16	0	1547	1285	0.0%	1.2%	45.4%
10/16	4250	0	0	1118	941	0.0%	0.0%	45.7%	12/1	4250	0	0	1428	1253	0.0%	0.0%	46.7%
10/17	4250	0	0	960	767	0.0%	0.0%	44.4%	12/2	4250	0	0	1489	1368	0.0%	0.0%	47.9%
10/18	4250	4	0	1404	991	0.0%	0.4%	41.4%	12/3	4250	16	0	1403	1174	0.0%	1.4%	45.6%
10/19	4250	24	0	1395	1132	0.0%	2.1%	44.8%	12/4	4250	4	0	1358	1050	0.0%	0.4%	43.6%
10/20	4250	4	0	784	491	0.0%	0.8%	38.5%	12/5	4250	0	0	893	736	0.0%	0.0%	45.2%
10/21	4250	0	0	1309	1035	0.0%	0.0%	44.2%	12/6	4250	12	0	1461	1005	0.0%	1.2%	40.8%
10/22	4250	4	0	1188	1163	0.0%	0.3%	49.5%	12/7	4250	0	0	1372	1219	0.0%	0.0%	47.0%
10/23	4250	16	0	1108	890	0.0%	1.8%	44.5%	12/8	4250	8	0	1351	1195	0.0%	0.7%	46.9%
10/24	4250	0	0	748	537	0.0%	0.0%	41.8%	12/9	4250	0	0	1397	1254	0.0%	0.0%	47.3%
10/25	4250	0	0	1281	1103	0.0%	0.0%	46.3%	12/10	4250	4	0	1401	1208	0.0%	0.3%	46.3%
10/26	4250	4	0	1362	1071	0.0%	0.4%	44.0%	12/11	4250	0	0	1130	919	0.0%	0.0%	44.9%
10/27	4250	0	0	1233	1111	0.0%	0.0%	47.4%	12/12	4250	4	0	948	702	0.0%	0.6%	42.5%
10/28	4250	8	0	1253	1080	0.0%	0.7%	46.3%	12/13	4250	0	0	810	648	0.0%	0.0%	44.4%
10/29	4250	20	0	1449	1152	0.0%	1.7%	44.3%	12/14	4250	0	0	1321	1188	0.0%	0.0%	47.3%
10/30	4250	8	0	1189	996	0.0%	0.8%	45.6%	12/15	4250	12	0	1422	1254	0.0%	1.0%	46.9%
10/31	4250	0	0	926	602	0.0%	0.0%	39.4%	12/16	4250	12	0	1380	1308	0.0%	0.9%	48.7%
12/17	4250	8	0	1476	1117	0.0%	0.7%	43.1%	11/1	4372	8	12	2032	658	0.6%	1.2%	24.5%
12/18	4250	12	0	1143	982	0.0%	1.2%	46.2%	11/2	4372	4	12	1944	700	0.6%	0.6%	26.5%
12/19	4250	0	0	847	689	0.0%	0.0%	44.9%	11/3	4372	0	44	2272	802	1.9%	0.0%	26.1%
12/20	4250	0	0	1334	1155	0.0%	0.0%	46.4%	11/4	4372	4	16	1842	807	0.9%	0.5%	30.5%
12/21	4250	0	0	1435	1249	0.0%	0.0%	46.5%	11/5	4372	0	8	2125	811	0.4%	0.0%	27.6%
12/22	4250	4	0	1387	1124	0.0%	0.4%	44.8%	11/6	4372	0	0	2168	775	0.0%	0.0%	26.3%
12/23	4250	0	0	1225	799	0.0%	0.0%	39.5%	11/7	4372	0	4	2277	356	0.2%	0.0%	13.5%
12/24	4250	0	0	1035	911	0.0%	0.0%	46.8%	11/8	4372	0	100	2090	834	4.8%	0.0%	28.5%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
12/25	4250	0	0	807	624	0.0%	0.0%	43.6%	11/9	4372	0	4	1844	118	0.2%	0.0%	6.0%
12/26	4250	0	0	668	511	0.0%	0.0%	43.3%	11/10	4372	8	24	2030	886	1.2%	0.9%	30.4%
12/27	4250	8	0	848	741	0.0%	1.1%	46.6%	11/11	4372	4	36	1966	764	1.8%	0.5%	28.0%
12/28	4250	4	0	1006	746	0.0%	0.5%	42.6%	11/12	4372	4	24	2242	849	1.1%	0.5%	27.5%
9/28	4372	0	0	1372	707	0.0%	0.0%	34.0%	11/13	4372	4	28	2117	642	1.3%	0.6%	23.3%
9/29	4372	4	0	1432	579	0.0%	0.7%	28.8%	11/14	4372	0	0	1531	567	0.0%	0.0%	27.0%
9/30	4372	4	0	1451	544	0.0%	0.7%	27.3%	11/15	4372	4	24	2360	550	1.0%	0.7%	18.9%
10/1	4372	4	0	1449	810	0.0%	0.5%	35.9%	11/16	4372	0	4	2222	304	0.2%	0.0%	12.0%
10/2	4372	4	0	1554	783	0.0%	0.5%	33.5%	11/17	4372	4	28	2527	714	1.1%	0.6%	22.0%
10/3	4372	0	0	1033	461	0.0%	0.0%	30.9%	11/18	4372	4	0	2287	732	0.0%	0.5%	24.2%
10/4	4372	0	0	1446	830	0.0%	0.0%	36.5%	11/19	4372	16	20	1750	492	1.1%	3.3%	21.9%
10/5	4372	0	4	1531	420	0.3%	0.0%	21.5%	11/20	4372	16	100	1808	707	5.5%	2.3%	28.1%
10/6	4372	4	56	1506	646	3.7%	0.6%	30.0%	11/21	4372	8	20	1668	432	1.2%	1.9%	20.6%
10/7	4372	0	28	1791	380	1.6%	0.0%	17.5%	11/22	4372	0	12	1869	442	0.6%	0.0%	19.1%
10/8	4372	4	32	1722	678	1.9%	0.6%	28.3%	11/23	4372	4	16	2091	466	0.8%	0.9%	18.2%
10/9	4372	4	20	1875	537	1.1%	0.7%	22.3%	11/24	4372	4	12	2952	502	0.4%	0.8%	14.5%
10/10	4372	4	12	1531	457	0.8%	0.9%	23.0%	11/25	4372	0	40	2063	700	1.9%	0.0%	25.3%
10/11	4372	4	24	2144	563	1.1%	0.7%	20.8%	11/26	4372	0	12	2433	604	0.5%	0.0%	19.9%
10/12	4372	0	8	1867	388	0.4%	0.0%	17.2%	11/27	4372	0	24	2302	622	1.0%	0.0%	21.3%
10/13	4372	24	44	1843	692	2.4%	3.5%	27.3%	11/28	4372	8	0	2565	501	0.0%	1.6%	16.3%
10/14	4372	36	32	2606	1099	1.2%	3.3%	29.7%	11/29	4372	0	8	1779	596	0.4%	0.0%	25.1%
10/15	4372	4	40	1603	774	2.5%	0.5%	32.6%	11/30	4372	4	28	1955	695	1.4%	0.6%	26.2%
10/16	4372	8	52	1745	628	3.0%	1.3%	26.5%	12/1	4372	8	36	1972	807	1.8%	1.0%	29.0%
10/17	4372	0	8	1380	410	0.6%	0.0%	22.9%	12/2	4372	4	32	2116	492	1.5%	0.8%	18.9%
10/18	4372	8	44	1581	430	2.8%	1.9%	21.4%	12/3	4372	0	4	1751	743	0.2%	0.0%	29.8%
10/19	4372	12	8	1538	492	0.5%	2.4%	24.2%	12/4	4372	0	16	2016	817	0.8%	0.0%	28.8%
10/20	4372	8	32	1394	369	2.3%	2.2%	20.9%	12/5	4372	0	0	1470	455	0.0%	0.0%	23.6%
10/21	4372	4	8	1552	649	0.5%	0.6%	29.5%	12/6	4372	12	16	1572	538	1.0%	2.2%	25.5%
10/22	4372	4	4	2077	829	0.2%	0.5%	28.5%	12/7	4372	0	48	1932	322	2.5%	0.0%	14.3%
10/23	4372	0	16	1755	325	0.9%	0.0%	15.6%	12/8	4372	8	4	1638	373	0.2%	2.1%	18.5%
10/24	4372	4	16	1443	378	1.1%	1.1%	20.8%	12/9	4372	0	20	1780	806	1.1%	0.0%	31.2%
10/25	4372	0	0	1891	861	0.0%	0.0%	31.3%	12/10	4372	8	4	1801	611	0.2%	1.3%	25.3%
10/26	4372	4	0	1587	397	0.0%	1.0%	20.0%	12/11	4372	4	16	2243	891	0.7%	0.4%	28.4%
10/27	4372	8	32	1780	586	1.8%	1.4%	24.8%	12/12	4372	12	0	1872	483	0.0%	2.5%	20.5%
10/28	4372	4	48	2033	631	2.4%	0.6%	23.7%	12/13	4372	0	8	1517	293	0.5%	0.0%	16.2%
10/29	4372	4	32	2581	432	1.2%	0.9%	14.3%	12/14	4372	4	0	1486	436	0.0%	0.9%	22.7%
10/30	4372	4	52	2323	821	2.2%	0.5%	26.1%	12/15	4372	348	0	1577	694	0.0%	50%	30.6%
10/31	4372	4	8	1608	549	0.5%	0.7%	25.5%	12/16	4372	128	0	1292	610	0.0%	21%	32.1%
12/17	4372	56	0	1242	783	0.0%	7.2%	38.7%	11/1	4801	4	4	1631	1411	0.2%	0.3%	46.4%
12/18	4372	136	0	1325	451	0.0%	30%	25.4%	11/2	4801	4	0	802	726	0.0%	0.6%	47.5%
12/19	4372	24	4	1089	397	0.4%	6.0%	26.7%	11/3	4801	8	0	732	640	0.0%	1.3%	46.6%
12/20	4372	64	0	1335	706	0.0%	9.1%	34.6%	11/4	4801	0	0	261	216	0.0%	0.0%	45.3%
12/21	4372	12	0	1312	643	0.0%	1.9%	32.9%	11/5	4801	0	20	1489	1278	1.3%	0.0%	46.2%
12/22	4372	0	8	1251	555	0.6%	0.0%	30.7%	11/6	4801	0	132	1571	1338	8.4%	0.0%	46.0%
12/23	4372	0	0	1218	667	0.0%	0.0%	35.4%	11/7	4801	8	8	1-334	1113	0.6%	0.7%	45.5%
12/24	4372	8	0	1399	719	0.0%	1.1%	33.9%	11/8	4801	4	116	1596	1360	7.3%	0.3%	46.0%
12/25	4372	12	0	933	495	0.0%	2.4%	34.7%	11/9	4801	4	4	996	715	0.4%	0.6%	41.8%

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						PCB	PHD								PCB	PHD	
12/26	4372	0	0	954	457	0.0%	0.0%	32.4%	11/10	4801	0	0	761	613	0.0%	0.0%	44.6%
12/27	4372	0	0	1025	433	0.0%	0.0%	29.7%	11/11	4801	0	0	274	315	0.0%	0.0%	53.5%
12/28	4372	8	0	1120	626	0.0%	1.3%	35.9%	11/12	4801	4	40	1433	1245	2.8%	0.3%	46.5%
9/28	4801	0	0	568	499	0.0%	0.0%	46.8%	11/13	4801	0	80	1487	1238	5.4%	0.0%	45.4%
9/29	4801	0	0	685	623	0.0%	0.0%	47.6%	11/14	4801	8	8	1485	1277	0.5%	0.6%	46.2%
9/30	4801	0	0	305	199	0.0%	0.0%	39.5%	11/15	4801	12	8	1542	1313	0.5%	0.9%	46.0%
10/1	4801	4	60	1566	1360	3.8%	0.3%	46.5%	11/16	4801	8	0	979	772	0.0%	1.0%	44.1%
10/2	4801	16	60	1607	1363	3.7%	1.2%	45.9%	11/17	4801	4	0	777	582	0.0%	0.7%	42.8%
10/3	4801	4	48	1517	1318	3.2%	0.3%	46.5%	11/18	4801	4	0	291	312	0.0%	1.3%	51.7%
10/4	4801	16	72	1682	1473	4.3%	1.1%	46.7%	11/19	4801	4	32	1639	1397	2.0%	0.3%	46.0%
10/5	4801	4	0	1070	941	0.0%	0.4%	46.8%	11/20	4801	4	36	1706	1463	2.1%	0.3%	46.2%
10/6	4801	4	0	759	690	0.0%	0.6%	47.6%	11/21	4801	4	32	1608	1330	2.0%	0.3%	45.3%
10/7	4801	4	0	285	257	0.0%	1.6%	47.4%	11/22	4801	4	32	1771	1547	1.8%	0.3%	46.6%
10/8	4801	8	28	1501	1244	1.9%	0.6%	45.3%	11/23	4801	0	0	996	891	0.0%	0.0%	47.2%
10/9	4801	0	124	1750	1498	7.1%	0.0%	46.1%	11/24	4801	0	0	706	619	0.0%	0.0%	46.7%
10/10	4801	8	16	1489	1298	1.1%	0.6%	46.6%	11/25	4801	4	0	387	340	0.0%	1.2%	46.8%
10/11	4801	12	100	1759	1493	5.7%	0.8%	45.9%	11/26	4801	0	72	1693	1458	4.3%	0.0%	46.3%
10/12	4801	0	4	1023	884	0.4%	0.0%	46.4%	11/27	4801	0	40	1936	1636	2.1%	0.0%	45.8%
10/13	4801	4	0	968	685	0.0%	0.6%	41.4%	11/28	4801	0	24	1594	1407	1.5%	0.0%	46.9%
10/14	4801	0	0	411	301	0.0%	0.0%	42.3%	11/29	4801	8	20	1620	1381	1.2%	0.6%	46.0%
10/15	4801	4	28	1767	1533	1.6%	0.3%	46.5%	11/30	4801	0	0	1119	982	0.0%	0.0%	46.7%
10/16	4801	4	20	1640	1416	1.2%	0.3%	46.3%	12/1	4801	8	0	820	753	0.0%	1.1%	47.9%
10/17	4801	0	0	344	260	0.0%	0.0%	43.0%	12/2	4801	4	0	396	275	0.0%	1.5%	41.0%
10/18	4801	0	16	1550	1399	1.0%	0.0%	47.4%	12/3	4801	16	40	1740	1502	2.3%	1.1%	46.3%
10/19	4801	4	0	1085	947	0.0%	0.4%	46.6%	12/4	4801	4	40	1669	1394	2.4%	0.3%	45.5%
10/20	4801	4	0	775	681	0.0%	0.6%	46.8%	12/5	4801	4	24	1647	1426	1.5%	0.3%	46.4%
10/21	4801	0	0	296	193	0.0%	0.0%	39.5%	12/6	4801	12	8	1819	1529	0.4%	0.8%	45.7%
10/22	4801	4	60	1559	1300	3.8%	0.3%	45.5%	12/7	4801	12	0	1203	1084	0.0%	1.1%	47.4%
10/23	4801	0	20	1425	1222	1.4%	0.0%	46.2%	12/8	4801	8	0	1069	964	0.0%	0.8%	47.4%
10/24	4801	8	20	1411	1196	1.4%	0.7%	45.9%	12/9	4801	0	0	237	126	0.0%	0.0%	34.7%
10/25	4801	0	44	1445	1234	3.0%	0.0%	46.1%	12/10	4801	4	0	246	235	0.0%	1.7%	48.9%
10/26	4801	4	4	906	813	0.4%	0.5%	47.3%	12/11	4801	0	0	501	408	0.0%	0.0%	44.9%
10/27	4801	4	0	661	517	0.0%	0.8%	43.9%	12/12	4801	4	0	523	440	0.0%	0.9%	45.7%
10/28	4801	0	0	254	244	0.0%	0.0%	49.0%	12/13	4801	0	0	438	368	0.0%	0.0%	45.7%
10/29	4801	4	4	1311	1162	0.3%	0.3%	47.0%	12/14	4801	0	0	436	115	0.0%	0.0%	20.9%
10/30	4801	0	56	1451	1313	3.9%	0.0%	47.5%	12/15	4801	0	0	292	182	0.0%	0.0%	38.4%
10/31	4801	12	12	1526	1315	0.8%	0.9%	46.3%	12/16	4801	4	0	202	131	0.0%	3.1%	39.3%
12/17	4801	0	0	484	420	0.0%	0.0%	46.5%	11/4	4830	12	0	1599	1283	0.0%	0.9%	44.5%
12/18	4801	8	0	464	363	0.0%	2.2%	43.9%	11/5	4830	12	0	1817	1453	0.0%	0.8%	44.4%
12/19	4801	0	0	363	251	0.0%	0.0%	40.9%	11/6	4830	16	0	1746	1582	0.0%	1.0%	47.5%
12/20	4801	4	0	362	327	0.0%	1.2%	47.5%	11/7	4830	16	0	1913	1701	0.0%	0.9%	47.1%
12/21	4801	4	0	319	128	0.0%	3.1%	28.6%	11/8	4830	8	0	1673	1492	0.0%	0.5%	47.1%
12/22	4801	0	0	146	92	0.0%	0.0%	38.7%	11/9	4830	12	0	1673	1337	0.0%	0.9%	44.4%
12/23	4801	0	0	134	166	0.0%	0.0%	55.3%	11/10	4830	0	0	1848	1553	0.0%	0.0%	45.7%
12/24	4801	0	0	181	147	0.0%	0.0%	44.8%	11/11	4830	8	0	1587	1461	0.0%	0.5%	47.9%
12/25	4801	0	0	255	138	0.0%	0.0%	35.1%	11/12	4830	16	0	1580	1416	0.0%	1.1%	47.3%
9/28	4830	16	0	1514	1401	0.0%	1.1%	48.1%	11/13	4830	28	0	2026	1738	0.0%	1.6%	46.2%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/29	4830	4	0	1716	1257	0.0%	0.3%	42.3%	11/14	4830	28	0	1718	1543	0.0%	1.8%	47.3%
9/30	4830	12	0	1617	1271	0.0%	0.9%	44.0%	11/15	4830	12	0	1728	1606	0.0%	0.7%	48.2%
10/1	4830	4	0	1722	1364	0.0%	0.3%	44.2%	11/16	4830	20	0	1728	1494	0.0%	1.3%	46.4%
10/2	4830	12	0	1915	1687	0.0%	0.7%	46.8%	11/17	4830	12	4	1656	1360	0.2%	0.9%	45.1%
10/3	4830	20	0	1725	1261	0.0%	1.6%	42.2%	11/18	4830	4	0	1838	1629	0.0%	0.2%	47.0%
10/4	4830	0	0	1877	1663	0.0%	0.0%	47.0%	11/19	4830	12	4	2200	1890	0.2%	0.6%	46.2%
10/5	4830	12	0	1507	1283	0.0%	0.9%	46.0%	11/20	4830	8	0	2280	1921	0.0%	0.4%	45.7%
10/6	4830	8	0	1661	1501	0.0%	0.5%	47.5%	11/21	4830	8	4	1907	1629	0.2%	0.5%	46.1%
10/7	4830	12	0	1734	1509	0.0%	0.8%	46.5%	11/22	4830	4	0	1977	1722	0.0%	0.2%	46.6%
10/8	4830	0	0	1830	1646	0.0%	0.0%	47.4%	11/23	4830	12	0	1811	1475	0.0%	0.8%	44.9%
10/9	4830	12	0	2128	1942	0.0%	0.6%	47.7%	11/24	4830	20	4	1891	1681	0.2%	1.2%	47.1%
10/10	4830	4	0	1963	1790	0.0%	0.2%	47.7%	11/25	4830	4	0	2084	1807	0.0%	0.2%	46.4%
10/11	4830	0	0	1725	1501	0.0%	0.0%	46.5%	11/26	4830	0	4	1921	1728	0.2%	0.0%	47.4%
10/12	4830	8	0	1689	1500	0.0%	0.5%	47.0%	11/27	4830	0	8	2253	2018	0.4%	0.0%	47.2%
10/13	4830	24	0	1675	1352	0.0%	1.8%	44.7%	11/28	4830	0	0	1798	1629	0.0%	0.0%	47.5%
10/14	4830	12	0	1551	1198	0.0%	1.0%	43.6%	11/29	4830	0	0	1940	1663	0.0%	0.0%	46.2%
10/15	4830	4	0	1677	1434	0.0%	0.3%	46.1%	11/30	4830	0	0	2017	1834	0.0%	0.0%	47.6%
10/16	4830	20	0	1884	1468	0.0%	1.4%	43.8%	12/1	4830	20	4	2244	1867	0.2%	1.1%	45.4%
10/17	4830	0	0	1922	1759	0.0%	0.0%	47.8%	12/2	4830	0	12	2363	2012	0.5%	0.0%	46.0%
10/18	4830	8	0	1659	1551	0.0%	0.5%	48.3%	12/3	4830	8	40	2141	1719	1.9%	0.5%	44.5%
10/19	4830	20	0	1539	1412	0.0%	1.4%	47.8%	12/4	4830	4	72	2620	2201	2.7%	0.2%	45.7%
10/20	4830	16	0	1882	1717	0.0%	0.9%	47.7%	12/5	4830	8	8	2212	1676	0.4%	0.5%	43.1%
10/21	4830	4	0	1489	1400	0.0%	0.3%	48.5%	12/6	4830	4	8	2212	1942	0.4%	0.2%	46.8%
10/22	4830	12	0	1555	1248	0.0%	1.0%	44.5%	12/7	4830	20	104	2094	1558	5.0%	1.3%	42.7%
10/23	4830	88	120	1614	1477	7.4%	6.0%	47.8%	12/8	4830	4	84	1959	1642	4.3%	0.2%	45.6%
10/24	4830	0	0	1632	1144	0.0%	0.0%	41.2%	12/9	4830	4	8	2228	1705	0.4%	0.2%	43.4%
10/25	4830	4	4	1950	1862	0.2%	0.2%	48.8%	12/10	4830	12	0	2351	1833	0.0%	0.7%	43.8%
10/26	4830	4	0	1649	1468	0.0%	0.3%	47.1%	12/11	4830	8	8	2243	1790	0.4%	0.4%	44.4%
10/27	4830	4	0	1734	1543	0.0%	0.3%	47.1%	12/12	4830	4	4	2179	1848	0.2%	0.2%	45.9%
10/28	4830	20	0	1489	1261	0.0%	1.6%	45.9%	12/13	4830	16	4	2195	1674	0.2%	1.0%	43.3%
10/29	4830	0	0	1737	1536	0.0%	0.0%	46.9%	12/14	4830	0	4	2193	1658	0.2%	0.0%	43.1%
10/30	4830	4	0	1806	1633	0.0%	0.2%	47.5%	12/15	4830	0	12	2221	1806	0.5%	0.0%	44.8%
10/31	4830	8	0	1780	1595	0.0%	0.5%	47.3%	12/16	4830	16	0	2282	1624	0.0%	1.0%	41.6%
11/1	4830	4	0	1808	1577	0.0%	0.3%	46.6%	12/17	4830	12	0	2275	1535	0.0%	0.8%	40.3%
11/2	4830	8	0	1617	1294	0.0%	0.6%	44.5%	12/18	4830	0	4	2304	1885	0.2%	0.0%	45.0%
11/3	4830	16	0	1681	1297	0.0%	1.2%	43.6%	12/19	4830	4	0	2008	1829	0.0%	0.2%	47.7%
12/20	4830	8	0	2166	1749	0.0%	0.5%	44.7%	11/5	5490	4	0	569	603	0.0%	0.7%	51.5%
12/21	4830	8	80	1941	1539	4.1%	0.5%	44.2%	11/6	5490	8	0	512	453	0.0%	1.8%	46.9%
12/22	4830	4	0	2142	1855	0.0%	0.2%	46.4%	11/7	5490	0	0	354	345	0.0%	0.0%	49.4%
12/23	4830	4	0	2270	1981	0.0%	0.2%	46.6%	11/8	5490	0	0	611	729	0.0%	0.0%	54.4%
12/24	4830	8	0	1667	1501	0.0%	0.5%	47.4%	11/9	5490	0	0	623	651	0.0%	0.0%	51.1%
12/25	4830	4	12	1400	1191	0.9%	0.3%	46.0%	11/10	5490	0	0	649	660	0.0%	0.0%	50.4%
12/26	4830	4	0	1615	1373	0.0%	0.3%	46.0%	11/11	5490	0	0	664	711	0.0%	0.0%	51.7%
12/27	4830	8	4	1958	1706	0.2%	0.5%	46.6%	11/12	5490	4	0	614	658	0.0%	0.6%	51.7%
9/28	5490	4	0	619	603	0.0%	0.7%	49.3%	11/13	5490	0	0	503	405	0.0%	0.0%	44.6%
9/29	5490	12	0	588	545	0.0%	2.2%	48.1%	11/14	5490	0	0	330	279	0.0%	0.0%	45.8%
9/30	5490	12	0	602	627	0.0%	1.9%	51.0%	11/15	5490	8	0	616	661	0.0%	1.2%	51.8%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/1	5490	12	0	629	572	0.0%	2.1%	47.6%	11/16	5490	8	0	616	555	0.0%	1.4%	47.4%
10/2	5490	12	0	591	551	0.0%	2.2%	48.2%	11/17	5490	4	0	658	701	0.0%	0.6%	51.6%
10/3	5490	4	0	330	304	0.0%	1.3%	47.9%	11/18	5490	4	0	510	388	0.0%	1.0%	43.2%
10/4	5490	12	0	663	526	0.0%	2.3%	44.2%	11/19	5490	0	0	629	603	0.0%	0.0%	48.9%
10/5	5490	12	0	758	766	0.0%	1.6%	50.3%	11/20	5490	4	0	436	329	0.0%	1.2%	43.0%
10/6	5490	0	0	701	669	0.0%	0.0%	48.8%	11/21	5490	0	0	369	371	0.0%	0.0%	50.1%
10/7	5490	0	0	596	586	0.0%	0.0%	49.6%	11/22	5490	8	0	608	672	0.0%	1.2%	52.5%
10/8	5490	4	0	697	674	0.0%	0.6%	49.2%	11/23	5490	4	0	613	564	0.0%	0.7%	47.9%
10/9	5490	0	0	507	467	0.0%	0.0%	47.9%	11/24	5490	4	0	634	668	0.0%	0.6%	51.3%
10/10	5490	4	0	353	337	0.0%	1.2%	48.8%	11/25	5490	4	0	555	662	0.0%	0.6%	54.4%
10/11	5490	0	0	698	636	0.0%	0.0%	47.7%	11/26	5490	0	0	613	572	0.0%	0.0%	48.3%
10/12	5490	0	0	652	482	0.0%	0.0%	42.5%	11/27	5490	4	0	475	316	0.0%	1.3%	39.9%
10/13	5490	0	0	739	683	0.0%	0.0%	48.0%	11/28	5490	4	0	356	272	0.0%	1.5%	43.3%
10/14	5490	4	0	670	477	0.0%	0.8%	41.6%	11/29	5490	12	0	610	680	0.0%	1.8%	52.7%
10/15	5490	12	0	674	651	0.0%	1.8%	49.1%	11/30	5490	4	0	624	611	0.0%	0.7%	49.5%
10/16	5490	8	0	509	408	0.0%	2.0%	44.5%	12/1	5490	8	0	650	705	0.0%	1.1%	52.0%
10/17	5490	4	0	462	422	0.0%	0.9%	47.7%	12/2	5490	0	0	692	694	0.0%	0.0%	50.1%
10/18	5490	0	0	657	596	0.0%	0.0%	47.6%	12/3	5490	0	0	691	706	0.0%	0.0%	50.5%
10/19	5490	0	0	632	611	0.0%	0.0%	49.2%	12/4	5490	4	0	463	347	0.0%	1.2%	42.8%
10/20	5490	0	0	410	288	0.0%	0.0%	41.3%	12/5	5490	0	0	352	266	0.0%	0.0%	43.0%
10/21	5490	4	0	583	527	0.0%	0.8%	47.5%	12/6	5490	0	0	628	366	0.0%	0.0%	36.8%
10/22	5490	8	0	584	689	0.0%	1.2%	54.1%	12/7	5490	8	0	630	702	0.0%	1.1%	52.7%
10/23	5490	4	0	438	385	0.0%	1.0%	46.8%	12/8	5490	8	0	655	603	0.0%	1.3%	47.9%
10/24	5490	8	0	345	307	0.0%	2.6%	47.1%	12/9	5490	4	0	673	734	0.0%	0.5%	52.2%
10/25	5490	0	0	590	602	0.0%	0.0%	50.5%	12/10	5490	4	0	617	662	0.0%	0.6%	51.8%
10/26	5490	8	0	605	608	0.0%	1.3%	50.1%	12/11	5490	4	0	488	256	0.0%	1.6%	34.4%
10/27	5490	0	0	630	598	0.0%	0.0%	48.7%	12/12	5490	0	0	336	314	0.0%	0.0%	48.3%
10/28	5490	0	0	596	539	0.0%	0.0%	47.5%	12/13	5490	0	0	377	318	0.0%	0.0%	45.8%
10/29	5490	4	0	574	606	0.0%	0.7%	51.4%	12/14	5490	8	0	595	627	0.0%	1.3%	51.3%
10/30	5490	12	0	487	477	0.0%	2.5%	49.5%	12/15	5490	0	0	606	608	0.0%	0.0%	50.1%
10/31	5490	0	0	354	346	0.0%	0.0%	49.4%	12/16	5490	4	0	579	664	0.0%	0.6%	53.4%
11/1	5490	8	0	643	636	0.0%	1.3%	49.7%	12/17	5490	8	0	693	640	0.0%	1.3%	48.0%
11/2	5490	4	0	631	591	0.0%	0.7%	48.4%	12/18	5490	4	0	556	544	0.0%	0.7%	49.5%
11/3	5490	0	0	679	591	0.0%	0.0%	46.5%	12/19	5490	0	0	366	291	0.0%	0.0%	44.3%
11/4	5490	0	4	666	721	0.6%	0.0%	52.0%	12/20	5490	4	0	665	716	0.0%	0.6%	51.8%
12/21	5490	4	0	584	617	0.0%	0.6%	51.4%	11/5	5851	12	8	1707	1528	0.5%	0.8%	47.2%
12/22	5490	12	0	640	693	0.0%	1.7%	52.0%	11/6	5851	16	0	1114	947	0.0%	1.7%	45.9%
12/23	5490	4	0	691	647	0.0%	0.6%	48.4%	11/7	5851	0	0	747	697	0.0%	0.0%	48.3%
12/24	5490	4	0	538	525	0.0%	0.8%	49.4%	11/8	5851	36	0	1825	1576	0.0%	2.3%	46.3%
12/25	5490	0	0	367	342	0.0%	0.0%	48.2%	11/9	5851	16	4	1666	1480	0.2%	1.1%	47.0%
12/26	5490	4	0	266	262	0.0%	1.5%	49.6%	11/10	5851	20	8	1600	1351	0.5%	1.5%	45.8%
12/27	5490	0	0	329	257	0.0%	0.0%	43.9%	11/11	5851	28	0	1701	1571	0.0%	1.8%	48.0%
12/28	5490	4	0	410	390	0.0%	1.0%	48.8%	11/12	5851	12	4	1714	1659	0.2%	0.7%	49.2%
9/28	5851	16	0	1697	1202	0.0%	1.3%	41.5%	11/13	5851	24	0	1056	995	0.0%	2.4%	48.5%
9/29	5851	8	4	1502	1282	0.3%	0.6%	46.0%	11/14	5851	0	8	700	530	1.1%	0.0%	43.1%
9/30	5851	20	4	1542	1359	0.3%	1.5%	46.8%	11/15	5851	32	16	1707	1538	0.9%	2.1%	47.4%
10/1	5851	8	4	1559	1193	0.3%	0.7%	43.4%	11/16	5851	4	0	1395	1220	0.0%	0.3%	46.7%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/2	5851	16	4	1204	1042	0.3%	1.5%	46.4%	11/17	5851	8	16	1781	1482	0.9%	0.5%	45.4%
10/3	5851	4	0	670	480	0.0%	0.8%	41.7%	11/18	5851	24	0	1628	1430	0.0%	1.7%	46.8%
10/4	5851	32	4	1875	1628	0.2%	2.0%	46.5%	11/19	5851	12	8	1654	1460	0.5%	0.8%	46.9%
10/5	5851	20	4	1792	1402	0.2%	1.4%	43.9%	11/20	5851	16	8	1149	1001	0.7%	1.6%	46.6%
10/6	5851	20	8	1658	1274	0.5%	1.6%	43.5%	11/21	5851	4	8	674	580	1.2%	0.7%	46.3%
10/7	5851	16	4	1633	1443	0.2%	1.1%	46.9%	11/22	5851	16	16	1871	1709	0.9%	0.9%	47.7%
10/8	5851	0	4	1426	1169	0.3%	0.0%	45.0%	11/23	5851	48	4	1929	1577	0.2%	3.0%	45.0%
10/9	5851	16	4	1196	984	0.3%	1.6%	45.1%	11/24	5851	32	8	1764	1506	0.5%	2.1%	46.1%
10/10	5851	8	0	745	597	0.0%	1.3%	44.5%	11/25	5851	20	0	1678	1544	0.0%	1.3%	47.9%
10/11	5851	12	4	1794	1488	0.2%	0.8%	45.3%	11/26	5851	16	4	1576	1439	0.3%	1.1%	47.7%
10/12	5851	12	8	1673	1307	0.5%	0.9%	43.9%	11/27	5851	24	0	1205	980	0.0%	2.4%	44.9%
10/13	5851	12	0	1641	1339	0.0%	0.9%	44.9%	11/28	5851	8	0	616	387	0.0%	2.1%	38.6%
10/14	5851	20	12	1704	1397	0.7%	1.4%	45.0%	11/29	5851	36	24	1949	1763	1.2%	2.0%	47.5%
10/15	5851	12	0	1521	1232	0.0%	1.0%	44.8%	11/30	5851	12	12	1841	1538	0.7%	0.8%	45.5%
10/16	5851	20	0	1088	902	0.0%	2.2%	45.3%	12/1	5851	36	12	1844	1598	0.7%	2.3%	46.4%
10/17	5851	4	0	675	538	0.0%	0.7%	44.4%	12/2	5851	24	24	1918	1501	1.3%	1.6%	43.9%
10/18	5851	20	4	1776	1435	0.2%	1.4%	44.7%	12/3	5851	12	16	1664	1505	1.0%	0.8%	47.5%
10/19	5851	8	20	1765	1474	1.1%	0.5%	45.5%	12/4	5851	24	4	1194	1116	0.3%	2.2%	48.3%
10/20	5851	0	0	843	533	0.0%	0.0%	38.7%	12/5	5851	8	4	636	457	0.6%	1.8%	41.8%
10/21	5851	0	0	1604	1351	0.0%	0.0%	45.7%	12/6	5851	12	4	1986	1840	0.2%	0.7%	48.1%
10/22	5851	16	8	1632	1503	0.5%	1.1%	47.9%	12/7	5851	32	20	1865	1653	1.1%	1.9%	47.0%
10/23	5851	20	0	1190	1077	0.0%	1.9%	47.5%	12/8	5851	8	24	1697	1524	1.4%	0.5%	47.3%
10/24	5851	0	0	653	639	0.0%	0.0%	49.5%	12/9	5851	36	28	1909	1750	1.5%	2.1%	47.8%
10/25	5851	32	12	1841	1635	0.7%	2.0%	47.0%	12/10	5851	24	8	1707	1248	0.5%	1.9%	42.2%
10/26	5851	4	4	1538	1292	0.3%	0.3%	45.7%	12/11	5851	0	0	1155	1034	0.0%	0.0%	47.2%
10/27	5851	16	4	1479	1375	0.3%	1.2%	48.2%	12/12	5851	24	0	760	709	0.0%	3.4%	48.3%
10/28	5851	16	0	1604	1459	0.0%	1.1%	47.6%	12/13	5851	0	0	1035	885	0.0%	0.0%	46.1%
10/29	5851	24	0	1563	1469	0.0%	1.6%	48.4%	12/14	5851	32	0	1799	1588	0.0%	2.0%	46.9%
10/30	5851	20	0	1130	940	0.0%	2.1%	45.4%	12/15	5851	16	4	1751	1592	0.2%	1.0%	47.6%
10/31	5851	0	0	706	498	0.0%	0.0%	41.4%	12/16	5851	8	16	1800	1475	0.9%	0.5%	45.0%
11/1	5851	20	4	1810	1677	0.2%	1.2%	48.1%	12/17	5851	20	28	1713	1558	1.6%	1.3%	47.6%
11/2	5851	12	8	1923	1708	0.4%	0.7%	47.0%	12/18	5851	4	4	1244	1200	0.3%	0.3%	49.1%
11/3	5851	52	0	1869	1660	0.0%	3.1%	47.0%	12/19	5851	16	0	809	715	0.0%	2.2%	46.9%
11/4	5851	40	20	1642	1491	1.2%	2.7%	47.6%	12/20	5851	8	4	1709	1601	0.2%	0.5%	48.4%
12/21	5851	12	0	1612	1579	0.0%	0.8%	49.5%	11/5	6111	6	0	449	402	0.0%	1.5%	47.2%
12/22	5851	16	16	1738	1563	0.9%	1.0%	47.3%	11/6	6111	0	0	448	417	0.0%	0.0%	48.2%
12/23	5851	4	8	1881	1768	0.4%	0.2%	48.5%	11/7	6111	6	6	408	425	1.5%	1.4%	51.0%
12/24	5851	8	0	1228	1093	0.0%	0.7%	47.1%	11/8	6111	12	0	432	368	0.0%	3.3%	46.0%
12/25	5851	4	0	618	542	0.0%	0.7%	46.7%	11/9	6111	6	0	414	330	0.0%	1.8%	44.4%
12/26	5851	0	0	570	331	0.0%	0.0%	36.7%	11/10	6111	0	0	497	319	0.0%	0.0%	39.1%
12/27	5851	8	4	1046	903	0.4%	0.9%	46.3%	11/11	6111	12	0	422	384	0.0%	3.1%	47.6%
12/28	5851	12	4	1439	1228	0.3%	1.0%	46.0%	11/12	6111	0	0	416	304	0.0%	0.0%	42.2%
9/28	6111	0	0	445	343	0.0%	0.0%	43.5%	11/13	6111	0	0	438	407	0.0%	0.0%	48.2%
9/29	6111	0	0	362	379	0.0%	0.0%	51.1%	11/14	6111	0	0	402	335	0.0%	0.0%	45.5%
9/30	6111	0	0	450	289	0.0%	0.0%	39.1%	11/15	6111	6	0	422	367	0.0%	1.6%	46.5%
10/1	6111	6	0	425	349	0.0%	1.7%	45.1%	11/16	6111	0	0	445	395	0.0%	0.0%	47.0%
10/2	6111	0	0	460	410	0.0%	0.0%	47.1%	11/17	6111	6	0	409	370	0.0%	1.6%	47.5%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/3	6111	0	0	398	329	0.0%	0.0%	45.3%	11/18	6111	0	0	425	390	0.0%	0.0%	47.9%
10/4	6111	0	0	407	376	0.0%	0.0%	48.0%	11/19	6111	0	0	443	213	0.0%	0.0%	32.5%
10/5	6111	18	0	456	458	0.0%	3.9%	50.1%	11/20	6111	12	0	428	375	0.0%	3.2%	46.7%
10/6	6111	6	0	430	378	0.0%	1.6%	46.8%	11/21	6111	0	0	442	455	0.0%	0.0%	50.7%
10/7	6111	12	0	457	423	0.0%	2.8%	48.1%	11/22	6111	0	0	427	415	0.0%	0.0%	49.3%
10/8	6111	0	0	474	341	0.0%	0.0%	41.8%	11/23	6111	0	0	434	338	0.0%	0.0%	43.8%
10/9	6111	0	0	454	369	0.0%	0.0%	44.8%	11/24	6111	0	0	398	414	0.0%	0.0%	51.0%
10/10	6111	0	0	416	399	0.0%	0.0%	49.0%	11/25	6111	0	0	455	391	0.0%	0.0%	46.2%
10/11	6111	6	0	414	340	0.0%	1.8%	45.1%	11/26	6111	12	0	428	429	0.0%	2.8%	50.1%
10/12	6111	0	0	407	438	0.0%	0.0%	51.8%	11/27	6111	0	0	441	406	0.0%	0.0%	47.9%
10/13	6111	6	0	397	321	0.0%	1.9%	44.7%	11/28	6111	0	0	427	329	0.0%	0.0%	43.5%
10/14	6111	0	0	364	289	0.0%	0.0%	44.3%	11/29	6111	6	0	426	391	0.0%	1.5%	47.9%
10/15	6111	0	0	418	336	0.0%	0.0%	44.6%	11/30	6111	12	6	399	357	1.5%	3.4%	47.2%
10/16	6111	0	0	445	474	0.0%	0.0%	51.6%	12/1	6111	0	0	414	371	0.0%	0.0%	47.3%
10/17	6111	6	0	371	369	0.0%	1.6%	49.9%	12/2	6111	6	0	423	398	0.0%	1.5%	48.5%
10/18	6111	6	0	356	318	0.0%	1.9%	47.2%	12/3	6111	6	0	455	396	0.0%	1.5%	46.5%
10/19	6111	0	0	389	425	0.0%	0.0%	52.2%	12/4	6111	6	0	489	387	0.0%	1.6%	44.2%
10/20	6111	0	0	372	320	0.0%	0.0%	46.2%	12/5	6111	6	0	425	386	0.0%	1.6%	47.6%
10/21	6111	0	0	379	332	0.0%	0.0%	46.7%	12/6	6111	6	6	498	391	1.2%	1.5%	44.0%
10/22	6111	12	0	349	332	0.0%	3.6%	48.8%	12/7	6111	0	0	521	335	0.0%	0.0%	39.1%
10/23	6111	6	0	398	308	0.0%	1.9%	43.6%	12/8	6111	6	0	443	378	0.0%	1.6%	46.0%
10/24	6111	0	0	329	299	0.0%	0.0%	47.6%	12/9	6111	0	0	386	373	0.0%	0.0%	49.1%
10/25	6111	0	0	340	333	0.0%	0.0%	49.5%	12/10	6111	12	0	477	412	0.0%	2.9%	46.3%
10/26	6111	0	0	351	349	0.0%	0.0%	49.9%	12/11	6111	6	0	393	385	0.0%	1.6%	49.5%
10/27	6111	6	0	383	332	0.0%	1.8%	46.4%	12/12	6111	6	0	378	365	0.0%	1.6%	49.1%
10/28	6111	6	0	341	334	0.0%	1.8%	49.5%	12/13	6111	0	0	401	349	0.0%	0.0%	46.5%
10/29	6111	0	0	376	304	0.0%	0.0%	44.7%	12/14	6111	0	0	453	350	0.0%	0.0%	43.6%
10/30	6111	24	0	446	251	0.0%	9.6%	36.0%	12/15	6111	0	0	460	415	0.0%	0.0%	47.4%
10/31	6111	0	0	367	250	0.0%	0.0%	40.5%	12/16	6111	0	0	400	426	0.0%	0.0%	51.6%
11/1	6111	0	0	429	291	0.0%	0.0%	40.4%	12/17	6111	0	0	475	455	0.0%	0.0%	48.9%
11/2	6111	6	0	415	318	0.0%	1.9%	43.4%	12/18	6111	0	0	410	289	0.0%	0.0%	41.3%
11/3	6111	0	0	452	229	0.0%	0.0%	33.6%	12/19	6111	0	0	452	339	0.0%	0.0%	42.9%
11/4	6111	0	0	395	366	0.0%	0.0%	48.1%	12/20	6111	6	0	508	435	0.0%	1.4%	46.1%
12/21	6111	0	0	427	404	0.0%	0.0%	48.6%	11/5	6112	6	0	692	622	0.0%	1.0%	47.3%
12/22	6111	0	0	483	408	0.0%	0.0%	45.8%	11/6	6112	12	0	680	652	0.0%	1.8%	48.9%
12/23	6111	0	0	446	379	0.0%	0.0%	45.9%	11/7	6112	0	0	590	498	0.0%	0.0%	45.8%
12/24	6111	0	0	416	387	0.0%	0.0%	48.2%	11/8	6112	12	0	800	649	0.0%	1.8%	44.8%
12/25	6111	0	0	310	251	0.0%	0.0%	44.7%	11/9	6112	6	6	685	526	0.9%	1.1%	43.4%
12/26	6111	0	0	320	229	0.0%	0.0%	41.7%	11/10	6112	0	0	735	584	0.0%	0.0%	44.3%
12/27	6111	6	0	290	214	0.0%	2.8%	42.5%	11/11	6112	0	0	735	511	0.0%	0.0%	41.0%
12/28	6111	0	0	348	363	0.0%	0.0%	51.1%	11/12	6112	18	0	1038	929	0.0%	1.9%	47.2%
9/28	6112	6	0	624	539	0.0%	1.1%	46.3%	11/13	6112	6	0	634	618	0.0%	1.0%	49.4%
9/29	6112	6	0	634	548	0.0%	1.1%	46.4%	11/14	6112	12	0	576	441	0.0%	2.7%	43.4%
9/30	6112	6	0	813	607	0.0%	1.0%	42.7%	11/15	6112	0	0	699	558	0.0%	0.0%	44.4%
10/1	6112	6	0	679	471	0.0%	1.3%	41.0%	11/16	6112	6	0	728	566	0.0%	1.1%	43.7%
10/2	6112	0	0	744	643	0.0%	0.0%	46.4%	11/17	6112	0	0	748	549	0.0%	0.0%	42.3%
10/3	6112	0	12	610	524	2.0%	0.0%	46.2%	11/18	6112	12	0	819	661	0.0%	1.8%	44.7%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/4	6112	0	6	720	654	0.8%	0.0%	47.6%	11/19	6112	0	0	701	556	0.0%	0.0%	44.2%
10/5	6112	0	0	670	508	0.0%	0.0%	43.1%	11/20	6112	0	6	657	585	0.9%	0.0%	47.1%
10/6	6112	0	0	821	473	0.0%	0.0%	36.6%	11/21	6112	12	0	572	511	0.0%	2.3%	47.2%
10/7	6112	12	0	762	569	0.0%	2.1%	42.7%	11/22	6112	0	6	731	596	0.8%	0.0%	44.9%
10/8	6112	18	0	709	619	0.0%	2.9%	46.6%	11/23	6112	6	0	696	461	0.0%	1.3%	39.8%
10/9	6112	12	0	662	606	0.0%	2.0%	47.8%	11/24	6112	6	0	954	511	0.0%	1.2%	34.9%
10/10	6112	0	6	556	497	1.1%	0.0%	47.2%	11/25	6112	18	0	692	589	0.0%	3.1%	46.0%
10/11	6112	12	0	682	613	0.0%	2.0%	47.3%	11/26	6112	12	0	758	640	0.0%	1.9%	45.8%
10/12	6112	0	0	681	556	0.0%	0.0%	44.9%	11/27	6112	0	0	638	587	0.0%	0.0%	47.9%
10/13	6112	6	12	728	605	1.6%	1.0%	45.4%	11/28	6112	0	0	593	472	0.0%	0.0%	44.3%
10/14	6112	0	0	745	498	0.0%	0.0%	40.1%	11/29	6112	0	0	690	641	0.0%	0.0%	48.2%
10/15	6112	12	0	694	507	0.0%	2.4%	42.2%	11/30	6112	0	6	720	596	0.8%	0.0%	45.3%
10/16	6112	6	0	579	543	0.0%	1.1%	48.4%	12/1	6112	18	0	819	639	0.0%	2.8%	43.8%
10/17	6112	0	0	505	552	0.0%	0.0%	52.2%	12/2	6112	12	18	683	627	2.6%	1.9%	47.9%
10/18	6112	0	0	676	607	0.0%	0.0%	47.3%	12/3	6112	0	0	709	595	0.0%	0.0%	45.6%
10/19	6112	6	0	666	587	0.0%	1.0%	46.8%	12/4	6112	0	0	738	635	0.0%	0.0%	46.2%
10/20	6112	0	0	566	531	0.0%	0.0%	48.4%	12/5	6112	18	6	583	529	1.0%	3.4%	47.6%
10/21	6112	12	0	630	594	0.0%	2.0%	48.5%	12/6	6112	6	6	710	572	0.8%	1.0%	44.6%
10/22	6112	12	0	555	424	0.0%	2.8%	43.3%	12/7	6112	12	6	789	626	0.8%	1.9%	44.2%
10/23	6112	0	0	617	548	0.0%	0.0%	47.0%	12/8	6112	0	6	759	621	0.8%	0.0%	45.0%
10/24	6112	12	0	517	482	0.0%	2.5%	48.2%	12/9	6112	6	0	834	624	0.0%	1.0%	42.8%
10/25	6112	6	0	623	485	0.0%	1.2%	43.8%	12/10	6112	0	0	995	787	0.0%	0.0%	44.2%
10/26	6112	18	0	595	538	0.0%	3.3%	47.5%	12/11	6112	0	0	1030	928	0.0%	0.0%	47.4%
10/27	6112	0	0	707	605	0.0%	0.0%	46.1%	12/12	6112	6	24	729	638	3.3%	0.9%	46.7%
10/28	6112	0	0	690	478	0.0%	0.0%	40.9%	12/13	6112	6	0	691	670	0.0%	0.9%	49.2%
10/29	6112	0	0	750	566	0.0%	0.0%	43.0%	12/14	6112	0	12	817	557	1.5%	0.0%	40.5%
10/30	6112	0	6	672	617	0.9%	0.0%	47.9%	12/15	6112	0	0	647	634	0.0%	0.0%	49.5%
10/31	6112	0	0	587	563	0.0%	0.0%	49.0%	12/16	6112	0	6	697	532	0.9%	0.0%	43.3%
11/1	6112	6	0	691	555	0.0%	1.1%	44.5%	12/17	6112	0	0	688	705	0.0%	0.0%	50.6%
11/2	6112	12	0	689	574	0.0%	2.1%	45.4%	12/18	6112	6	0	624	530	0.0%	1.1%	45.9%
11/3	6112	0	0	725	639	0.0%	0.0%	46.8%	12/19	6112	6	6	602	519	1.0%	1.2%	46.3%
11/4	6112	6	0	785	717	0.0%	0.8%	47.7%	12/20	6112	42	0	670	618	0.0%	6.8%	48.0%
12/21	6112	0	6	649	462	0.9%	0.0%	41.6%	11/5	6720	12	0	1314	1092	0.0%	1.1%	45.4%
12/22	6112	12	12	616	566	1.9%	2.1%	47.9%	11/6	6720	18	0	816	829	0.0%	2.2%	50.4%
12/23	6112	0	0	658	556	0.0%	0.0%	45.8%	11/7	6720	6	0	528	578	0.0%	1.0%	52.3%
12/24	6112	6	0	583	544	0.0%	1.1%	48.3%	11/8	6720	30	0	1204	1118	0.0%	2.7%	48.1%
12/25	6112	0	0	395	378	0.0%	0.0%	48.9%	11/9	6720	18	0	1143	1061	0.0%	1.7%	48.1%
12/26	6112	0	0	366	357	0.0%	0.0%	49.4%	11/10	6720	12	0	1104	1123	0.0%	1.1%	50.4%
12/27	6112	0	0	490	428	0.0%	0.0%	46.6%	11/11	6720	12	0	1300	1285	0.0%	0.9%	49.7%
12/28	6112	6	0	436	377	0.0%	1.6%	46.4%	11/12	6720	12	0	1227	1074	0.0%	1.1%	46.7%
9/28	6720	6	0	1754	1500	0.0%	0.4%	46.1%	11/13	6720	6	0	892	955	0.0%	0.6%	51.7%
9/29	6720	12	0	1647	1332	0.0%	0.9%	44.7%	11/14	6720	6	0	467	503	0.0%	1.2%	51.9%
9/30	6720	0	0	1751	1410	0.0%	0.0%	44.6%	11/15	6720	24	6	1224	1248	0.5%	1.9%	50.5%
10/1	6720	18	0	1845	1686	0.0%	1.1%	47.7%	11/16	6720	6	0	1274	1080	0.0%	0.6%	45.9%
10/2	6720	12	0	1530	1364	0.0%	0.9%	47.1%	11/17	6720	24	0	1173	1136	0.0%	2.1%	49.2%
10/3	6720	6	0	741	647	0.0%	0.9%	46.6%	11/18	6720	12	0	1193	1202	0.0%	1.0%	50.2%
10/4	6720	30	6	1715	1509	0.3%	2.0%	46.8%	11/19	6720	6	0	1219	1246	0.0%	0.5%	50.5%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/5	6720	18	0	1828	1548	0.0%	1.2%	45.9%	11/20	6720	24	0	816	629	0.0%	3.8%	43.5%
10/6	6720	0	0	1784	1673	0.0%	0.0%	48.4%	11/21	6720	6	0	515	489	0.0%	1.2%	48.7%
10/7	6720	18	0	1751	1560	0.0%	1.2%	47.1%	11/22	6720	12	0	1254	1203	0.0%	1.0%	49.0%
10/8	6720	12	0	1847	1587	0.0%	0.8%	46.2%	11/23	6720	18	0	1290	1194	0.0%	1.5%	48.1%
10/9	6720	6	0	1574	1518	0.0%	0.4%	49.1%	11/24	6720	0	0	1203	1155	0.0%	0.0%	49.0%
10/10	6720	24	0	742	584	0.0%	4.1%	44.0%	11/25	6720	30	0	1271	1273	0.0%	2.4%	50.0%
10/11	6720	6	0	1869	1708	0.0%	0.4%	47.7%	11/26	6720	18	6	1224	1155	0.5%	1.6%	48.5%
10/12	6720	0	0	1744	1647	0.0%	0.0%	48.6%	11/27	6720	18	0	848	787	0.0%	2.3%	48.1%
10/13	6720	6	0	1705	1394	0.0%	0.4%	45.0%	11/28	6720	12	0	433	435	0.0%	2.8%	50.1%
10/14	6720	0	0	1693	1397	0.0%	0.0%	45.2%	11/29	6720	12	0	1265	1168	0.0%	1.0%	48.0%
10/15	6720	36	0	1587	1486	0.0%	2.4%	48.4%	11/30	6720	6	0	1273	1300	0.0%	0.5%	50.5%
10/16	6720	18	0	1346	1190	0.0%	1.5%	46.9%	12/1	6720	12	0	1288	1286	0.0%	0.9%	50.0%
10/17	6720	0	0	854	688	0.0%	0.0%	44.6%	12/2	6720	12	0	1537	1361	0.0%	0.9%	47.0%
10/18	6720	24	0	1296	1211	0.0%	2.0%	48.3%	12/3	6720	6	12	1452	1387	0.8%	0.4%	48.9%
10/19	6720	6	0	1223	1235	0.0%	0.5%	50.2%	12/4	6720	0	0	895	834	0.0%	0.0%	48.2%
10/20	6720	12	0	696	501	0.0%	2.4%	41.9%	12/5	6720	0	0	546	516	0.0%	0.0%	48.6%
10/21	6720	6	0	1079	929	0.0%	0.6%	46.3%	12/6	6720	12	0	1317	1277	0.0%	0.9%	49.2%
10/22	6720	12	0	1022	896	0.0%	1.3%	46.7%	12/7	6720	24	0	1335	1078	0.0%	2.2%	44.7%
10/23	6720	12	0	892	625	0.0%	1.9%	41.2%	12/8	6720	12	0	1432	1267	0.0%	0.9%	46.9%
10/24	6720	0	0	459	487	0.0%	0.0%	51.5%	12/9	6720	12	6	1340	1324	0.4%	0.9%	49.7%
10/25	6720	18	0	1121	1144	0.0%	1.6%	50.5%	12/10	6720	12	0	1265	1189	0.0%	1.0%	48.5%
10/26	6720	12	0	1063	1009	0.0%	1.2%	48.7%	12/11	6720	18	0	906	644	0.0%	2.8%	41.5%
10/27	6720	18	0	1104	1084	0.0%	1.7%	49.5%	12/12	6720	0	0	481	459	0.0%	0.0%	48.8%
10/28	6720	6	0	991	988	0.0%	0.6%	49.9%	12/13	6720	6	0	710	729	0.0%	0.8%	50.7%
10/29	6720	0	0	1172	1200	0.0%	0.0%	50.6%	12/14	6720	6	0	1356	1242	0.0%	0.5%	47.8%
10/30	6720	6	0	874	908	0.0%	0.7%	51.0%	12/15	6720	0	6	1461	1382	0.4%	0.0%	48.6%
10/31	6720	6	0	511	553	0.0%	1.1%	52.0%	12/16	6720	24	0	1244	1267	0.0%	1.9%	50.5%
11/1	6720	0	0	1191	1089	0.0%	0.0%	47.8%	12/17	6720	6	6	1530	1476	0.4%	0.4%	49.1%
11/2	6720	18	0	1251	1303	0.0%	1.4%	51.0%	12/18	6720	0	0	902	693	0.0%	0.0%	43.4%
11/3	6720	12	0	1378	1156	0.0%	1.0%	45.6%	12/19	6720	6	0	499	554	0.0%	1.1%	52.6%
11/4	6720	0	0	1170	253	0.0%	0.0%	17.8%	12/20	6720	12	0	1417	1318	0.0%	0.9%	48.2%
12/21	6720	0	6	1428	1260	0.4%	0.0%	46.9%	11/5	6982	24	24	3158	2328	0.8%	1.0%	42.4%
12/22	6720	12	0	1370	1325	0.0%	0.9%	49.2%	11/6	6982	18	0	1847	1275	0.0%	1.4%	40.8%
12/23	6720	24	0	1311	1203	0.0%	2.0%	47.9%	11/7	6982	6	0	1520	722	0.0%	0.8%	32.2%
12/24	6720	6	0	926	873	0.0%	0.7%	48.5%	11/8	6982	42	6	2846	2201	0.2%	1.9%	43.6%
12/25	6720	0	0	455	461	0.0%	0.0%	50.3%	11/9	6982	6	6	2641	793	0.2%	0.8%	23.1%
12/26	6720	0	0	391	393	0.0%	0.0%	50.1%	11/10	6982	18	0	2604	1871	0.0%	1.0%	41.8%
12/27	6720	6	0	605	533	0.0%	0.0%	47%	11/11	6982	30	30	2967	2147	1.0%	1.4%	42.0%
12/28	6720	0	0	907	915	0.0%	0.0%	50.2%	11/12	6982	36	6	3031	2071	0.2%	1.7%	40.6%
9/28	6982	24	18	2859	2161	0.6%	1.1%	43.0%	11/13	6982	12	6	1625	626	0.4%	1.9%	27.8%
9/29	6982	30	0	2685	895	0.0%	3.4%	25.0%	11/14	6982	12	0	1600	594	0.0%	2.0%	27.1%
9/30	6982	126	18	2851	2062	0.6%	6.1%	42.0%	11/15	6982	36	6	3132	2297	0.2%	1.6%	42.3%
10/1	6982	12	12	2804	2089	0.4%	0.6%	42.7%	11/16	6982	18	18	2956	778	0.6%	2.3%	20.8%
10/2	6982	0	0	1956	608	0.0%	0.0%	23.7%	11/17	6982	24	12	2848	862	0.4%	2.8%	23.2%
10/3	6982	24	6	1677	761	0.4%	3.2%	31.2%	11/18	6982	30	42	2856	2030	1.5%	1.5%	41.5%
10/4	6982	30	36	3234	2420	1.1%	1.2%	42.8%	11/19	6982	60	54	2797	2069	1.9%	2.9%	42.5%
10/5	6982	48	48	3068	2296	1.6%	2.1%	42.8%	11/20	6982	36	12	2168	1458	0.6%	2.5%	40.2%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
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						PCB	PHD								PCB	PHD	
10/6	6982	30	36	3024	2274	1.2%	1.3%	42.9%	11/21	6982	18	0	1718	747	0.0%	2.4%	30.3%
10/7	6982	30	54	3236	2316	1.7%	1.3%	41.7%	11/22	6982	24	30	3216	1830	0.9%	1.3%	36.3%
10/8	6982	18	60	3274	2449	1.8%	0.7%	42.8%	11/23	6982	6	18	3145	2202	0.6%	0.3%	41.2%
10/9	6982	48	0	2152	1536	0.0%	3.1%	41.6%	11/24	6982	36	54	2924	2196	1.8%	1.6%	42.9%
10/10	6982	12	6	1708	581	0.4%	2.1%	25.4%	11/25	6982	24	30	2919	2199	1.0%	1.1%	43.0%
10/11	6982	36	36	3074	2309	1.2%	1.6%	42.9%	11/26	6982	18	42	2810	2132	1.5%	0.8%	43.1%
10/12	6982	24	54	3236	2311	1.7%	1.0%	41.7%	11/27	6982	6	0	1731	1273	0.0%	0.5%	42.4%
10/13	6982	12	12	2888	823	0.4%	1.5%	22.2%	11/28	6982	24	0	1426	694	0.0%	3.5%	32.7%
10/14	6982	42	24	2766	1933	0.9%	2.2%	41.1%	11/29	6982	36	108	3251	2404	3.3%	1.5%	42.5%
10/15	6982	24	36	3270	2432	1.1%	1.0%	42.7%	11/30	6982	18	24	2646	944	0.9%	1.9%	26.3%
10/16	6982	18	0	2099	1537	0.0%	1.2%	42.3%	12/1	6982	42	12	3034	2274	0.4%	1.8%	42.8%
10/17	6982	12	0	1757	721	0.0%	1.7%	29.1%	12/2	6982	24	0	2808	851	0.0%	2.8%	23.3%
10/18	6982	60	66	3418	2555	1.9%	2.3%	42.8%	12/3	6982	48	36	3000	1897	1.2%	2.5%	38.7%
10/19	6982	24	96	3141	2298	3.1%	1.0%	42.3%	12/4	6982	18	6	1846	1402	0.3%	1.3%	43.2%
10/20	6982	18	12	2986	1309	0.4%	1.4%	99.8%	12/5	6982	36	0	1618	701	0.0%	5.1%	30.2%
10/21	6982	30	24	2949	2201	0.8%	1.4%	42.7%	12/6	6982	24	6	3301	2172	0.2%	1.1%	39.7%
10/22	6982	42	42	3096	2261	1.4%	1.9%	42.2%	12/7	6982	24	18	2971	2028	0.6%	1.2%	40.6%
10/23	6982	24	0	1956	1117	0.0%	2.1%	36.3%	12/8	6982	24	24	2914	1976	0.8%	1.2%	40.4%
10/24	6982	18	0	1585	700	0.0%	2.6%	30.6%	12/9	6982	30	6	2631	1836	0.2%	1.6%	41.1%
10/25	6982	6	0	3240	2397	0.0%	0.3%	42.5%	12/10	6982	48	0	2899	2162	0.0%	2.2%	42.7%
10/26	6982	18	0	2676	780	0.0%	2.3%	22.6%	12/11	6982	18	6	1893	1154	0.3%	1.6%	37.9%
10/27	6982	6	0	2586	1726	0.0%	0.3%	40.0%	12/12	6982	18	0	1274	712	0.0%	2.5%	35.9%
10/28	6982	12	0	2713	1871	0.0%	0.6%	40.8%	12/13	6982	24	0	1575	902	0.0%	2.7%	36.4%
10/29	6982	0	60	2960	2202	2.0%	0.0%	42.7%	12/14	6982	0	18	3071	2157	0.6%	0.0%	41.3%
10/30	6982	18	0	1964	1094	0.0%	1.6%	35.8%	12/15	6982	12	54	3056	2165	1.8%	0.6%	41.5%
10/31	6982	42	0	1700	1070	0.0%	3.9%	38.6%	12/16	6982	66	24	2980	2063	0.8%	3.2%	40.9%
11/1	6982	42	30	3218	2352	0.9%	1.8%	42.2%	12/17	6982	36	6	2847	1992	0.2%	1.8%	41.2%
11/2	6982	18	18	2948	2112	0.6%	0.9%	41.7%	12/18	6982	24	0	1684	1182	0.0%	2.0%	41.2%
11/3	6982	0	12	2677	910	0.4%	0.0%	25.4%	12/19	6982	6	6	1497	746	0.4%	0.8%	33.3%
11/4	6982	24	0	2654	849	0.0%	2.8%	24.2%	12/20	6982	54	30	3044	1977	1.0%	2.7%	39.4%
12/21	6982	36	30	2795	2017	1.1%	1.8%	41.9%	11/5	7490	4	12	1694	1338	0.7%	0.3%	44.1%
12/22	6982	12	18	2590	1908	0.7%	0.6%	42.4%	11/6	7490	8	8	2030	1711	0.4%	0.5%	45.7%
12/23	6982	18	60	2533	1748	2.4%	1.0%	40.8%	11/7	7490	0	0	1469	1006	0.0%	0.0%	40.6%
12/24	6982	12	18	2215	1490	0.8%	0.8%	40.2%	11/8	7490	4	0	1416	1074	0.0%	0.4%	43.1%
12/25	6982	18	0	1274	867	0.0%	2.1%	40.5%	11/9	7490	12	4	1381	1086	0.3%	1.1%	44.0%
12/26	6982	12	0	1122	413	0.0%	2.9%	26.9%	11/10	7490	20	0	1379	1039	0.0%	1.9%	43.0%
12/27	6982	6	0	1790	1196	0.0%	0.5%	40.1%	11/11	7490	4	0	1435	1117	0.0%	0.4%	43.8%
12/28	6982	18	24	2301	1577	1.0%	1.1%	40.7%	11/12	7490	20	0	1854	1314	0.0%	1.5%	41.5%
9/28	7490	12	0	1343	942	0.0%	1.3%	41.2%	11/13	7490	8	0	1677	1304	0.0%	0.6%	43.7%
9/29	7490	4	0	1285	727	0.0%	0.6%	36.1%	11/14	7490	4	0	1438	1091	0.0%	0.4%	43.1%
9/30	7490	16	0	1366	1027	0.0%	1.6%	42.9%	11/15	7490	4	0	1827	1383	0.0%	0.3%	43.1%
10/1	7490	4	0	1397	1098	0.0%	0.4%	44.0%	11/16	7490	8	16	2038	1634	0.8%	0.5%	44.5%
10/2	7490	12	0	1792	1268	0.0%	0.9%	41.4%	11/17	7490	8	0	1618	1330	0.0%	0.6%	45.1%
10/3	7490	4	0	1298	953	0.0%	0.4%	42.3%	11/18	7490	4	0	1519	1185	0.0%	0.3%	43.8%
10/4	7490	0	0	1440	902	0.0%	0.0%	38.5%	11/19	7490	0	12	1347	1003	0.9%	0.0%	42.7%
10/5	7490	24	0	1410	1070	0.0%	2.2%	43.1%	11/20	7490	0	0	1515	1211	0.0%	0.0%	44.4%
10/6	7490	8	0	1478	982	0.0%	0.8%	39.9%	11/21	7490	4	0	1193	925	0.0%	0.4%	43.7%

NON BUSY HOUR DATA ANALYSIS FOR OPERATOR ONE- NAIROBI TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/7	7490	8	0	1325	1029	0.0%	0.8%	43.7%	11/22	7490	0	4	1432	849	0.3%	0.0%	37.2%
10/8	7490	4	0	1453	1066	0.0%	0.4%	42.3%	11/23	7490	4	0	1352	831	0.0%	0.5%	38.1%
10/9	7490	8	0	1527	1142	0.0%	0.7%	42.8%	11/24	7490	4	4	1434	1027	0.3%	0.4%	41.7%
10/10	7490	0	0	1248	875	0.0%	0.0%	41.2%	11/25	7490	0	0	1322	911	0.0%	0.0%	40.8%
10/11	7490	8	0	1460	1098	0.0%	0.7%	42.9%	11/26	7490	28	0	1454	1206	0.0%	2.3%	45.3%
10/12	7490	4	0	1848	1197	0.0%	0.3%	39.3%	11/27	7490	8	0	1481	1114	0.0%	0.7%	42.9%
10/13	7490	12	0	1517	1054	0.0%	1.1%	41.0%	11/28	7490	4	0	1179	929	0.0%	0.4%	44.1%
10/14	7490	0	0	1739	1143	0.0%	0.0%	39.7%	11/29	7490	0	0	1264	944	0.0%	0.0%	42.8%
10/15	7490	0	4	1463	1047	0.3%	0.0%	41.7%	11/30	7490	4	0	1463	855	0.0%	0.5%	36.9%
10/16	7490	8	0	1623	1137	0.0%	0.7%	41.2%	12/1	7490	0	8	1453	1128	0.6%	0.0%	43.7%
10/17	7490	4	0	1373	868	0.0%	0.5%	38.7%	12/2	7490	4	0	1475	1108	0.0%	0.4%	42.9%
10/18	7490	4	0	1398	1018	0.0%	0.4%	42.1%	12/3	7490	4	0	1486	639	0.0%	0.6%	30.1%
10/19	7490	0	0	1503	1058	0.0%	0.0%	41.3%	12/4	7490	8	0	1717	1339	0.0%	0.6%	43.8%
10/20	7490	4	0	1324	1027	0.0%	0.4%	43.7%	12/5	7490	4	0	1344	1033	0.0%	0.4%	43.5%
10/21	7490	8	0	1376	1104	0.0%	0.7%	44.5%	12/6	7490	8	0	1576	1141	0.0%	0.7%	42.0%
10/22	7490	8	12	1525	1256	0.8%	0.6%	45.2%	12/7	7490	0	0	1418	1105	0.0%	0.0%	43.8%
10/23	7490	4	0	1745	1236	0.0%	0.3%	41.5%	12/8	7490	8	0	1458	1093	0.0%	0.7%	42.8%
10/24	7490	0	0	1443	1136	0.0%	0.0%	44.0%	12/9	7490	0	0	1386	1148	0.0%	0.0%	45.3%
10/25	7490	12	0	1514	1115	0.0%	1.1%	42.4%	12/10	7490	4	0	1455	1118	0.0%	0.4%	43.5%
10/26	7490	4	0	1428	1119	0.0%	0.4%	43.9%	12/11	7490	0	0	1795	1013	0.0%	0.0%	36.1%
10/27	7490	4	0	1504	1079	0.0%	0.4%	41.8%	12/12	7490	4	0	1262	870	0.0%	0.5%	40.8%
10/28	7490	4	0	1660	1330	0.0%	0.3%	44.5%	12/13	7490	4	4	1274	670	0.3%	0.6%	34.5%
10/29	7490	12	0	1594	1303	0.0%	0.9%	45.0%	12/14	7490	8	8	1482	1206	0.5%	0.7%	44.9%
10/30	7490	8	0	1625	1318	0.0%	0.6%	44.8%	12/15	7490	24	0	1497	1115	0.0%	2.2%	42.7%
10/31	7490	8	4	2095	1731	0.2%	0.5%	45.2%	12/16	7490	4	0	1404	1149	0.0%	0.3%	45.0%
11/1	7490	8	0	1549	1199	0.0%	0.7%	43.6%	12/17	7490	0	0	1451	1209	0.0%	0.0%	45.5%
11/2	7490	4	0	1524	1191	0.0%	0.3%	43.9%	12/18	7490	12	0	1524	1146	0.0%	1.0%	42.9%
11/3	7490	12	0	1706	1160	0.0%	1.0%	40.5%	12/19	7490	4	0	1224	995	0.0%	0.4%	44.8%
11/4	7490	4	4	1801	1420	0.2%	0.3%	44.1%	12/20	7490	12	0	1593	1091	0.0%	1.1%	40.6%
12/21	7490	12	0	1616	1348	0.0%	0.9%	45.5%	12/25	7490	0	0	1121	923	0.0%	0.0%	45.2%
12/22	7490	8	0	1490	1203	0.0%	0.7%	44.7%	12/26	7490	0	0	1071	789	0.0%	0.0%	42.4%
12/23	7490	8	4	1662	1231	0.2%	0.6%	42.6%	12/27	7490	12	0	1028	787	0.0%	1.5%	43.4%
12/24	7490	12	0	1684	1324	0.0%	0.9%	44.0%	12/28	7490	12	0	1267	992	0.0%	1.2%	43.9%
																	HO/CP
					NTCHD		NCB		NCS		NHO				PCB	PHD	
AVERAGES					11.855705		6.31711409		1375.631711		1066.891779				0.5%	1.1%	43.7%
OVERALL AREA GRADE OF SERVICE										**0.74%**							

Table A2.4 Basic analysis of Operator One non Busy Hour data for Nakuru Town

NON BH DATA ANALYSIS FOR OPERATOR ONE- NAKURU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/28	13890	32	0	2223	1985	0.0%	1.6%	47.2%	11/13	13890	0	0	2139	1792	0.0%	0.0%	45.6%
9/29	13890	16	0	2588	2239	0.0%	0.7%	46.4%	11/14	13890	0	0	1215	555	0.0%	0.0%	31.4%
9/30	13890	12	0	2205	1830	0.0%	0.7%	45.4%	11/15	13890	12	0	2489	2189	0.0%	0.5%	46.8%
10/1	13890	8	0	2309	1995	0.0%	0.4%	46.4%	11/16	13890	4	0	2435	2129	0.0%	0.2%	46.6%
10/2	13890	8	0	2227	2024	0.0%	0.4%	47.6%	11/17	13890	8	0	2735	2386	0.0%	0.3%	46.6%
10/3	13890	0	0	1189	972	0.0%	0.0%	45.0%	11/18	13890	0	0	2733	2342	0.0%	0.0%	46.1%
10/4	13890	8	0	2723	2337	0.0%	0.3%	46.2%	11/19	13890	8	0	2420	2026	0.0%	0.4%	45.6%
10/5	13890	4	0	2492	2219	0.0%	0.2%	47.1%	11/20	13890	8	0	2119	1734	0.0%	0.5%	45.0%
10/6	13890	8	0	2387	1745	0.0%	0.5%	42.2%	11/21	13890	4	0	1254	1023	0.0%	0.4%	44.9%
10/7	13890	12	0	2487	2086	0.0%	0.6%	45.6%	11/22	13890	0	0	2279	1906	0.0%	0.0%	45.5%
10/8	13890	12	0	2464	2019	0.0%	0.6%	45.0%	11/23	13890	8	0	2157	1837	0.0%	0.4%	46.0%
10/9	13890	16	0	2289	1824	0.0%	0.9%	44.3%	11/24	13890	0	0	2521	2136	0.0%	0.0%	45.9%
10/10	13890	0	0	1425	1208	0.0%	0.0%	45.9%	11/25	13890	4	0	2614	2057	0.0%	0.2%	44.0%
10/11	13890	8	0	2663	2273	0.0%	0.4%	46.0%	11/26	13890	4	0	2447	2103	0.0%	0.2%	46.2%
10/12	13890	16	0	2964	2527	0.0%	0.6%	46.0%	11/27	13890	12	0	2069	1838	0.0%	0.7%	47.0%
10/13	13890	0	0	2949	2395	0.0%	0.0%	44.8%	11/28	13890	4	0	1092	495	0.0%	0.8%	31.2%
10/14	13890	8	0	2458	2113	0.0%	0.4%	46.2%	11/29	13890	8	0	2570	2186	0.0%	0.4%	46.0%
10/15	13890	8	0	2568	2187	0.0%	0.4%	46.0%	11/30	13890	0	0	2765	2194	0.0%	0.0%	44.2%
10/16	13890	12	0	2485	2057	0.0%	0.6%	45.3%	12/1	13890	4	0	2618	2203	0.0%	0.2%	45.7%
10/17	13890	0	0	1365	461	0.0%	0.0%	25.2%	12/2	13890	16	0	2642	2368	0.0%	0.7%	47.3%
10/18	13890	12	0	2513	2183	0.0%	0.5%	46.5%	12/3	13890	8	0	2862	2531	0.0%	0.3%	46.9%
10/19	13890	16	0	2422	2104	0.0%	0.8%	46.5%	12/4	13890	8	0	2378	2047	0.0%	0.4%	46.3%
10/20	13890	0	0	1843	1513	0.0%	0.0%	45.1%	12/5	13890	0	0	1216	1032	0.0%	0.0%	45.9%
10/21	13890	0	0	2537	1915	0.0%	0.0%	43.0%	12/6	13890	16	0	2525	1946	0.0%	0.8%	43.5%
10/22	13890	8	0	2249	1928	0.0%	0.4%	46.2%	12/7	13890	12	0	2880	2487	0.0%	0.5%	46.3%
10/23	13890	16	0	1958	1554	0.0%	1.0%	44.2%	12/8	13890	4	0	2561	2229	0.0%	0.2%	46.5%
10/24	13890	0	0	1063	873	0.0%	0.0%	45.1%	12/9	13890	4	0	2779	2394	0.0%	0.2%	46.3%
10/25	13890	8	0	2563	2288	0.0%	0.3%	47.2%	12/10	13890	4	0	2658	2314	0.0%	0.2%	46.5%
10/26	13890	12	0	2246	2018	0.0%	0.6%	47.3%	12/11	13890	4	0	2237	1931	0.0%	0.2%	46.3%
10/27	13890	4	0	2236	2021	0.0%	0.2%	47.5%	12/12	13890	8	0	1213	916	0.0%	0.9%	43.0%
10/28	13890	4	0	2505	2043	0.0%	0.2%	44.9%	12/13	13890	4	0	1980	1705	0.0%	0.2%	46.3%
10/29	13890	8	0	2672	2328	0.0%	0.3%	46.6%	12/14	13890	4	0	2514	2156	0.0%	0.2%	46.2%
10/30	13890	16	0	2187	1705	0.0%	0.9%	43.8%	12/15	13890	8	0	2218	1711	0.0%	0.5%	43.5%
10/31	13890	4	0	1148	218	0.0%	1.8%	16.0%	12/16	13890	8	0	2400	2089	0.0%	0.4%	46.5%
11/1	13890	0	0	2490	2130	0.0%	0.0%	46.1%	12/17	13890	12	0	2609	2213	0.0%	0.5%	45.9%
11/2	13890	12	0	2709	2394	0.0%	0.5%	46.9%	12/18	13890	12	0	2297	1985	0.0%	0.6%	46.4%
11/3	13890	8	0	2622	2211	0.0%	0.4%	45.7%	12/19	13890	12	0	1193	996	0.0%	1.2%	45.5%
11/4	13890	0	0	2313	1852	0.0%	0.0%	44.5%	12/20	13890	4	0	2767	2408	0.0%	0.2%	46.5%
11/5	13890	8	0	2836	2408	0.0%	0.3%	45.9%	12/21	13890	8	0	2528	2182	0.0%	0.4%	46.3%
11/6	13890	0	0	2856	2406	0.0%	0.0%	45.7%	12/22	13890	20	0	2184	1861	0.0%	1.1%	46.0%
11/7	13890	4	0	1073	868	0.0%	0.5%	44.7%	12/23	13890	4	0	2395	2027	0.0%	0.2%	45.8%
11/8	13890	8	0	2471	2194	0.0%	0.4%	47.0%	12/24	13890	16	0	2498	2186	0.0%	0.7%	46.7%
11/9	13890	20	0	2192	1889	0.0%	1.1%	46.3%	12/25	13890	4	0	840	711	0.0%	0.6%	45.8%
11/10	13890	12	0	2456	2060	0.0%	0.6%	45.6%	12/26	13890	4	0	790	685	0.0%	0.6%	46.4%
11/11	13890	4	0	2395	2089	0.0%	0.2%	46.6%	12/27	13890	12	0	1990	1620	0.0%	0.7%	44.9%

NON BH DATA ANALYSIS FOR OPERATOR ONE- NAKURU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
11/12	13890	0	0	2528	2193	0.0%	0.0%	46.5%	12/28	13890	24	0	1990	1689	0.0%	1.4%	45.9%
9/28	13935	0	0	152	181	0.0%	0.0%	54.4%	11/13	13935	0	0	208	175	0.0%	0.0%	45.7%
9/29	13935	4	0	245	250	0.0%	1.6%	50.5%	11/14	13935	0	0	246	227	0.0%	0.0%	48.0%
9/30	13935	0	0	136	183	0.0%	0.0%	57.4%	11/15	13935	0	0	223	311	0.0%	0.0%	58.2%
10/1	13935	0	0	181	137	0.0%	0.0%	43.1%	11/16	13935	0	0	267	299	0.0%	0.0%	52.8%
10/2	13935	12	0	163	164	0.0%	7.3%	50.2%	11/17	13935	4	0	242	237	0.0%	1.7%	49.5%
10/3	13935	0	0	168	279	0.0%	0.0%	62.4%	11/18	13935	0	0	213	305	0.0%	0.0%	58.9%
10/4	13935	0	0	197	243	0.0%	0.0%	55.2%	11/19	13935	0	0	198	299	0.0%	0.0%	60.2%
10/5	13935	4	0	199	241	0.0%	1.7%	54.8%	11/20	13935	0	0	177	205	0.0%	0.0%	53.7%
10/6	13935	0	0	215	241	0.0%	0.0%	52.9%	11/21	13935	4	0	193	221	0.0%	1.8%	53.4%
10/7	13935	0	0	184	190	0.0%	0.0%	50.8%	11/22	13935	4	0	189	239	0.0%	1.7%	55.8%
10/8	13935	8	0	178	247	0.0%	3.2%	58.1%	11/23	13935	0	0	226	190	0.0%	0.0%	45.7%
10/9	13935	0	0	171	278	0.0%	0.0%	61.9%	11/24	13935	4	0	193	224	0.0%	1.8%	53.7%
10/10	13935	0	0	160	151	0.0%	0.0%	48.6%	11/25	13935	0	0	192	219	0.0%	0.0%	53.3%
10/11	13935	0	0	199	210	0.0%	0.0%	51.3%	11/26	13935	0	0	184	203	0.0%	0.0%	52.5%
10/12	13935	0	0	155	201	0.0%	0.0%	56.5%	11/27	13935	4	0	187	257	0.0%	1.6%	57.9%
10/13	13935	0	0	182	216	0.0%	0.0%	54.3%	11/28	13935	0	0	167	182	0.0%	0.0%	52.1%
10/14	13935	0	0	178	205	0.0%	0.0%	53.5%	11/29	13935	0	0	176	181	0.0%	0.0%	50.7%
10/15	13935	0	0	161	269	0.0%	0.0%	62.6%	11/30	13935	4	0	188	240	0.0%	1.7%	56.1%
10/16	13935	0	0	172	233	0.0%	0.0%	57.5%	12/1	13935	0	0	185	179	0.0%	0.0%	49.2%
10/17	13935	0	0	174	210	0.0%	0.0%	54.7%	12/2	13935	0	0	205	241	0.0%	0.0%	54.0%
10/18	13935	4	0	168	227	0.0%	1.8%	57.5%	12/3	13935	0	0	179	266	0.0%	0.0%	59.8%
10/19	13935	0	0	175	206	0.0%	0.0%	54.1%	12/4	13935	0	0	193	254	0.0%	0.0%	56.8%
10/20	13935	0	0	178	246	0.0%	0.0%	58.0%	12/5	13935	0	0	238	242	0.0%	0.0%	50.4%
10/21	13935	0	0	264	270	0.0%	0.0%	50.6%	12/6	13935	4	0	242	312	0.0%	1.3%	56.3%
10/22	13935	0	0	182	265	0.0%	0.0%	59.3%	12/7	13935	4	0	238	312	0.0%	1.3%	56.7%
10/23	13935	0	0	208	182	0.0%	0.0%	46.7%	12/8	13935	0	0	237	238	0.0%	0.0%	50.1%
10/24	13935	0	0	211	176	0.0%	0.0%	45.5%	12/9	13935	0	0	237	305	0.0%	0.0%	56.3%
10/25	13935	0	0	183	217	0.0%	0.0%	54.3%	12/10	13935	0	0	211	219	0.0%	0.0%	50.9%
10/26	13935	0	0	159	218	0.0%	0.0%	57.8%	12/11	13935	0	0	264	189	0.0%	0.0%	41.7%
10/27	13935	0	0	202	244	0.0%	0.0%	54.7%	12/12	13935	4	0	168	219	0.0%	1.8%	56.6%
10/28	13935	0	0	190	214	0.0%	0.0%	53.0%	12/13	13935	0	0	221	210	0.0%	0.0%	48.7%
10/29	13935	0	0	217	205	0.0%	0.0%	48.6%	12/14	13935	0	0	231	172	0.0%	0.0%	42.7%
10/30	13935	0	0	215	202	0.0%	0.0%	48.4%	12/15	13935	0	0	225	237	0.0%	0.0%	51.3%
10/31	13935	4	0	163	223	0.0%	1.8%	57.8%	12/16	13935	0	0	215	258	0.0%	0.0%	54.5%
11/1	13935	0	0	182	199	0.0%	0.0%	52.2%	12/17	13935	0	0	264	199	0.0%	0.0%	43.0%
11/2	13935	0	0	166	255	0.0%	0.0%	60.6%	12/18	13935	0	0	228	286	0.0%	0.0%	55.6%
11/3	13935	4	0	162	195	0.0%	2.1%	54.6%	12/19	13935	0	0	194	202	0.0%	0.0%	51.0%
11/4	13935	0	0	173	228	0.0%	0.0%	56.9%	12/20	13935	0	0	197	269	0.0%	0.0%	57.7%
11/5	13935	0	0	174	236	0.0%	0.0%	57.6%	12/21	13935	0	0	224	225	0.0%	0.0%	50.1%
11/6	13935	0	0	204	211	0.0%	0.0%	50.8%	12/22	13935	0	0	198	217	0.0%	0.0%	52.3%
11/7	13935	0	0	184	195	0.0%	0.0%	51.5%	12/23	13935	0	0	207	183	0.0%	0.0%	46.9%
11/8	13935	0	0	197	240	0.0%	0.0%	54.9%	12/24	13935	0	0	224	298	0.0%	0.0%	57.1%
11/9	13935	0	0	165	260	0.0%	0.0%	61.2%	12/25	13935	0	0	281	186	0.0%	0.0%	39.8%
11/10	13935	0	0	235	240	0.0%	0.0%	50.5%	12/26	13935	0	0	185	178	0.0%	0.0%	49.0%
11/11	13935	0	0	177	269	0.0%	0.0%	60.3%	12/27	13935	4	0	214	238	0.0%	1.7%	52.7%
11/12	13935	0	0	215	232	0.0%	0.0%	51.9%	12/28	13935	0	0	230	242	0.0%	0.0%	51.3%

NON BH DATA ANALYSIS FOR OPERATOR ONE- NAKURU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/28	30086	16	108	670	1174	16%	1.4%	63.7%	11/13	30086	0	0	889	1274	0.0%	0.0%	58.9%
9/29	30086	20	56	799	1337	7.0%	1.5%	62.6%	11/14	30086	16	0	968	1457	0.0%	1.1%	60.1%
9/30	30086	28	56	879	1341	6.4%	2.1%	60.4%	11/15	30086	12	0	943	1474	0.0%	0.8%	61.0%
10/1	30086	16	124	1025	1338	12%	1.2%	56.6%	11/16	30086	16	0	854	1366	0.0%	1.2%	61.5%
10/2	30086	24	56	833	1289	6.7%	1.9%	60.7%	11/17	30086	8	0	924	1484	0.0%	0.5%	61.6%
10/3	30086	4	100	761	1236	13%	0.3%	61.9%	11/18	30086	20	0	817	1325	0.0%	1.5%	61.9%
10/4	30086	32	132	964	1346	14%	2.4%	58.3%	11/19	30086	12	0	876	1349	0.0%	0.9%	60.6%
10/5	30086	8	0	760	1277	0.0%	0.6%	62.7%	11/20	30086	20	0	938	1311	0.0%	1.5%	58.3%
10/6	30086	24	8	785	1374	1.0%	1.7%	63.6%	11/21	30086	24	0	948	1317	0.0%	1.8%	58.1%
10/7	30086	12	28	874	1300	3.2%	0.9%	59.8%	11/22	30086	8	0	977	1499	0.0%	0.5%	60.5%
10/8	30086	16	92	830	1284	11%	1.2%	60.7%	11/23	30086	28	0	900	1419	0.0%	2.0%	61.2%
10/9	30086	20	8	861	1278	0.9%	1.6%	59.7%	11/24	30086	40	0	882	1465	0.0%	2.7%	62.4%
10/10	30086	40	328	1045	1361	31%	2.9%	56.6%	11/25	30086	4	0	907	1519	0.0%	0.3%	62.6%
10/11	30086	12	48	828	1252	5.8%	1.0%	60.2%	11/26	30086	12	0	869	1363	0.0%	0.9%	61.1%
10/12	30086	24	24	831	1412	2.9%	1.7%	63.0%	11/27	30086	4	0	909	1406	0.0%	0.3%	60.7%
10/13	30086	12	140	903	1373	16%	0.9%	60.3%	11/28	30086	16	0	1158	1377	0.0%	1.2%	54.3%
10/14	30086	12	200	822	1288	24%	0.9%	61.0%	11/29	30086	12	0	973	1441	0.0%	0.8%	59.7%
10/15	30086	20	28	849	1259	3.3%	1.6%	59.7%	11/30	30086	32	0	978	1395	0.0%	2.3%	58.8%
10/16	30086	20	12	803	1290	1.5%	1.6%	61.6%	12/1	30086	0	4	942	1594	0.4%	0.0%	62.9%
10/17	30086	28	72	853	1381	8.4%	2.0%	61.8%	12/2	30086	8	16	796	1373	2.0%	0.6%	63.3%
10/18	30086	24	12	776	1272	1.5%	1.9%	62.1%	12/3	30086	24	4	926	1454	0.4%	1.7%	61.1%
10/19	30086	32	208	750	1282	28%	2.5%	63.1%	12/4	30086	8	0	926	1400	0.0%	0.6%	60.2%
10/20	30086	16	32	782	1425	4.1%	1.1%	64.6%	12/5	30086	8	0	889	1432	0.0%	0.6%	61.7%
10/21	30086	24	36	749	1308	4.8%	1.8%	63.6%	12/6	30086	20	0	1021	1535	0.0%	1.3%	60.1%
10/22	30086	8	0	842	1415	0.0%	0.6%	62.7%	12/7	30086	4	0	958	1372	0.0%	0.3%	58.9%
10/23	30086	24	0	716	1222	0.0%	2.0%	63.1%	12/8	30086	20	0	1008	1468	0.0%	1.4%	59.3%
10/24	30086	12	0	876	1277	0.0%	0.9%	59.3%	12/9	30086	12	12	959	1453	1.3%	0.8%	60.2%
10/25	30086	16	0	756	1233	0.0%	1.3%	62.0%	12/10	30086	20	4	901	1596	0.4%	1.3%	63.9%
10/26	30086	8	0	801	1219	0.0%	0.7%	60.3%	12/11	30086	8	0	1053	1562	0.0%	0.5%	59.7%
10/27	30086	24	0	746	1182	0.0%	2.0%	61.3%	12/12	30086	4	4	1044	1525	0.4%	0.3%	59.4%
10/28	30086	24	0	741	1319	0.0%	1.8%	64.0%	12/13	30086	4	0	899	1380	0.0%	0.3%	60.6%
10/29	30086	20	0	835	1283	0.0%	1.6%	60.6%	12/14	30086	12	0	884	1426	0.0%	0.8%	61.7%
10/30	30086	20	0	959	1295	0.0%	1.5%	57.5%	12/15	30086	4	0	911	1422	0.0%	0.3%	61.0%
10/31	30086	20	0	863	1456	0.0%	1.4%	62.8%	12/16	30086	0	20	999	1440	2.0%	0.0%	59.0%
11/1	30086	28	0	931	1395	0.0%	2.0%	60.0%	12/17	30086	8	0	1082	1538	0.0%	0.5%	58.7%
11/2	30086	24	0	733	1377	0.0%	1.7%	65.3%	12/18	30086	4	8	1058	1616	0.8%	0.2%	60.4%
11/3	30086	36	0	775	1321	0.0%	2.7%	63.0%	12/19	30086	8	4	1015	1614	0.4%	0.5%	61.4%
11/4	30086	0	0	772	1400	0.0%	0.0%	64.5%	12/20	30086	4	0	959	1647	0.0%	0.2%	63.2%
11/5	30086	4	0	883	1270	0.0%	0.3%	59.0%	12/21	30086	8	0	922	1339	0.0%	0.6%	59.2%
11/6	30086	20	0	929	1426	0.0%	1.4%	60.6%	12/22	30086	4	0	1016	1421	0.0%	0.3%	58.3%
11/7	30086	12	0	891	1344	0.0%	0.9%	60.1%	12/23	30086	20	4	1027	1429	0.4%	1.4%	58.2%
11/8	30086	12	0	809	1388	0.0%	0.9%	63.2%	12/24	30086	4	0	1213	1389	0.0%	0.3%	53.4%
11/9	30086	8	0	859	1432	0.0%	0.6%	62.5%	12/25	30086	12	0	1126	1397	0.0%	0.9%	55.4%
11/10	30086	24	0	1362	1379	0.0%	1.7%	50.3%	12/26	30086	16	0	846	1188	0.0%	1.3%	58.4%
11/11	30086	4	4	812	1537	0.5%	0.3%	65.4%	12/27	30086	12	0	911	1402	0.0%	0.9%	60.6%
11/12	30086	16	0	897	1398	0.0%	1.1%	60.9%	12/28	30086	16	0	955	1450	0.0%	1.1%	60.3%
9/28	30495	0	0	58	93	0.0%	0.0%	61.6%	11/13	30495	0	0	68	65	0.0%	0.0%	48.9%

NON BH DATA ANALYSIS FOR OPERATOR ONE- NAKURU TOWN																	
Date	CI	NT CH D	NB C	NCS	NHO	QoS Metrics		HO/ CP	Date	CI	NT CH D	NB C	NCS	NHO	QoS Metrics		HO/ CP
						PCB	PHD								PCB	PHD	
9/29	30495	4	0	73	80	0.0%	5.0%	52.3%	11/14	30495	4	0	83	97	0.0%	4.1%	53.9%
9/30	30495	0	0	51	58	0.0%	0.0%	53.2%	11/15	30495	0	0	63	89	0.0%	0.0%	58.6%
10/1	30495	4	0	48	99	0.0%	4.0%	67.3%	11/16	30495	4	0	58	88	0.0%	4.5%	60.3%
10/2	30495	4	0	65	94	0.0%	4.3%	59.1%	11/17	30495	0	0	79	93	0.0%	0.0%	54.1%
10/3	30495	4	0	59	82	0.0%	4.9%	58.2%	11/18	30495	4	0	71	153	0.0%	2.6%	68.3%
10/4	30495	0	0	60	116	0.0%	0.0%	65.9%	11/19	30495	0	0	70	96	0.0%	0.0%	57.8%
10/5	30495	0	0	48	65	0.0%	0.0%	57.5%	11/20	30495	0	0	65	123	0.0%	0.0%	65.4%
10/6	30495	0	0	69	93	0.0%	0.0%	57.4%	11/21	30495	0	0	91	76	0.0%	0.0%	45.5%
10/7	30495	4	0	49	113	0.0%	3.5%	69.8%	11/22	30495	0	0	88	111	0.0%	0.0%	55.8%
10/8	30495	4	0	64	113	0.0%	3.5%	63.8%	11/23	30495	4	0	61	100	0.0%	4.0%	62.1%
10/9	30495	0	0	82	131	0.0%	0.0%	61.5%	11/24	30495	0	4	72	117	5.6%	0.0%	61.9%
10/10	30495	0	0	59	82	0.0%	0.0%	58.2%	11/25	30495	0	0	62	109	0.0%	0.0%	63.7%
10/11	30495	4	0	47	58	0.0%	6.9%	55.2%	11/26	30495	0	0	65	77	0.0%	0.0%	54.2%
10/12	30495	0	0	100	81	0.0%	0.0%	44.8%	11/27	30495	0	0	61	101	0.0%	0.0%	62.3%
10/13	30495	0	0	78	96	0.0%	0.0%	55.2%	11/28	30495	0	0	62	77	0.0%	0.0%	55.4%
10/14	30495	0	0	62	77	0.0%	0.0%	55.4%	11/29	30495	0	0	58	68	0.0%	0.0%	54.0%
10/15	30495	0	0	65	68	0.0%	0.0%	51.1%	11/30	30495	0	0	67	113	0.0%	0.0%	62.8%
10/16	30495	0	0	59	107	0.0%	0.0%	64.5%	12/1	30495	0	0	74	70	0.0%	0.0%	48.6%
10/17	30495	0	0	60	81	0.0%	0.0%	57.4%	12/2	30495	0	0	75	133	0.0%	0.0%	63.9%
10/18	30495	0	0	65	83	0.0%	0.0%	56.1%	12/3	30495	0	0	81	123	0.0%	0.0%	60.3%
10/19	30495	8	0	49	73	0.0%	11%	59.8%	12/4	30495	4	0	111	158	0.0%	2.5%	58.7%
10/20	30495	0	0	65	72	0.0%	0.0%	52.6%	12/5	30495	0	0	66	69	0.0%	0.0%	51.1%
10/21	30495	0	0	49	74	0.0%	0.0%	60.2%	12/6	30495	0	8	91	121	8.8%	0.0%	57.1%
10/22	30495	4	0	58	82	0.0%	4.9%	58.6%	12/7	30495	0	0	64	78	0.0%	0.0%	54.9%
10/23	30495	0	0	48	92	0.0%	0.0%	65.7%	12/8	30495	0	0	113	127	0.0%	0.0%	52.9%
10/24	30495	0	0	68	76	0.0%	0.0%	52.8%	12/9	30495	0	0	72	118	0.0%	0.0%	62.1%
10/25	30495	0	0	50	88	0.0%	0.0%	63.8%	12/10	30495	4	0	79	97	0.0%	4.1%	55.1%
10/26	30495	0	0	49	97	0.0%	0.0%	66.4%	12/11	30495	0	0	64	98	0.0%	0.0%	60.5%
10/27	30495	0	0	59	131	0.0%	0.0%	68.9%	12/12	30495	4	0	107	115	0.0%	3.5%	51.8%
10/28	30495	0	0	63	77	0.0%	0.0%	55.0%	12/13	30495	0	0	65	68	0.0%	0.0%	51.1%
10/29	30495	4	0	61	91	0.0%	4.4%	59.9%	12/14	30495	0	0	62	90	0.0%	0.0%	59.2%
10/30	30495	4	0	61	92	0.0%	4.3%	60.1%	12/15	30495	0	0	50	81	0.0%	0.0%	61.8%
10/31	30495	0	0	64	80	0.0%	0.0%	55.6%	12/16	30495	0	0	72	72	0.0%	0.0%	50.0%
11/1	30495	8	0	58	71	0.0%	11%	55.0%	12/17	30495	0	0	112	135	0.0%	0.0%	54.7%
11/2	30495	0	0	47	69	0.0%	0.0%	59.5%	12/18	30495	0	0	82	118	0.0%	0.0%	59.0%
11/3	30495	0	0	63	95	0.0%	0.0%	60.1%	12/19	30495	0	0	81	93	0.0%	0.0%	53.4%
11/4	30495	4	0	46	65	0.0%	6.2%	58.6%	12/20	30495	4	0	69	100	0.0%	4.0%	59.2%
11/5	30495	4	0	57	100	0.0%	4.0%	63.7%	12/21	30495	0	0	75	108	0.0%	0.0%	59.0%
11/6	30495	4	0	52	50	0.0%	8.0%	49.0%	12/22	30495	0	0	64	104	0.0%	0.0%	61.9%
11/7	30495	4	0	90	77	0.0%	5.2%	46.1%	12/23	30495	0	0	88	95	0.0%	0.0%	51.9%
11/8	30495	0	0	59	100	0.0%	0.0%	62.9%	12/24	30495	0	0	118	115	0.0%	0.0%	49.4%
11/9	30495	0	0	53	70	0.0%	0.0%	56.9%	12/25	30495	12	68	180	205	38%	5.9%	53.2%
11/10	30495	4	0	63	91	0.0%	4.4%	59.1%	12/26	30495	0	8	150	133	5.3%	0.0%	47.0%
11/11	30495	4	0	58	93	0.0%	4.3%	61.6%	12/27	30495	0	0	52	95	0.0%	0.0%	64.6%
11/12	30495	0	0	52	78	0.0%	0.0%	60.0%	12/28	30495	0	0	73	95	0.0%	0.0%	56.5%
9/28	30545	20	0	392	967	0.0%	2.1%	71.2%	11/13	30545	4	0	114	334	0.0%	1.2%	74.6%
9/29	30545	4	4	481	1009	0.8%	0.4%	67.7%	11/14	30545	0	0	73	193	0.0%	0.0%	72.6%

NON BH DATA ANALYSIS FOR OPERATOR ONE- NAKURU TOWN																			
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/30	30545	8	0	434	1158	0.0%	0.7%	72.7%	11/15	30545	8	68	772	1288	8.8%	0.6%	62.5%
10/1	30545	4	12	541	1134	2.2%	0.4%	67.7%	11/16	30545	8	4	645	1155	0.6%	0.7%	64.2%
10/2	30545	0	0	97	214	0.0%	0.0%	68.8%	11/17	30545	8	8	523	1004	1.5%	0.8%	65.7%
10/3	30545	0	0	57	146	0.0%	0.0%	71.9%	11/18	30545	4	4	457	1122	0.9%	0.4%	71.1%
10/4	30545	4	12	554	1371	2.2%	0.3%	71.2%	11/19	30545	0	0	483	986	0.0%	0.0%	67.1%
10/5	30545	4	8	541	1149	1.5%	0.3%	68.0%	11/20	30545	0	0	93	281	0.0%	0.0%	75.1%
10/6	30545	4	0	501	1126	0.0%	0.4%	69.2%	11/21	30545	0	0	50	151	0.0%	0.0%	75.1%
10/7	30545	12	4	531	1102	0.8%	1.1%	67.5%	11/22	30545	0	8	586	1332	1.4%	0.0%	69.4%
10/8	30545	4	0	460	1055	0.0%	0.4%	69.6%	11/23	30545	8	0	515	1111	0.0%	0.7%	68.3%
10/9	30545	8	0	114	329	0.0%	2.4%	74.3%	11/24	30545	12	0	588	1139	0.0%	1.1%	66.0%
10/10	30545	0	0	67	149	0.0%	0.0%	69.0%	11/25	30545	12	0	448	940	0.0%	1.3%	67.7%
10/11	30545	8	16	501	1382	3.2%	0.6%	73.4%	11/26	30545	0	8	505	1050	1.6%	0.0%	67.5%
10/12	30545	8	0	487	1042	0.0%	0.8%	68.1%	11/27	30545	0	0	106	276	0.0%	0.0%	72.3%
10/13	30545	0	24	574	1138	4.2%	0.0%	66.5%	11/28	30545	0	0	91	134	0.0%	0.0%	59.6%
10/14	30545	4	0	577	1165	0.0%	0.3%	66.9%	11/29	30545	8	12	521	1252	2.3%	0.6%	70.6%
10/15	30545	8	0	463	992	0.0%	0.8%	68.2%	11/30	30545	8	24	645	1277	3.7%	0.6%	66.4%
10/16	30545	0	0	89	302	0.0%	0.0%	77.2%	12/1	30545	8	0	449	1127	0.0%	0.7%	71.5%
10/17	30545	0	0	62	165	0.0%	0.0%	72.7%	12/2	30545	8	0	493	1145	0.0%	0.7%	69.9%
10/18	30545	0	32	556	1214	5.8%	0.0%	68.6%	12/3	30545	12	0	505	1074	0.0%	1.1%	68.0%
10/19	30545	8	0	463	1006	0.0%	0.8%	68.5%	12/4	30545	0	0	103	314	0.0%	0.0%	75.3%
10/20	30545	0	0	55	160	0.0%	0.0%	74.4%	12/5	30545	0	0	51	151	0.0%	0.0%	74.8%
10/21	30545	4	0	523	1095	0.0%	0.4%	67.7%	12/6	30545	16	28	575	1405	4.9%	1.1%	71.0%
10/22	30545	12	0	543	955	0.0%	1.3%	63.8%	12/7	30545	12	4	505	1182	0.8%	1.0%	70.1%
10/23	30545	0	0	98	329	0.0%	0.0%	77.0%	12/8	30545	8	8	518	1243	1.5%	0.6%	70.6%
10/24	30545	0	0	60	169	0.0%	0.0%	73.8%	12/9	30545	4	0	492	1120	0.0%	0.4%	69.5%
10/25	30545	4	24	560	1175	4.3%	0.3%	67.7%	12/10	30545	8	0	454	1107	0.0%	0.7%	70.9%
10/26	30545	0	4	506	1074	0.8%	0.0%	68.0%	12/11	30545	4	0	87	275	0.0%	1.5%	76.0%
10/27	30545	4	0	492	976	0.0%	0.4%	66.5%	12/12	30545	0	0	58	206	0.0%	0.0%	78.0%
10/28	30545	0	0	513	1020	0.0%	0.0%	66.5%	12/13	30545	0	0	77	241	0.0%	0.0%	75.8%
10/29	30545	8	4	431	973	0.9%	0.8%	69.3%	12/14	30545	4	48	552	1195	8.7%	0.3%	68.4%
10/30	30545	0	0	85	248	0.0%	0.0%	74.5%	12/15	30545	16	8	563	1190	1.4%	1.3%	67.9%
10/31	30545	0	0	62	159	0.0%	0.0%	71.9%	12/16	30545	12	4	509	1099	0.8%	1.1%	68.3%
11/1	30545	16	0	480	1310	0.0%	1.2%	73.2%	12/17	30545	4	4	538	1122	0.7%	0.4%	67.6%
11/2	30545	4	80	619	1183	13%	0.3%	65.6%	12/18	30545	4	0	113	312	0.0%	1.3%	73.4%
11/3	30545	0	12	534	1231	2.2%	0.0%	69.7%	12/19	30545	0	0	55	152	0.0%	0.0%	73.4%
11/4	30545	0	12	482	1083	2.5%	0.0%	69.2%	12/20	30545	8	28	644	1371	4.3%	0.6%	68.0%
11/5	30545	4	4	495	1246	0.8%	0.3%	71.6%	12/21	30545	12	0	566	1148	0.0%	1.0%	67.0%
11/6	30545	0	0	82	308	0.0%	0.0%	79.0%	12/22	30545	0	0	538	1143	0.0%	0.0%	68.0%
11/7	30545	0	0	67	167	0.0%	0.0%	71.4%	12/23	30545	4	8	457	1152	1.8%	0.3%	71.6%
11/8	30545	4	36	546	1413	6.6%	0.3%	72.1%	12/24	30545	0	0	375	1034	0.0%	0.0%	73.4%
11/9	30545	12	0	512	1127	0.0%	1.1%	68.8%	12/25	30545	4	0	52	99	0.0%	4.0%	65.6%
11/10	30545	4	0	504	1181	0.0%	0.3%	70.1%	12/26	30545	0	0	66	159	0.0%	0.0%	70.7%
11/11	30545	24	0	500	1180	0.0%	2.0%	70.2%	12/27	30545	4	0	218	529	0.0%	0.8%	70.8%
11/12	30545	12	4	557	1067	0.7%	1.1%	65.7%	12/28	30545	4	0	282	733	0.0%	0.5%	72.2%
AREA		6	5.8	760	888	0.8%	0.7%	53.9%									
OVERALL NAKURU TOWN GRADE OF SERVICE								**0.71%**									

Table A2.5 Basic non Busy Hour data analysis for Operator One Mombasa Town

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/28	22100	28	0	1556	526	0.0%	5.3%	25.3%	11/13	22100	8	0	1627	545	0.0%	1.5%	25.1%
9/29	22100	20	0	1505	524	0.0%	3.8%	25.8%	11/14	22100	12	0	1361	482	0.0%	2.5%	26.2%
9/30	22100	8	0	1466	574	0.0%	1.4%	28.1%	11/15	22100	8	0	1611	566	0.0%	1.4%	26.0%
10/1	22100	12	0	385	586	0.0%	2.0%	60.4%	11/16	22100	8	0	1905	679	0.0%	1.2%	26.3%
10/2	22100	24	0	1797	520	0.0%	4.6%	22.4%	11/17	22100	16	0	1755	522	0.0%	3.1%	22.9%
10/3	22100	4	0	1409	471	0.0%	0.8%	25.1%	11/18	22100	4	0	1674	536	0.0%	0.7%	24.3%
10/4	22100	8	8	1821	688	0.4%	1.2%	27.4%	11/19	22100	4	0	1607	540	0.0%	0.7%	25.2%
10/5	22100	16	0	376	583	0.0%	2.7%	60.8%	11/20	22100	52	0	1567	492	0.0%	11%	23.9%
10/6	22100	16	0	1607	511	0.0%	3.1%	24.1%	11/21	22100	28	0	1344	462	0.0%	6.1%	25.6%
10/7	22100	24	0	1609	629	0.0%	3.8%	28.1%	11/22	22100	36	0	1704	537	0.0%	6.7%	24.0%
10/8	22100	24	0	1687	541	0.0%	4.4%	24.3%	11/23	22100	12	0	1621	596	0.0%	2.0%	26.9%
10/9	22100	16	0	1555	578	0.0%	2.8%	27.1%	11/24	22100	8	0	1699	576	0.0%	1.4%	25.3%
10/10	22100	12	0	1366	483	0.0%	2.5%	26.1%	11/25	22100	20	0	1663	554	0.0%	3.6%	25.0%
10/11	22100	16	0	1607	547	0.0%	2.9%	25.4%	11/26	22100	8	0	1715	546	0.0%	1.5%	24.1%
10/12	22100	8	0	1283	494	0.0%	1.6%	27.8%	11/27	22100	12	0	1945	612	0.0%	2.0%	23.9%
10/13	22100	8	0	1557	577	0.0%	1.4%	27.0%	11/28	22100	8	4	1405	433	0.3%	1.8%	23.6%
10/14	22100	12	0	1461	579	0.0%	2.1%	28.4%	11/29	22100	24	4	1064	578	0.4%	4.2%	35.2%
10/15	22100	8	0	1558	493	0.0%	1.6%	24.0%	11/30	22100	12	0	1769	567	0.0%	2.1%	24.3%
10/16	22100	12	0	1414	545	0.0%	2.2%	27.8%	12/1	22100	20	0	1989	597	0.0%	3.4%	23.1%
10/17	22100	24	0	1302	459	0.0%	5.2%	26.1%	12/2	22100	4	0	1809	572	0.0%	0.7%	24.0%
10/18	22100	12	0	1420	550	0.0%	2.2%	27.9%	12/3	22100	8	0	1869	610	0.0%	1.3%	24.6%
10/19	22100	12	0	1485	502	0.0%	2.4%	25.3%	12/4	22100	28	0	1967	578	0.0%	4.8%	22.7%
10/20	22100	28	0	1356	460	0.0%	6.1%	25.3%	12/5	22100	16	0	1480	442	0.0%	3.6%	23.0%
10/21	22100	12	0	1555	523	0.0%	2.3%	25.2%	12/6	22100	0	4	1938	552	0.2%	0.0%	22.2%
10/22	22100	16	0	1565	518	0.0%	3.1%	24.9%	12/7	22100	28	0	1792	537	0.0%	5.2%	23.1%
10/23	22100	8	0	1560	478	0.0%	1.7%	23.5%	12/8	22100	20	0	1823	512	0.0%	3.9%	21.9%
10/24	22100	8	0	193	406	0.0%	2.0%	67.8%	12/9	22100	12	0	1716	622	0.0%	1.9%	26.6%
10/25	22100	16	0	620	528	0.0%	3.0%	46.0%	12/10	22100	4	0	1868	612	0.0%	0.7%	24.7%
10/26	22100	8	0	1471	566	0.0%	1.4%	27.8%	12/11	22100	20	0	2002	615	0.0%	3.3%	23.5%
10/27	22100	8	0	1464	564	0.0%	1.4%	27.8%	12/12	22100	36	0	1890	521	0.0%	6.9%	21.6%
10/28	22100	12	0	1441	538	0.0%	2.2%	27.2%	12/13	22100	28	0	1460	459	0.0%	6.1%	23.9%
10/29	22100	12	0	1562	543	0.0%	2.2%	25.8%	12/14	22100	20	0	1759	579	0.0%	3.5%	24.8%
10/30	22100	16	0	1575	491	0.0%	3.3%	23.8%	12/15	22100	4	0	1882	535	0.0%	0.7%	22.1%
10/31	22100	16	0	482	456	0.0%	3.5%	48.6%	12/16	22100	4	0	1665	540	0.0%	0.7%	24.5%
11/1	22100	8	0	1554	598	0.0%	1.3%	27.8%	12/17	22100	16	0	1834	545	0.0%	2.9%	22.9%
11/2	22100	8	0	1536	536	0.0%	1.5%	25.9%	12/18	22100	8	0	2035	611	0.0%	1.3%	23.1%
11/3	22100	24	0	1608	509	0.0%	4.7%	24.0%	12/19	22100	16	0	1604	457	0.0%	3.5%	22.2%
11/4	22100	0	0	1584	545	0.0%	0.0%	25.6%	12/20	22100	16	0	1837	562	0.0%	2.8%	23.4%
11/5	22100	4	0	119	564	0.0%	0.7%	82.6%	12/21	22100	32	0	2084	640	0.0%	5.0%	23.5%
11/6	22100	12	4	242	549	1.7%	2.2%	69.4%	12/22	22100	16	0	1934	591	0.0%	2.7%	23.4%
11/7	22100	24	16	1369	523	1.2%	4.6%	27.6%	12/23	22100	36	0	2448	770	0.0%	4.7%	23.9%
11/8	22100	12	8	1440	513	0.6%	2.3%	26.3%	12/24	22100	20	4	3707	872	0.1%	2.3%	19.0%

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
11/9	22100	20	4	1447	523	0.3%	3.8%	26.5%	12/25	22100	36	0	3222	768	0.0%	4.7%	19.2%
11/10	22100	32	0	94	482	0.0%	6.6%	83.7%	12/26	22100	16	0	1968	475	0.0%	3.4%	19.4%
11/11	22100	8	0	1533	528	0.0%	1.5%	25.6%	12/27	22100	16	0	2207	617	0.0%	2.6%	21.8%
11/12	22100	8	0	1749	526	0.0%	1.5%	23.1%	12/28	22100	12	0	2144	594	0.0%	2.0%	21.7%
9/28	22331	8	0	272	328	0.0%	2.4%	54.7%	10/16	23580	44	0	1820	180	0.0%	24.4%	9.0%
9/29	22331	4	0	311	310	0.0%	1.3%	49.9%	10/17	23580	24	0	1777	190	0.0%	12.6%	9.7%
9/30	22331	4	0	244	207	0.0%	1.9%	45.9%	10/18	23580	8	0	1561	185	0.0%	4.3%	10.6%
10/1	22331	4	0	431	276	0.0%	1.4%	39.1%	10/19	23580	32	0	1950	200	0.0%	16.0%	9.3%
10/2	22331	8	0	428	434	0.0%	1.8%	50.3%	10/20	23580	40	0	1518	137	0.0%	29.2%	8.3%
10/3	22331	4	0	699	252	0.0%	1.6%	26.5%	10/21	23580	44	0	773	166	0.0%	26.5%	17.7%
10/4	22331	8	0	312	312	0.0%	2.6%	50.0%	10/22	23580	24	0	1614	178	0.0%	13.5%	9.9%
10/5	22331	0	0	328	287	0.0%	0.0%	46.6%	10/23	23580	20	0	1443	161	0.0%	12.4%	10.0%
10/6	22331	8	0	406	226	0.0%	3.5%	35.8%	10/24	23580	24	0	315	163	0.0%	14.7%	34.1%
10/7	22331	16	0	297	237	0.0%	6.8%	44.4%	10/25	23580	32	0	742	173	0.0%	18.5%	18.9%
10/8	22331	0	0	307	208	0.0%	0.0%	40.4%	10/26	23580	20	0	1593	167	0.0%	12.0%	9.5%
10/9	22331	8	0	470	136	0.0%	5.9%	22.4%	10/27	23580	16	0	1779	155	0.0%	10.3%	8.0%
10/10	22331	12	4	859	253	0.5%	4.7%	22.8%	10/28	23580	12	0	1573	154	0.0%	7.8%	8.9%
10/11	22331	8	0	277	188	0.0%	4.3%	40.4%	10/29	23580	28	0	1923	215	0.0%	13.0%	10.1%
10/12	22331	12	0	285	205	0.0%	5.9%	41.8%	10/30	23580	16	0	1881	173	0.0%	9.2%	8.4%
10/13	22331	12	0	220	212	0.0%	5.7%	49.1%	10/31	23580	4	0	426	174	0.0%	2.3%	29.0%
10/14	22331	4	0	303	156	0.0%	2.6%	34.0%	11/1	23580	24	0	1521	166	0.0%	14.5%	9.8%
10/15	22331	4	0	351	204	0.0%	2.0%	36.8%	11/2	23580	4	0	1572	197	0.0%	2.0%	11.1%
10/16	22331	0	0	411	180	0.0%	0.0%	30.5%	11/3	23580	12	0	1476	133	0.0%	9.0%	8.3%
10/17	22331	4	0	821	182	0.0%	2.2%	18.1%	11/4	23580	36	0	1722	163	0.0%	22.1%	8.6%
10/18	22331	4	0	282	147	0.0%	2.7%	34.3%	11/5	23580	16	0	669	165	0.0%	9.7%	19.8%
10/19	22331	0	0	246	126	0.0%	0.0%	33.9%	11/6	23580	20	0	485	133	0.0%	15.0%	21.5%
10/20	22331	4	0	844	217	0.0%	1.8%	20.5%	11/7	23580	32	0	1632	164	0.0%	19.5%	9.1%
10/21	22331	4	0	251	123	0.0%	3.3%	32.9%	11/8	23580	24	0	1569	165	0.0%	14.5%	9.5%
10/22	22331	0	0	255	141	0.0%	0.0%	35.6%	11/9	23580	12	0	1536	160	0.0%	7.5%	9.4%
10/23	22331	0	0	410	173	0.0%	0.0%	29.7%	11/10	23580	24	0	939	153	0.0%	15.7%	14.0%
10/24	22331	4	0	254	107	0.0%	3.7%	29.7%	11/11	23580	20	0	1621	186	0.0%	10.8%	10.3%
10/25	22331	8	0	681	162	0.0%	4.9%	19.2%	11/12	23580	32	0	1676	153	0.0%	20.9%	8.4%
9/28	23580	28	0	1495	101	0.0%	27.7%	6.3%	11/13	23580	40	0	1724	184	0.0%	21.7%	9.6%
9/29	23580	32	0	1454	133	0.0%	24.1%	8.4%	11/14	23580	40	0	1616	161	0.0%	24.8%	9.1%
9/30	23580	16	0	1631	187	0.0%	8.6%	10.3%	11/15	23580	32	0	1629	174	0.0%	18.4%	9.7%
10/1	23580	20	0	476	157	0.0%	12.7%	24.8%	11/16	23580	12	-0	1457	137	0.0%	8.8%	8.6%
10/2	23580	24	0	1854	186	0.0%	12.9%	9.1%	11/17	23580	40	0	1503	152	0.0%	26.3%	9.2%
10/3	23580	64	0	1691	165	0.0%	38.8%	8.9%	11/18	23580	32	0	1466	190	0.0%	16.8%	11.5%
10/4	23580	24	0	1614	189	0.0%	12.7%	10.5%	11/19	23580	28	0	1588	189	0.0%	14.8%	10.6%
10/5	23580	32	0	281	177	0.0%	18.1%	38.7%	11/20	23580	40	0	1454	152	0.0%	26.3%	9.5%
10/6	23580	16	0	1600	209	0.0%	7.7%	11.6%	11/21	23580	20	0	1453	133	0.0%	15.0%	8.4%
10/7	23580	24	0	1747	204	0.0%	11.8%	10.5%	11/22	23580	28	0	1536	132	0.0%	21.2%	7.9%
10/8	23580	24	0	1779	185	0.0%	13.0%	9.4%	11/23	23580	12	0	1435	142	0.0%	8.5%	9.0%
10/9	23580	24	0	1750	164	0.0%	14.6%	8.6%	11/24	23580	20	0	1724	222	0.0%	9.0%	11.4%

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/10	23580	16	0	1665	165	0.0%	9.7%	9.0%	11/25	23580	36	0	1428	147	0.0%	24.5%	9.3%
10/11	23580	12	0	1827	145	0.0%	8.3%	7.4%	11/26	23580	40	0	1571	193	0.0%	20.7%	10.9%
10/12	23580	20	0	1664	161	0.0%	12.4%	8.8%	11/27	23580	8	0	1453	127	0.0%	6.3%	8.0%
10/13	23580	8	0	1619	143	0.0%	5.6%	8.1%	11/28	23580	32	0	1758	144	0.0%	22.2%	7.6%
10/14	23580	8	0	1842	164	0.0%	4.9%	8.2%	11/29	23580	36	0	1160	140	0.0%	25.7%	10.8%
10/15	23580	12	0	1711	201	0.0%	6.0%	10.5%	11/30	23580	24	0	1645	152	0.0%	15.8%	8.5%
12/1	23580	16	0	1742	159	0.0%	10.1%	8.4%	10/16	23890	8	0	669	96	0.0%	8.3%	12.5%
12/2	23580	36	0	1833	203	0.0%	17.7%	10.0%	10/17	23890	24	0	481	85	0.0%	28.2%	15.0%
12/3	23580	12	0	1566	158	0.0%	7.6%	9.2%	10/18	23890	0	0	686	89	0.0%	0.0%	11.5%
12/4	23580	36	0	1415	110	0.0%	32.7%	7.2%	10/19	23890	16	0	670	109	0.0%	14.7%	14.0%
12/5	23580	20	0	1878	207	0.0%	9.7%	9.9%	10/20	23890	28	0	667	110	0.0%	25.5%	14.2%
12/6	23580	44	0	1560	162	0.0%	27.2%	9.4%	10/21	23890	4	0	878	144	0.0%	2.8%	14.1%
12/7	23580	16	0	1588	135	0.0%	11.9%	7.8%	10/22	23890	12	0	889	118	0.0%	10.2%	11.7%
12/8	23580	28	0	1639	126	0.0%	22.2%	7.1%	10/23	23890	56	4	722	143	0.6%	39.2%	16.5%
12/9	23580	24	0	1538	133	0.0%	18.0%	8.0%	10/24	23890	0	0	376	54	0.0%	0.0%	12.6%
12/10	23580	40	0	1480	177	0.0%	22.6%	10.7%	10/25	23890	8	0	803	114	0.0%	7.0%	12.4%
12/11	23580	16	0	1685	159	0.0%	10.1%	8.6%	10/26	23890	4	0	636	84	0.0%	4.8%	11.7%
12/12	23580	60	0	1818	168	0.0%	35.7%	8.5%	10/27	23890	0	0	649	106	0.0%	0.0%	14.0%
12/13	23580	28	0	1430	138	0.0%	20.3%	8.8%	10/28	23890	4	0	625	87	0.0%	4.6%	12.2%
12/14	23580	40	0	1326	136	0.0%	29.4%	9.3%	10/29	23890	0	0	587	94	0.0%	0.0%	13.8%
12/15	23580	36	0	1584	153	0.0%	23.5%	8.8%	10/30	23890	36	4	668	99	0.6%	36.4%	12.9%
12/16	23580	28	0	1705	140	0.0%	20.0%	7.6%	10/31	23890	8	0	398	56	0.0%	14.3%	12.3%
12/17	23580	16	0	1625	146	0.0%	11.0%	8.2%	11/1	23890	0	0	570	89	0.0%	0.0%	13.5%
12/18	23580	44	0	1706	183	0.0%	24.0%	9.7%	11/2	23890	0	0	498	94	0.0%	0.0%	15.9%
12/19	23580	44	0	1750	185	0.0%	23.8%	9.6%	11/3	23890	20	0	669	97	0.0%	20.6%	12.7%
12/20	23580	24	0	1739	144	0.0%	16.7%	7.6%	11/4	23890	8	8	592	116	1.4%	6.9%	16.4%
12/21	23580	52	0	1801	180	0.0%	28.9%	9.1%	11/5	23890	4	0	59	53	0.0%	7.5%	47.3%
12/22	23580	56	0	1790	152	0.0%	36.8%	7.8%	11/6	23890	4	0	616	98	0.0%	4.1%	13.7%
12/23	23580	20	0	1800	190	0.0%	10.5%	9.5%	11/7	23890	4	0	538	62	0.0%	6.5%	10.3%
12/24	23580	12	0	1409	133	0.0%	9.0%	8.6%	11/8	23890	4	0	876	97	0.0%	4.1%	10.0%
12/25	23580	40	0	1690	215	0.0%	18.6%	11.3%	11/9	23890	12	0	739	112	0.0%	10.7%	13.2%
12/26	23580	8	0	1413	164	0.0%	4.9%	10.4%	11/10	23890	12	4	983	106	0.4%	11.3%	9.7%
12/27	23580	24	0	1372	112	0.0%	21.4%	7.5%	11/11	23890	8	4	736	122	0.5%	6.6%	14.2%
12/28	23580	12	0	1285	170	0.0%	7.1%	11.7%	11/12	23890	4	0	649	75	0.0%	5.3%	10.4%
9/28	23890	12	0	616	110	0.0%	10.9%	15.2%	11/13	23890	44	4	726	117	0.6%	37.6%	13.9%
9/29	23890	8	0	558	64	0.0%	12.5%	10.3%	11/14	23890	4	0	413	57	0.0%	7.0%	12.1%
9/30	23890	4	0	717	97	0.0%	4.1%	11.9%	11/15	23890	0	0	645	93	0.0%	0.0%	12.6%
10/1	23890	0	0	522	81	0.0%	0.0%	13.4%	11/16	23890	4	16	1416	81	1.1%	4.9%	5.4%
10/2	23890	4	4	597	92	0.7%	4.3%	13.4%	11/17	23890	0	36	1097	91	3.3%	0.0%	7.7%
10/3	23890	0	0	475	54	0.0%	0.0%	10.2%	11/18	23890	20	0	952	138	0.0%	14.5%	12.7%
10/4	23890	8	4	722	61	0.6%	13.1%	7.8%	11/19	23890	4	0	772	106	0.0%	3.8%	12.1%
10/5	23890	0	60	233	133	26%	0.0%	36.3%	11/20	23890	4	4	-821	112	0.5%	3.6%	12.0%
10/6	23890	16	16	959	120	1.7%	13.3%	11.1%	11/21	23890	20	0	737	52	0.0%	38.5%	6.6%
10/7	23890	12	0	614	91	0.0%	13.2%	12.9%	11/22	23890	12	0	673	141	0.0%	8.5%	17.3%

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/8	23890	20	0	857	102	0.0%	19.6%	10.6%	11/23	23890	4	0	530	97	0.0%	4.1%	15.5%
10/9	23890	8	4	956	132	0.4%	6.1%	12.1%	11/24	23890	0	0	620	95	0.0%	0.0%	13.3%
10/10	23890	0	4	582	61	0.7%	0.0%	9.5%	11/25	23890	8	0	739	133	0.0%	6.0%	15.3%
10/11	23890	28	0	722	159	0.0%	17.6%	18.0%	11/26	23890	12	4	842	109	0.5%	11.0%	11.5%
10/12	23890	8	0	634	117	0.0%	6.8%	15.6%	11/27	23890	16	0	802	142	0.0%	11.3%	15.0%
10/13	23890	0	0	573	101	0.0%	0.0%	15.0%	11/28	23890	0	0	616	67	0.0%	0.0%	9.8%
10/14	23890	16	0	749	99	0.0%	16.2%	11.7%	11/29	23890	0	4	904	142	0.4%	0.0%	13.6%
10/15	23890	4	0	602	108	0.0%	3.7%	15.2%	11/30	23890	0	4	904	109	0.4%	0.0%	10.8%
12/1	23890	16	0	839	103	0.0%	15.5%	10.9%	10/16	23891	0	0	102	36	0.0%	0.0%	26.1%
12/2	23890	8	4	912	118	0.4%	6.8%	11.5%	10/17	23891	0	0	81	57	0.0%	0.0%	41.3%
12/3	23890	0	4	903	79	0.4%	0.0%	8.0%	10/18	23891	0	0	54	24	0.0%	0.0%	30.8%
12/4	23890	8	0	827	143	0.0%	5.6%	14.7%	10/19	23891	0	0	41	24	0.0%	0.0%	36.9%
12/5	23890	24	0	733	86	0.0%	27.9%	10.5%	10/20	23891	0	0	38	20	0.0%	0.0%	34.5%
12/6	23890	4	0	898	118	0.0%	3.4%	11.6%	10/21	23891	0	0	99	15	0.0%	0.0%	13.2%
12/7	23890	20	0	848	83	0.0%	24.1%	8.9%	10/22	23891	0	0	75	31	0.0%	0.0%	29.2%
12/8	23890	4	0	826	125	0.0%	3.2%	13.1%	10/23	23891	0	0	56	48	0.0%	0.0%	46.2%
12/9	23890	4	0	911	150	0.0%	2.7%	14.1%	10/24	23891	0	0	437	18	0.0%	0.0%	4.0%
12/10	23890	4	0	928	174	0.0%	2.3%	15.8%	10/25	23891	0	0	864	42	0.0%	0.0%	4.6%
12/11	23890	20	4	947	155	0.4%	12.9%	14.1%	10/26	23891	0	0	80	33	0.0%	0.0%	29.2%
12/12	23890	4	0	721	74	0.0%	5.4%	9.3%	10/27	23891	0	0	71	43	0.0%	0.0%	37.7%
12/13	23890	8	0	610	110	0.0%	7.3%	15.3%	10/28	23891	0	0	59	27	0.0%	0.0%	31.4%
12/14	23890	8	8	840	130	1.0%	6.2%	13.4%	10/29	23891	0	0	39	26	0.0%	0.0%	40.0%
12/15	23890	0	12	1290	114	0.9%	0.0%	8.1%	10/30	23891	0	0	64	44	0.0%	0.0%	40.7%
12/16	23890	4	0	782	111	0.0%	3.6%	12.4%	10/31	23891	0	0	370	44	0.0%	0.0%	10.6%
12/17	23890	4	0	856	134	0.0%	3.0%	13.5%	11/1	23891	0	0	58	9	0.0%	0.0%	13.4%
12/18	23890	0	0	838	92	0.0%	0.0%	9.9%	11/2	23891	0	0	57	28	0.0%	0.0%	32.9%
12/19	23890	8	0	681	101	0.0%	7.9%	12.9%	11/3	23891	0	0	59	40	0.0%	0.0%	40.4%
12/20	23890	8	0	765	93	0.0%	8.6%	10.8%	11/4	23891	0	0	66	21	0.0%	0.0%	24.1%
12/21	23890	4	0	814	124	0.0%	3.2%	13.2%	11/5	23891	0	0	519	8	0.0%	0.0%	1.5%
12/22	23890	0	0	711	96	0.0%	0.0%	11.9%	11/6	23891	0	0	748	38	0.0%	0.0%	4.8%
12/23	23890	4	0	890	148	0.0%	2.7%	14.3%	11/7	23891	0	0	87	23	0.0%	0.0%	20.9%
12/24	23890	20	0	1098	114	0.0%	17.5%	9.4%	11/8	23891	0	0	50	22	0.0%	0.0%	30.6%
12/25	23890	16	0	897	160	0.0%	10.0%	15.1%	11/9	23891	0	0	68	70	0.0%	0.0%	50.7%
12/26	23890	0	0	857	142	0.0%	0.0%	14.2%	11/10	23891	0	0	1027	45	0.0%	0.0%	4.2%
12/27	23890	12	0	876	167	0.0%	7.2%	16.0%	11/11	23891	0	0	32	20	0.0%	0.0%	38.5%
12/28	23890	4	0	842	109	0.0%	3.7%	11.5%	11/12	23891	0	0	83	57	0.0%	0.0%	40.7%
9/28	23891	0	0	64	14	0.0%	0.0%	17.9%	11/13	23891	4	0	63	30	0.0%	13.3%	32.3%
9/29	23891	0	0	51	50	0.0%	0.0%	49.5%	11/14	23891	0	0	68	30	0.0%	0.0%	30.6%
9/30	23891	0	0	43	15	0.0%	0.0%	25.9%	11/15	23891	0	0	109	44	0.0%	0.0%	28.8%
10/1	23891	0	0	567	7	0.0%	0.0%	1.2%	11/16	23891	0	0	145	87	0.0%	0.0%	37.5%
10/2	23891	0	0	13	16	0.0%	0.0%	55.2%	11/17	23891	0	0	123	43	0.0%	0.0%	25.9%
10/3	23891	0	0	27	8	0.0%	0.0%	22.9%	11/18	23891	0	0	104	57	0.0%	0.0%	35.4%
10/4	23891	0	0	150	58	0.0%	0.0%	27.9%	11/19	23891	0	0	40	26	0.0%	0.0%	39.4%
10/5	23891	0	0	185	65	0.0%	0.0%	26.0%	11/20	23891	0	0	68	45	0.0%	0.0%	39.8%

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/6	23891	0	0	122	62	0.0%	0.0%	33.7%	11/21	23891	4	0	101	37	0.0%	10.8%	26.8%
10/7	23891	0	0	91	60	0.0%	0.0%	39.7%	11/22	23891	0	0	59	48	0.0%	0.0%	44.9%
10/8	23891	0	0	77	34	0.0%	0.0%	30.6%	11/23	23891	4	0	53	42	0.0%	9.5%	44.2%
10/9	23891	0	0	88	90	0.0%	0.0%	50.6%	11/24	23891	0	0	63	27	0.0%	0.0%	30.0%
10/10	23891	0	0	33	14	0.0%	0.0%	29.8%	11/25	23891	0	0	48	29	0.0%	0.0%	37.7%
10/11	23891	0	0	93	35	0.0%	0.0%	27.3%	11/26	23891	0	0	73	19	0.0%	0.0%	20.7%
10/12	23891	0	0	102	44	0.0%	0.0%	30.1%	11/27	23891	0	0	67	57	0.0%	0.0%	46.0%
10/13	23891	0	0	81	34	0.0%	0.0%	29.6%	11/28	23891	0	0	46	13	0.0%	0.0%	22.0%
10/14	23891	0	0	110	40	0.0%	0.0%	26.7%	11/29	23891	0	0	96	40	0.0%	0.0%	29.4%
10/15	23891	0	0	113	73	0.0%	0.0%	39.2%	11/30	23891	0	0	96	31	0.0%	0.0%	24.4%
12/1	23891	0	0	84	38	0.0%	0.0%	31.1%	10/16	25140	16	0	694	630	0.0%	2.5%	47.6%
12/2	23891	0	0	73	41	0.0%	0.0%	36.0%	10/17	25140	4	0	582	423	0.0%	0.9%	42.1%
12/3	23891	0	0	74	24	0.0%	0.0%	24.5%	10/18	25140	8	0	583	524	0.0%	1.5%	47.3%
12/4	23891	0	0	95	73	0.0%	0.0%	43.5%	10/19	25140	4	0	598	545	0.0%	0.7%	47.7%
12/5	23891	8	0	68	45	0.0%	17.8%	39.8%	10/20	25140	0	0	678	535	0.0%	0.0%	44.1%
12/6	23891	0	0	95	49	0.0%	0.0%	34.0%	10/21	25140	12	0	657	575	0.0%	2.1%	46.7%
12/7	23891	0	0	87	42	0.0%	0.0%	32.6%	10/22	25140	20	0	636	567	0.0%	3.5%	47.1%
12/8	23891	0	0	64	51	0.0%	0.0%	44.3%	10/23	25140	16	0	467	434	0.0%	3.7%	48.2%
12/9	23891	0	0	93	34	0.0%	0.0%	26.8%	10/24	25140	0	0	498	354	0.0%	0.0%	41.6%
12/10	23891	4	0	79	36	0.0%	11.1%	31.3%	10/25	25140	12	0	925	622	0.0%	1.9%	40.2%
12/11	23891	0	0	101	92	0.0%	0.0%	47.7%	10/26	25140	8	0	635	564	0.0%	1.4%	47.0%
12/12	23891	8	0	67	59	0.0%	13.6%	46.8%	10/27	25140	8	0	621	672	0.0%	1.2%	52.0%
12/13	23891	0	0	49	34	0.0%	0.0%	41.0%	10/28	25140	4	0	559	526	0.0%	0.8%	48.5%
12/14	23891	0	0	66	38	0.0%	0.0%	36.5%	10/29	25140	8	0	531	499	0.0%	1.6%	48.4%
12/15	23891	0	0	71	47	0.0%	0.0%	39.8%	10/30	25140	12	0	538	436	0.0%	2.8%	44.8%
12/16	23891	0	0	70	15	0.0%	0.0%	17.6%	10/31	25140	0	0	342	410	0.0%	0.0%	54.5%
12/17	23891	0	0	59	32	0.0%	0.0%	35.2%	11/1	25140	8	0	559	506	0.0%	1.6%	47.5%
12/18	23891	0	0	105	58	0%	0.0%	35.6%	11/2	25140	12	0	628	503	0.0%	2.4%	44.5%
12/19	23891	16	0	80	53	0.0%	30.2%	39.8%	11/3	25140	8	0	519	492	0.0%	1.6%	48.7%
12/20	23891	0	0	114	52	0.0%	0.0%	31.3%	11/4	25140	4	0	533	479	0.0%	0.8%	47.3%
12/21	23891	0	0	101	58	0.0%	0.0%	36.5%	11/5	25140	6	0	311	522	0.0%	1.1%	62.7%
12/22	23891	0	0	78	34	0.0%	0.0%	30.4%	11/6	25140	0	0	879	562	0.0%	0.0%	39.0%
12/23	23891	4	0	79	57	0.0%	7.0%	41.9%	11/7	25140	4	0	521	494	0.0%	0.8%	48.7%
12/24	23891	0	0	88	45	0.0%	0.0%	33.8%	11/8	25140	12	0	480	439	0.0%	2.7%	47.8%
12/25	23891	0	0	126	48	0.0%	0.0%	27.6%	11/9	25140	8	0	514	469	0.0%	1.7%	47.7%
12/26	23891	0	0	120	54	0.0%	0.0%	31.0%	11/10	25140	4	0	1071	445	0.0%	0.9%	29.4%
12/27	23891	0	0	102	73	0.0%	0.0%	41.7%	11/11	25140	8	0	608	603	0.0%	1.3%	49.8%
12/28	23891	0	0	97	45	0.0%	0.0%	31.7%	11/12	25140	4	0	594	525	0.0%	0.8%	46.9%
9/28	25140	0	0	509	402	0.0%	0.0%	44.1%	11/13	25140	0	0	633	571	0.0%	0.0%	47.4%
9/29	25140	0	0	554	424	0.0%	0.0%	43.4%	11/14	25140	8	0	553	232	0.0%	3.4%	29.6%
9/30	25140	8	0	705	636	0.0%	1.3%	47.4%	11/15	25140	12	12	1098	399	1.1%	3.0%	26.7%
10/1	25140	0	0	613	472	0.0%	0.0%	43.5%	11/16	25140	0	0	583	570	0.0%	0.0%	49.4%
10/2	25140	8	0	583	490	0.0%	1.6%	45.7%	11/17	25140	8	0	588	499	0.0%	1.6%	45.9%
10/3	25140	0	0	470	475	0.0%	0.0%	50.3%	11/18	25140	12	360	1480	471	24.3%	2.5%	24.1%

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Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/4	25140	8	0	744	639	0.0%	1.3%	46.2%	11/19	25140	8	0	613	539	0.0%	1.5%	46.8%
10/5	25140	4	0	138	469	0.0%	0.9%	77.3%	11/20	25140	0	0	638	600	0.0%	0.0%	48.5%
10/6	25140	4	0	579	551	0.0%	0.7%	48.8%	11/21	25140	8	0	1143	671	0.0%	1.2%	37.0%
10/7	25140	8	0	571	576	0.0%	1.4%	50.2%	11/22	25140	8	0	546	546	0.0%	1.5%	50.0%
10/8	25140	8	0	712	565	0.0%	1.4%	44.2%	11/23	25140	8	0	522	506	0.0%	1.6%	49.2%
10/9	25140	0	0	580	550	0.0%	0.0%	48.7%	11/24	25140	4	0	583	544	0.0%	0.7%	48.3%
10/10	25140	8	0	506	513	0.0%	1.6%	50.3%	11/25	25140	4	0	880	760	0.0%	0.5%	46.3%
10/11	25140	8	0	542	475	0.0%	1.7%	46.7%	11/26	25140	4	0	743	627	0.0%	0.6%	45.8%
10/12	25140	20	0	531	497	0.0%	4.0%	48.3%	11/27	25140	8	0	610	572	0.0%	1.4%	48.4%
10/13	25140	0	0	467	494	0.0%	0.0%	51.4%	11/28	25140	8	0	968	545	0.0%	1.5%	36.0%
10/14	25140	12	0	585	476	0.0%	2.5%	44.9%	11/29	25140	12	0	583	656	0.0%	1.8%	52.9%
10/15	25140	4	0	617	504	0.0%	0.8%	45.0%	11/30	25140	8	0	583	589	0.0%	1.4%	50.3%
12/1	25140	4	0	619	627	0.0%	0.6%	50.3%	10/16	25202	0	0	547	58	0.0%	0.0%	9.6%
12/2	25140	8	0	661	573	0.0%	1.4%	46.4%	10/17	25202	12	0	1177	185	0.0%	6.5%	13.6%
12/3	25140	24	0	772	590	0.0%	4.1%	43.3%	10/18	25202	8	0	256	26	0.0%	30.8%	9.2%
12/4	25140	8	0	753	650	0.0%	1.2%	46.3%	10/19	25202	0	0	313	71	0.0%	0.0%	18.5%
12/5	25140	8	0	1401	865	0.0%	0.9%	38.2%	10/20	25202	8	0	610	133	0.0%	6.0%	17.9%
12/6	25140	4	0	718	622	0.0%	0.6%	46.4%	10/21	25202	0	0	277	43	0.0%	0.0%	13.4%
12/7	25140	12	0	702	584	0.0%	2.1%	45.4%	10/22	25202	4	0	362	72	0.0%	5.6%	16.6%
12/8	25140	0	0	713	563	0.0%	0.0%	44.1%	10/23	25202	0	0	424	56	0.0%	0.0%	11.7%
12/9	25140	0	0	723	632	0.0%	0.0%	46.6%	10/24	25202	16	0	559	98	0.0%	16.3%	14.9%
12/10	25140	4	0	748	634	0.0%	0.6%	45.9%	10/25	25202	0	0	986	44	0.0%	0.0%	4.3%
12/11	25140	8	0	903	672	0.0%	1.2%	42.7%	10/26	25202	0	0	206	33	0.0%	0.0%	13.8%
12/12	25140	16	24	2422	1221	1.0%	1.3%	33.5%	10/27	25202	0	0	288	63	0.0%	0.0%	17.9%
12/13	25140	4	0	1016	627	0.0%	0.6%	38.2%	10/28	25202	0	0	322	60	0.0%	0.0%	15.7%
12/14	25140	12	0	704	678	0.0%	1.8%	49.1%	10/29	25202	0	0	438	64	0.0%	0.0%	12.7%
12/15	25140	0	0	796	655	0.0%	0.0%	45.1%	10/30	25202	28	0	510	80	0.0%	35.0%	13.6%
12/16	25140	4	0	1172	941	0.0%	0.4%	44.5%	10/31	25202	36	0	314	198	0.0%	18.2%	38.7%
12/17	25140	0	0	907	823	0.0%	0.0%	47.6%	11/1	25202	4	0	240	48	0.0%	8.3%	16.7%
12/18	25140	28	0	789	647	0.0%	4.3%	45.1%	11/2	25202	8	0	333	53	0.0%	15.1%	13.7%
12/19	25140	8	0	1546	1075	0.0%	0.7%	41.0%	11/3	25202	4	0	311	54	0.0%	7.4%	14.8%
12/20	25140	8	0	691	617	0.0%	1.3%	47.2%	11/4	25202	8	0	326	51	0.0%	15.7%	13.5%
12/21	25140	4	0	737	597	0.0%	0.7%	44.8%	11/5	25202	0	0	1584	72	0.0%	0.0%	4.3%
12/22	25140	0	0	585	433	0.0%	0.0%	42.5%	11/6	25202	16	0	1011	112	0.0%	14.3%	10.0%
12/23	25140	0	0	757	558	0.0%	0.0%	42.4%	11/7	25202	8	0	920	166	0.0%	4.8%	15.3%
12/24	25140	8	0	981	833	0.0%	1.0%	45.9%	11/8	25202	12	0	294	54	0.0%	22.2%	15.5%
12/25	25140	20	8	2030	1193	0.4%	1.7%	37.0%	11/9	25202	4	0	304	86	0.0%	4.7%	22.1%
12/26	25140	4	4	1225	817	0.3%	0.5%	40.0%	11/10	25202	4	0	1115	95	0.0%	4.2%	7.9%
12/27	25140	8	4	1320	872	0.3%	0.9%	39.8%	11/11	25202	4	0	311	57	0.0%	7.0%	15.5%
12/28	25140	4	0	692	592	0.0%	0.7%	46.1%	11/12	25202	0	0	420	74	0.0%	0.0%	15.0%
9/28	25202	4	0	260	44	0.0%	9.1%	14.5%	11/13	25202	4	0	543	133	0.0%	3.0%	19.7%
9/29	25202	0	0	222	42	0.0%	0.0%	15.9%	11/14	25202	4	0	773	175	0.0%	2.3%	18.5%
9/30	25202	0	0	134	40	0.0%	0.0%	23.0%	11/15	25202	4	0	313	79	0.0%	5.1%	20.2%
10/1	25202	4	0	658	65	0.0%	6.2%	9.0%	11/16	25202	0	0	546	106	0.0%	0.0%	16.3%

NON BH DATA ANALYSIS FOR OPERATOR ONE- MOMBASA TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
10/2	25202	4	0	480	79	0.0%	5.1%	14.1%	11/17	25202	4	0	717	174	0.0%	2.3%	19.5%
10/3	25202	12	0	953	190	0.0%	6.3%	16.6%	11/18	25202	4	0	291	88	0.0%	4.5%	23.2%
10/4	25202	0	0	365	81	0.0%	0.0%	18.2%	11/19	25202	0	0	326	84	0.0%	0.0%	20.5%
10/5	25202	0	0	89.8	50	0.0%	0.0%	35.8%	11/20	25202	0	0	472	112	0.0%	0.0%	19.2%
10/6	25202	0	0	291	68	0.0%	0.0%	18.9%	11/21	25202	8	0	1287	251	0.0%	3.2%	16.3%
10/7	25202	4	0	316	74	0.0%	5.4%	19.0%	11/22	25202	4	0	344	78	0.0%	5.1%	18.5%
10/8	25202	0	0	277	69	0.0%	0.0%	19.9%	11/23	25202	0	0	270	68	0.0%	0.0%	20.1%
10/9	25202	4	0	475	94	0.0%	4.3%	16.5%	11/24	25202	8	0	303	79	0.0%	10.1%	20.7%
10/10	25202	4	0	802	181	0.0%	2.2%	18.4%	11/25	25202	8	0	343	90	0.0%	8.9%	20.8%
10/11	25202	4	0	215	52	0.0%	7.7%	19.5%	11/26	25202	0	0	247	63	0.0%	0.0%	20.3%
10/12	25202	8	0	254	66	0.0%	12.1%	20.6%	11/27	25202	4	0	514	95	0.0%	4.2%	15.6%
10/13	25202	0	0	116	27	0.0%	0.0%	18.9%	11/28	25202	36	0	1016	244	0.0%	14.8%	19.4%
10/14	25202	8	0	254	37	0.0%	21.6%	12.7%	11/29	25202	0	0	1352	82	0.0%	0.0%	5.7%
10/15	25202	4	0	520	68	0.0%	5.9%	11.6%	11/30	25202	8	0	333	80	0.0%	10.0%	19.4%
12/1	25202	0	0	412	80	0.0%	0.0%	16.3%	12/15	25202	24	0	481	96	0.0%	25.0%	16.6%
12/2	25202	8	0	322	68	0.0%	11.8%	17.4%	12/16	25202	0	0	391	86	0.0%	0.0%	18.0%
12/3	25202	8	0	466	118	0.0%	6.8%	20.2%	12/17	25202	4	0	500	119	0.0%	3.4%	19.2%
12/4	25202	0	0	524	131	0.0%	0.0%	20.0%	12/18	25202	8	0	627	168	0.0%	4.8%	21.1%
12/5	25202	12	0	1036	278	0.0%	4.3%	21.2%	12/19	25202	28	0	1416	299	0.0%	9.4%	17.4%
12/6	25202	8	0	313	85	0.0%	9.4%	21.4%	12/20	25202	4	0	365	100	0.0%	4.0%	21.5%
12/7	25202	4	0	337	70	0.0%	5.7%	17.2%	12/21	25202	0	0	379	67	0.0%	0.0%	15.0%
12/8	25202	4	0	250	56	0.0%	7.1%	18.3%	12/22	25202	0	0	372	118	0.0%	0.0%	24.1%
12/9	25202	4	0	291	61	0.0%	6.6%	17.3%	12/23	25202	4	0	352	97	0.0%	4.1%	21.6%
12/10	25202	4	0	409	95	0.0%	4.2%	18.8%	12/24	25202	4	0	640	116	0.0%	3.4%	15.3%
12/11	25202	12	0	570	151	0.0%	7.9%	20.9%	12/25	25202	56	64	3325	905	1.9%	6.2%	21.4%
12/12	25202	12	4	1610	396	0.2%	3.0%	19.7%	12/26	25202	24	0	1350	394	0.0%	6.1%	22.6%
12/13	25202	8	0	654	169	0.0%	4.7%	20.5%	12/27	25202	0	0	597	138	0.0%	0.0%	18.8%
12/14	25202	0	0	385	57	0.0%	0.0%	12.9%	12/28	25202	0	0	403	88	0.0%	0.0%	17.9%
												QoS Metrics					
				NTCHD		NBC		NCS		NHO		PCB		PHD		HO/CP	
AVERAGE VALUES				10.41724		1.3103448		849.14736		256.7914		0.15%		4.06%		23.22%	
OVERALL GRADE OF SERVICE															**1.06%**		

Table A2.6 Basic analysis ofOperator One Busy Hour data for Kisumu Town

NON BH DATA ANALYSIS FOR OPERATOR ONE -KISUMU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
9/28	15000	8	0	1538	918	0.0%	0.9%	37.4%	11/6	15000	24	0	871	829	0.0%	2.9%	48.8%
9/29	15000	16	0	1654	847	0.0%	1.9%	33.9%	11/7	15000	16	0	596	417	0.0%	3.8%	41.2%
9/30	15000	12	0	1504	893	0.0%	1.3%	37.3%	11/8	15000	28	0	1908	1066	0.0%	2.6%	35.8%
10/1	15000	8	0	2755	1164	0.0%	0.7%	29.7%	11/9	15000	16	0	1716	919	0.0%	1.7%	34.9%
10/2	15000	20	0	1544	787	0.0%	2.5%	33.8%	11/10	15000	12	0	2632	976	0.0%	1.2%	27.1%
10/3	15000	8	0	626	459	0.0%	1.7%	42.3%	11/11	15000	8	0	1554	1064	0.0%	0.8%	40.6%
10/4	15000	12	0	1757	1064	0.0%	1.1%	37.7%	11/12	15000	12	0	1749	1066	0.0%	1.1%	37.9%
10/5	15000	12	0	2640	1007	0.0%	1.2%	27.6%	11/13	15000	24	0	1372	773	0.0%	3.1%	36.0%
10/6	15000	12	0	1799	1001	0.0%	1.2%	35.8%	11/14	15000	4	0	521	440	0.0%	0.9%	45.8%
10/7	15000	8	0	1642	872	0.0%	0.9%	34.7%	11/15	15000	24	0	1597	1020	0.0%	2.4%	39.0%
10/8	15000	12	0	1879	1073	0.0%	1.1%	36.3%	11/16	15000	28	0	1548	940	0.0%	3.0%	37.8%
10/9	15000	12	0	1457	814	0.0%	1.5%	35.8%	11/17	15000	12	0	1577	916	0.0%	1.3%	36.7%
10/10	15000	4	0	589	352	0.0%	1.1%	37.4%	11/18	15000	28	0	1725	1018	0.0%	2.8%	37.1%
10/11	15000	20	0	1746	943	0.0%	2.1%	35.1%	11/19	15000	0	0	1848	1105	0.0%	0.0%	37.4%
10/12	15000	12	0	1437	887	0.0%	1.4%	38.2%	11/20	15000	24	0	1437	798	0.0%	3.0%	35.7%
10/13	15000	16	0	1518	915	0.0%	1.7%	37.6%	11/21	15000	12	0	684	372	0.0%	3.2%	35.2%
10/14	15000	16	0	1459	973	0.0%	1.6%	40.0%	11/22	15000	12	0	1765	1058	0.0%	1.1%	37.5%
10/15	15000	8	0	1562	1052	0.0%	0.8%	40.2%	11/23	15000	8	0	1663	988	0.0%	0.8%	37.3%
10/16	15000	8	0	1351	738	0.0%	1.1%	35.3%	11/24	15000	20	0	1609	927	0.0%	2.2%	36.6%
10/17	15000	8	0	537	355	0.0%	2.3%	39.8%	11/25	15000	12	0	1551	996	0.0%	1.2%	39.1%
10/18	15000	16	0	1728	980	0.0%	1.6%	36.2%	11/26	15000	20	0	1820	1083	0.0%	1.8%	37.3%
10/19	15000	16	0	1593	957	0.0%	1.7%	37.5%	11/27	15000	8	0	1318	637	0.0%	1.3%	32.6%
10/20	15000	24	0	856	535	0.0%	4.5%	38.5%	11/28	15000	0	0	469	274	0.0%	0.0%	36.9%
10/21	15000	24	0	1539	874	0.0%	2.7%	36.2%	11/29	15000	20	0	932	1164	0.0%	1.7%	55.5%
10/22	15000	16	0	1471	981	0.0%	1.6%	40.0%	11/30	15000	0	0	2098	1006	0.0%	0.0%	32.4%
10/23	15000	4	0	1635	765	0.0%	0.5%	31.9%	12/1	15000	8	0	1912	1191	0.0%	0.7%	38.4%
10/24	15000	12	0	1347	313	0.0%	3.8%	18.9%	12/2	15000	20	0	1897	1083	0.0%	1.8%	36.3%
10/25	15000	20	0	1167	896	0.0%	2.2%	43.4%	12/3	15000	8	0	1996	1354	0.0%	0.6%	40.4%
10/26	15000	8	0	1467	813	0.0%	1.0%	35.7%	12/4	15000	12	0	1617	820	0.0%	1.5%	33.6%
10/27	15000	8	0	1369	793	0.0%	1.0%	36.7%	12/5	15000	0	0	738	350	0.0%	0.0%	32.2%
10/28	15000	4	0	1541	944	0.0%	0.4%	38.0%	12/6	15000	20	0	2014	1199	0.0%	1.7%	37.3%
10/29	15000	12	0	1690	1043	0.0%	1.2%	38.2%	12/7	15000	16	0	1991	1145	0.0%	1.4%	36.5%
10/30	15000	0	0	1809	777	0.0%	0.0%	30.0%	12/8	15000	28	0	1741	1091	0.0%	2.6%	38.5%
10/31	15000	4	0	2563	445	0.0%	0.9%	14.8%	12/9	15000	16	0	1925	1045	0.0%	1.5%	35.2%
11/1	15000	28	0	1663	953	0.0%	2.9%	36.4%	12/10	15000	20	0	2057	1173	0.0%	1.7%	36.3%
11/2	15000	24	0	1823	959	0.0%	2.5%	34.5%	12/11	15000	0	0	1522	896	0.0%	0.0%	37.1%
11/3	15000	28	0	1727	1111	0.0%	2.5%	39.1%	12/12	15000	16	0	723	401	0.0%	4.0%	35.7%
11/4	15000	32	0	1809	1091	0.0%	2.9%	37.6%	12/13	15000	12	0	1149	569	0.0%	2.1%	33.1%
11/5	15000	4	0	1146	1292	0.0%	0.3%	53.0%	12/14	15000	24	0	1900	1125	0.0%	2.1%	37.2%
12/15	15000	8	0	1815	1011	0.0%	0.8%	35.8%	10/23	40170	4	64	2600	1746	2.5%	0.2%	40.2%
12/16	15000	8	0	1671	980	0.0%	0.8%	37.0%	10/24	40170	4	0	1311	463	0.0%	0.9%	26.1%
12/17	15000	20	0	2007	1140	0.0%	1.8%	36.2%	10/25	40170	12	100	1131	1701	8.8%	0.7%	60.1%
12/18	15000	4	0	1333	857	0.0%	0.5%	39.1%	10/26	40170	28	100	2424	1948	4.1%	1.4%	44.6%
12/19	15000	12	0	595	391	0.0%	3.1%	39.7%	10/27	40170	16	108	2346	1772	4.6%	0.9%	43.0%
12/20	15000	12	0	2053	1152	0.0%	1.0%	35.9%	10/28	40170	4	88	2251	1853	3.9%	0.2%	45.2%
12/21	15000	16	0	2043	1042	0.0%	1.5%	33.8%	10/29	40170	16	116	2534	2074	4.6%	0.8%	45.0%
12/22	15000	8	0	2021	1071	0.0%	0.7%	34.6%	10/30	40170	12	108	2612	1904	4.1%	0.6%	42.2%
12/23	15000	20	0	1980	1152	0.0%	1.7%	36.8%	10/31	40170	16	0	448	466	0.0%	3.4%	51.0%

NON BH DATA ANALYSIS FOR OPERATOR ONE -KISUMU TOWN

Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
12/24	15000	8	0	2233	1086	0.0%	0.7%	32.7%	11/1	40170	20	164	2865	2040	5.7%	1.0%	41.6%
12/25	15000	24	0	1291	580	0.0%	4.1%	31.0%	11/2	40170	4	128	2499	1828	5.1%	0.2%	42.2%
12/26	15000	8	0	462	325	0.0%	2.5%	41.3%	11/3	40170	8	148	2780	1872	5.3%	0.4%	40.2%
12/27	15000	16	0	1332	905	0.0%	1.8%	40.5%	11/4	40170	8	128	2641	2060	4.8%	0.4%	43.8%
12/28	15000	4	0	1709	911	0.0%	0.4%	34.8%	11/5	40170	6	80	1091	2294	7.3%	0.3%	67.8%
9/28	40170	4	88	2383	1798	3.7%	0.2%	43.0%	11/6	40170	4	144	816	2262	17.6%	0.2%	73.5%
9/29	40170	16	88	2378	1815	3.7%	0.9%	43.3%	11/7	40170	4	0	541	605	0.0%	0.7%	52.8%
9/30	40170	0	132	2431	2023	5.4%	0.0%	45.4%	11/8	40170	20	240	2715	2351	8.8%	0.9%	46.4%
10/1	40170	0	164	763	1946	21.5%	0.0%	71.8%	11/9	40170	16	152	2412	1908	6.3%	0.8%	44.2%
10/2	40170	20	92	2642	1841	3.5%	1.1%	41.1%	11/10	40170	12	128	2486	1776	5.1%	0.7%	41.7%
10/3	40170	0	0	580	513	0.0%	0.0%	46.9%	11/11	40170	20	140	2739	2177	5.1%	0.9%	44.3%
10/4	40170	20	164	2882	2230	5.7%	0.9%	43.6%	11/12	40170	12	180	3096	2132	5.8%	0.6%	40.8%
10/5	40170	8	124	514	2083	24.1%	0.4%	80.2%	11/13	40170	0	84	2616	1814	3.2%	0.0%	40.9%
10/6	40170	4	148	2552	1923	5.8%	0.2%	43.0%	11/14	40170	4	0	457	430	0.0%	0.9%	48.5%
10/7	40170	12	108	2557	2227	4.2%	0.5%	46.6%	11/15	40170	4	164	2730	2041	6.0%	0.2%	42.8%
10/8	40170	12	132	2792	2113	4.7%	0.6%	43.1%	11/16	40170	28	184	2444	2064	7.5%	1.4%	45.8%
10/9	40170	4	92	2518	1760	3.7%	0.2%	41.1%	11/17	40170	16	132	2648	2150	5.0%	0.7%	44.8%
10/10	40170	4	0	394	401	0.0%	1.0%	50.4%	11/18	40170	4	192	2461	1949	7.8%	0.2%	44.2%
10/11	40170	28	132	2513	2056	5.3%	1.4%	45.0%	11/19	40170	8	156	2599	2092	6.0%	0.4%	44.6%
10/12	40170	4	52	2331	1875	2.2%	0.2%	44.6%	11/20	40170	36	60	2265	1903	2.6%	1.9%	45.7%
10/13	40170	12	56	2218	1878	2.5%	0.6%	45.8%	11/21	40170	0	0	445	362	0.0%	0.0%	44.9%
10/14	40170	4	84	2423	1871	3.5%	0.2%	43.6%	11/22	40170	44	100	2751	2066	3.6%	2.1%	42.9%
10/15	40170	12	96	2434	1910	3.9%	0.6%	44.0%	11/23	40170	4	116	2357	1966	4.9%	0.2%	45.5%
10/16	40170	12	108	2504	1911	4.3%	0.6%	43.3%	11/24	40170	12	88	2400	1898	3.7%	0.6%	44.2%
10/17	40170	0	0	461	364	0.0%	0.0%	44.1%	11/25	40170	0	112	2541	1907	4.4%	0.0%	42.9%
10/18	40170	12	140	2607	2213	5.4%	0.5%	45.9%	11/26	40170	36	268	2670	1959	10.0%	1.8%	42.3%
10/19	40170	12	176	2644	2194	6.7%	0.5%	45.3%	11/27	40170	40	88	2415	1702	3.6%	2.4%	41.3%
10/20	40170	8	0	862	756	0.0%	1.1%	46.7%	11/28	40170	4	0	414	378	0.0%	1.1%	47.7%
10/21	40170	4	72	2118	1807	3.4%	0.2%	46.0%	11/29	40170	4	236	1303	2146	18.1%	0.2%	62.2%
10/22	40170	20	116	2478	1865	4.7%	1.1%	42.9%	11/30	40170	20	176	2382	2066	7.4%	1.0%	46.4%
12/1	40170	20	172	2755	2030	6.2%	1.0%	42.4%	10/9	40171	32	0	2214	1185	0.0%	2.7%	34.9%
12/2	40170	0	236	2909	2059	8.1%	0.0%	41.4%	10/10	40171	4	0	764	355	0.0%	1.1%	31.7%
12/3	40170	20	240	2933	2131	8.2%	0.9%	42.1%	10/11	40171	12	8	2455	1319	0.3%	0.9%	34.9%
12/4	40170	16	204	2920	2204	7.0%	0.7%	43.0%	10/12	40171	12	0	1967	1306	0.0%	0.9%	39.9%
12/5	40170	8	0	532	721	0.0%	1.1%	57.5%	10/13	40171	4	4	2010	1067	0.2%	0.4%	34.7%
12/6	40170	20	256	3130	2168	8.2%	0.9%	40.9%	10/14	40171	16	0	2455	1470	0.0%	1.1%	37.5%
12/7	40170	32	180	2799	2072	6.4%	1.5%	42.5%	10/15	40171	4	8	2363	1315	0.3%	0.3%	35.8%
12/8	40170	8	188	2652	1996	7.1%	0.4%	42.9%	10/16	40171	20	0	1869	1156	0.0%	1.7%	38.2%
12/9	40170	24	140	2671	2062	5.2%	1.2%	43.6%	10/17	40171	0	0	815	353	0.0%	0.0%	30.2%
12/10	40170	32	240	2731	2129	8.8%	1.5%	43.8%	10/18	40171	8	0	2233	1304	0.0%	0.6%	36.9%
12/11	40170	32	84	2596	1941	3.2%	1.6%	42.8%	10/19	40171	20	0	2305	1204	0.0%	1.7%	34.3%
12/12	40170	0	0	437	427	0.0%	0.0%	49.4%	10/20	40171	8	0	992	495	0.0%	1.6%	33.3%
12/13	40170	16	0	1080	868	0.0%	1.8%	44.6%	10/21	40171	16	0	2148	1285	0.0%	1.2%	37.4%
12/14	40170	16	272	3002	2195	9.1%	0.7%	42.2%	10/22	40171	0	8	2225	1216	0.4%	0.0%	35.3%
12/15	40170	16	124	2534	1971	4.9%	0.8%	43.8%	10/23	40171	8	0	1798	1041	0.0%	0.8%	36.7%
12/16	40170	4	184	2330	1936	7.9%	0.2%	45.4%	10/24	40171	16	0	1275	301	0.0%	5.3%	19.1%
12/17	40170	20	240	2683	2154	8.9%	0.9%	44.5%	10/25	40171	20	4	1095	1059	0.4%	1.9%	49.2%
12/18	40170	12	80	2536	1781	3.2%	0.7%	41.3%	10/26	40171	12	0	2058	1058	0.0%	1.1%	34.0%

NON BH DATA ANALYSIS FOR OPERATOR ONE -KISUMU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
12/19	40170	4	0	468	442	0.0%	0.9%	48.6%	10/27	40171	8	4	2121	1188	0.2%	0.7%	35.9%
12/20	40170	12	260	2914	2147	8.9%	0.6%	42.4%	10/28	40171	12	8	2033	1096	0.4%	1.1%	35.0%
12/21	40170	12	336	3224	2322	10.4%	0.5%	41.9%	10/29	40171	0	16	2201	1179	0.7%	0.0%	34.9%
12/22	40170	20	284	3069	2134	9.3%	0.9%	41.0%	10/30	40171	8	0	2071	1237	0.0%	0.6%	37.4%
12/23	40170	24	84	3139	2238	2.7%	1.1%	41.6%	10/31	40171	0	0	1333	300	0.0%	0.0%	18.4%
12/24	40170	16	96	3071	2296	3.1%	0.7%	42.8%	11/1	40171	12	4	2453	1369	0.2%	0.9%	35.8%
12/25	40170	12	0	423	305	0.0%	3.9%	41.9%	11/2	40171	12	0	2177	1071	0.0%	1.1%	33.0%
12/26	40170	0	0	343	275	0.0%	0.0%	44.5%	11/3	40171	16	8	2278	1111	0.4%	1.4%	32.8%
12/27	40170	12	0	1755	1319	0.0%	0.9%	42.9%	11/4	40171	4	4	2403	1269	0.2%	0.3%	34.6%
12/28	40170	20	0	2405	2037	0.0%	1.0%	45.9%	11/5	40171	6	30	1036	1476	2.9%	0.4%	58.8%
9/28	40171	32	8	2283	1201	0.4%	2.7%	34.5%	11/6	40171	4	8	761	1323	1.1%	0.3%	63.5%
9/29	40171	4	4	2025	1040	0.2%	0.4%	33.9%	11/7	40171	8	0	856	407	0.0%	2.0%	32.2%
9/30	40171	4	12	2291	1394	0.5%	0.3%	37.8%	11/8	40171	4	16	2474	1351	0.6%	0.3%	35.3%
10/1	40171	16	0	701	1307	0.0%	1.2%	65.1%	11/9	40171	16	16	2187	1248	0.7%	1.3%	36.3%
10/2	40171	8	0	2140	1076	0.0%	0.7%	33.5%	11/10	40171	24	4	1340	1264	0.3%	1.9%	48.5%
10/3	40171	4	0	701	507	0.0%	0.8%	42.0%	11/11	40171	4	24	2246	1323	1.1%	0.3%	37.1%
10/4	40171	4	8	2484	1471	0.3%	0.3%	37.2%	11/12	40171	4	8	2671	1253	0.3%	0.3%	31.9%
10/5	40171	4	8	1388	1298	0.6%	0.3%	48.3%	11/13	40171	0	0	1951	1169	0.0%	0.0%	37.5%
10/6	40171	12	4	2471	1254	0.2%	1.0%	33.7%	11/14	40171	4	0	712	377	0.0%	1.1%	34.6%
10/7	40171	8	0	2246	1202	0.0%	0.7%	34.9%	11/15	40171	12	4	2466	1216	0.2%	1.0%	33.0%
10/8	40171	28	8	2536	1260	0.3%	2.2%	33.2%	11/16	40171	4	0	2145	1408	0.0%	0.3%	39.6%
11/17	40171	8	0	2180	1169	0.0%	0.7%	34.9%	12/26	40171	0	0	709	356	0.0%	0.0%	33.4%
11/18	40171	4	12	2095	1184	0.6%	0.3%	36.1%	12/27	40171	24	0	1362	675	0.0%	3.6%	33.1%
11/19	40171	0	0	2347	1184	0.0%	0.0%	33.5%	12/28	40171	16	8	2535	1328	0.3%	1.2%	34.4%
11/20	40171	8	0	1998	1268	0.0%	0.6%	38.8%	9/28	42272	12	16	803	666	2.0%	1.8%	45.3%
11/21	40171	0	0	634	354	0.0%	0.0%	35.8%	9/29	42272	32	40	757	674	5.3%	4.7%	47.1%
11/22	40171	12	8	2428	1236	0.3%	1.0%	33.7%	9/30	42272	0	40	739	784	5.4%	0.0%	51.5%
11/23	40171	32	8	2534	1187	0.3%	2.7%	31.9%	10/1	42272	12	0	143	714	0.0%	1.7%	83.3%
11/24	40171	0	0	2201	1223	0.0%	0.0%	35.7%	10/2	42272	12	0	736	556	0.0%	2.2%	43.0%
11/25	40171	0	12	2118	1192	0.6%	0.0%	36.0%	10/3	42272	8	0	143	161	0.0%	5.0%	53.0%
11/26	40171	8	8	2435	1296	0.3%	0.6%	34.7%	10/4	42272	28	116	892	840	13.0%	3.3%	48.5%
11/27	40171	28	0	2073	1139	0.0%	2.5%	35.5%	10/5	42272	16	32	293	853	10.9%	1.9%	74.4%
11/28	40171	12	0	731	463	0.0%	2.6%	38.8%	10/6	42272	20	48	850	684	5.6%	2.9%	44.6%
11/29	40171	20	28	1674	1376	1.7%	1.5%	45.1%	10/7	42272	44	36	875	725	4.1%	6.1%	45.3%
11/30	40171	16	12	2626	1214	0.5%	1.3%	31.6%	10/8	42272	32	88	843	897	10.4%	3.6%	51.6%
12/1	40171	28	16	2674	1255	0.6%	2.2%	31.9%	10/9	42272	44	0	851	577	0.0%	7.6%	40.4%
12/2	40171	44	12	2451	1320	0.5%	3.3%	35.0%	10/10	42272	4	0	119	188	0.0%	2.1%	61.2%
12/3	40171	8	8	2709	1429	0.3%	0.6%	34.5%	10/11	42272	20	76	862	792	8.8%	2.5%	47.9%
12/4	40171	8	0	2086	1335	0.0%	0.6%	39.0%	10/12	42272	12	32	816	676	3.9%	1.8%	45.3%
12/5	40171	8	0	863	428	0.0%	1.9%	33.2%	10/13	42272	20	28	754	719	3.7%	2.8%	48.8%
12/6	40171	0	20	2788	1482	0.7%	0.0%	34.7%	10/14	42272	40	28	761	622	3.7%	6.4%	45.0%
12/7	40171	16	32	2626	1425	1.2%	1.1%	35.2%	10/15	42272	12	52	809	773	6.4%	1.6%	48.9%
12/8	40171	16	8	2491	1249	0.3%	1.3%	33.4%	10/16	42272	24	0	741	598	0.0%	4.0%	44.7%
12/9	40171	16	24	2472	1348	1.0%	1.2%	35.3%	10/17	42272	40	0	148	144	0.0%	27.8%	49.3%
12/10	40171	20	8	2618	1364	0.3%	1.5%	34.3%	10/18	42272	24	20	866	696	2.3%	3.4%	44.6%
12/11	40171	28	0	2220	1259	0.0%	2.2%	36.2%	10/19	42272	28	20	949	722	2.1%	3.9%	43.2%
12/12	40171	8	0	798	447	0.0%	1.8%	35.9%	10/20	42272	16	0	297	265	0.0%	6.0%	47.2%
12/13	40171	0	0	1107	558	0.0%	0.0%	33.5%	10/21	42272	28	28	778	874	3.6%	3.2%	52.9%

NON BH DATA ANALYSIS FOR OPERATOR ONE -KISUMU TOWN																	
Date	CI	NT CH D	NB C	N CS	N HO	QoS Metrics		HO/ CP	Date	CI	N TC H D	NB C	NCS	NH O	QoS Metrics		HO/ CP
						PCB	PHD								PCB	PHD	
12/14	40171	12	24	2686	1381	0.9%	0.9%	34.0%	10/22	42272	32	16	811	711	2.0%	4.5%	46.7%
12/15	40171	28	24	2546	1454	0.9%	1.9%	36.4%	10/23	42272	20	0	733	555	0.0%	3.6%	43.1%
12/16	40171	20	4	2180	1171	0.2%	1.7%	34.9%	10/24	42272	12	0	1239	164	0.0%	7.3%	11.7%
12/17	40171	16	0	2394	1186	0.0%	1.3%	33.1%	10/25	42272	44	20	1059	548	1.9%	8.0%	34.1%
12/18	40171	16	0	2217	1206	0.0%	1.3%	35.2%	10/26	42272	24	48	770	730	6.2%	3.3%	48.7%
12/19	40171	0	0	796	540	0.0%	0.0%	40.4%	10/27	42272	28	8	757	619	1.1%	4.5%	45.0%
12/20	40171	20	8	2752	1356	0.3%	1.5%	33.0%	10/28	42272	40	40	811	734	4.9%	5.4%	47.5%
12/21	40171	12	8	2709	1445	0.3%	0.8%	34.8%	10/29	42272	16	24	833	692	2.9%	2.3%	45.4%
12/22	40171	8	8	2899	1521	0.3%	0.5%	34.4%	10/30	42272	20	20	793	615	2.5%	3.3%	43.7%
12/23	40171	12	12	2732	1465	0.4%	0.8%	34.9%	10/31	42272	24	0	1218	236	0.0%	10.2%	16.2%
12/24	40171	16	28	2674	1453	1.0%	1.1%	35.2%	11/1	42272	36	112	797	748	14%	4.8%	48.4%
12/25	40171	16	0	917	494	0.0%	3.2%	35.0%	11/2	42272	24	32	829	731	3.9%	3.3%	46.9%
11/3	42272	28	40	863	780	4.6%	3.6%	47.5%	12/12	42272	28	0	143	193	0.0%	14.5%	57.4%
11/4	42272	8	8	803	754	1.0%	1.1%	48.4%	12/13	42272	24	0	307	263	0.0%	9.1%	46.1%
11/5	42272	6	22	981	756	2.2%	0.8%	43.5%	12/14	42272	32	104	1023	818	10.2%	3.9%	44.4%
11/6	42272	32	12	706	633	1.7%	5.1%	47.3%	12/15	42272	20	80	901	718	8.9%	2.8%	44.3%
11/7	42272	32	0	152	192	0.0%	16.7%	55.8%	12/16	42272	20	52	913	667	5.7%	3.0%	42.2%
11/8	42272	28	84	934	808	9.0%	3.5%	46.4%	12/17	42272	36	52	931	685	5.6%	5.3%	42.4%
11/9	42272	16	28	924	755	3.0%	2.1%	45.0%	12/18	42272	16	0	767	480	0.0%	3.3%	38.5%
11/10	42272	16	20	1194	706	1.7%	2.3%	37.2%	12/19	42272	36	0	130	154	0.0%	23.4%	54.2%
11/11	42272	28	84	815	766	10.3%	3.7%	48.5%	12/20	42272	40	68	932	639	7.3%	6.3%	40.7%
11/12	42272	28	52	924	761	5.6%	3.7%	45.2%	12/21	42272	20	48	922	676	5.2%	3.0%	42.3%
11/13	42272	24	16	845	515	1.9%	4.7%	37.9%	12/22	42272	16	32	942	575	3.4%	2.8%	37.9%
11/14	42272	8	0	159	206	0.0%	3.9%	56.4%	12/23	42272	28	76	968	691	7.9%	4.1%	41.7%
11/15	42272	32	72	899	776	8.0%	4.1%	46.3%	12/24	42272	32	32	947	701	3.4%	4.6%	42.5%
11/16	42272	28	16	806	716	2.0%	3.9%	47.0%	12/25	42272	36	0	177	257	0.0%	14.0%	59.2%
11/17	42272	8	24	761	696	3.2%	1.1%	47.8%	12/26	42272	20	0	126	169	0.0%	11.8%	57.3%
11/18	42272	36	8	816	750	1.0%	4.8%	47.9%	12/27	42272	48	0	536	347	0.0%	13.8%	39.3%
11/19	42272	28	8	774	769	1.0%	3.6%	49.8%	12/28	42272	24	0	781	561	0.0%	4.3%	41.8%
11/20	42272	20	32	710	555	4.5%	3.6%	43.9%	9/28	42281	8	120	1665	1324	7.2%	0.6%	44.3%
11/21	42272	16	0	144	234	0.0%	6.8%	61.9%	9/29	42281	8	68	1598	1203	4.3%	0.7%	42.9%
11/22	42272	56	120	921	831	13.0%	6.7%	47.4%	9/30	42281	8	96	1747	1171	5.5%	0.7%	40.1%
11/23	42272	20	52	987	743	5.3%	2.7%	99.9%	10/1	42281	16	32	446	1306	7.2%	1.2%	74.5%
11/24	42272	32	32	695	607	4.6%	5.3%	46.6%	10/2	42281	0	72	1799	1368	4.0%	0.0%	43.2%
11/25	42272	28	36	862	650	4.2%	4.3%	43.0%	10/3	42281	4	0	642	496	0.0%	0.8%	43.6%
11/26	42272	52	16	774	724	2.1%	7.2%	48.3%	10/4	42281	12	48	1766	1352	2.7%	0.9%	43.4%
11/27	42272	36	4	715	503	0.6%	7.2%	41.3%	10/5	42281	16	56	1046	1373	5.4%	1.2%	56.8%
11/28	42272	20	0	190	149	0.0%	13.4%	44.0%	10/6	42281	16	32	1567	1240	2.0%	1.3%	44.2%
11/29	42272	32	64	2045	682	3.1%	4.7%	25.0%	10/7	42281	0	28	1794	1243	1.6%	0.0%	40.9%
11/30	42272	40	92	889	752	10.3%	5.3%	45.8%	10/8	42281	4	64	1726	1191	3.7%	0.3%	40.8%
12/1	42272	36	56	924	750	6.1%	4.8%	44.8%	10/9	42281	16	4	1739	1204	0.2%	1.3%	40.9%
12/2	42272	36	32	829	716	3.9%	5.0%	46.3%	10/10	42281	0	4	467	454	0.9%	0.0%	49.3%
12/3	42272	32	16	860	731	1.9%	4.4%	45.9%	10/11	42281	20	80	1828	1363	4.4%	1.5%	42.7%
12/4	42272	32	32	903	561	3.5%	5.7%	38.3%	10/12	42281	8	64	1679	1245	3.8%	0.6%	42.6%
12/5	42272	20	0	181	176	0.0%	11.4%	49.3%	10/13	42281	4	36	1467	1260	2.5%	0.3%	46.2%
12/6	42272	36	48	978	773	4.9%	4.7%	44.1%	10/14	42281	8	80	1647	1258	4.9%	0.6%	43.3%
12/7	42272	44	28	894	735	3.1%	6.0%	45.1%	10/15	42281	20	36	1742	1369	2.1%	1.5%	44.0%
12/8	42272	24	24	794	694	3.0%	3.5%	46.6%	10/16	42281	0	4	1632	1253	0.2%	0.0%	43.4%

NON BH DATA ANALYSIS FOR OPERATOR ONE -KISUMU TOWN																	
Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP	Date	CI	NTCHD	NBC	NCS	NHO	QoS Metrics		HO/CP
						PCB	PHD								PCB	PHD	
12/9	42272	28	48	866	746	5.5%	3.8%	46.3%	10/17	42281	16	0	467	386	0.0%	4.1%	45.3%
12/10	42272	24	12	836	677	1.4%	3.5%	44.7%	10/18	42281	8	28	1629	1208	1.7%	0.7%	42.6%
12/11	42272	32	4	899	569	0.4%	5.6%	38.8%	10/19	42281	0	20	1716	1293	1.2%	0.0%	43.0%
10/20	42281	4	4	726	719	0.6%	0.6%	49.8%	11/24	42281	16	24	1644	1179	1.5%	1.4%	41.8%
10/21	42281	4	40	1658	1277	2.4%	0.3%	43.5%	11/25	42281	12	64	1765	1146	3.6%	1.0%	39.4%
10/22	42281	4	28	1621	1226	1.7%	0.3%	43.1%	11/26	42281	12	64	1692	1197	3.8%	1.0%	41.4%
10/23	42281	8	52	1726	1202	3.0%	0.7%	41.1%	11/27	42281	8	96	1702	1115	5.6%	0.7%	39.6%
10/24	42281	0	0	1203	451	0.0%	0.0%	27.3%	11/28	42281	0	0	561	368	0.0%	0.0%	39.6%
10/25	42281	8	20	510	1253	3.9%	0.6%	71.1%	11/29	42281	8	140	2416	1348	5.8%	0.6%	35.8%
10/26	42281	0	44	1594	1158	2.8%	0.0%	42.1%	11/30	42281	12	36	1875	1296	1.9%	0.9%	40.9%
10/27	42281	12	28	1610	1138	1.7%	1.1%	41.4%	12/1	42281	8	56	1726	1173	3.2%	0.7%	40.5%
10/28	42281	148	32	1666	1167	1.9%	12.7%	41.2%	12/2	42281	12	124	1768	1262	7.0%	1.0%	41.7%
10/29	42281	4	36	1659	1212	2.2%	0.3%	42.2%	12/3	42281	28	108	1849	1326	5.8%	2.1%	41.8%
10/30	42281	4	4	1678	1288	0.2%	0.3%	43.4%	12/4	42281	12	172	1865	1271	9.2%	0.9%	40.5%
10/31	42281	4	0	461	437	0.0%	0.9%	48.7%	12/5	42281	4	0	413	377	0.0%	1.1%	47.7%
11/1	42281	12	56	1809	1247	3.1%	1.0%	40.8%	12/6	42281	12	92	1985	1345	4.6%	0.9%	40.4%
11/2	42281	36	56	1925	1303	2.9%	2.8%	40.4%	12/7	42281	20	84	1743	1239	4.8%	1.6%	41.5%
11/3	42281	24	76	1802	1181	4.2%	2.0%	39.6%	12/8	42281	16	108	1873	1268	5.8%	1.3%	40.4%
11/4	42281	16	100	1724	1288	5.8%	1.2%	42.8%	12/9	42281	12	140	1847	1203	7.6%	1.0%	39.4%
11/5	42281	10	44	926	1277	4.8%	0.8%	58.0%	12/10	42281	4	72	1952	1267	3.7%	0.3%	39.4%
11/6	42281	24	28	651	1349	4.3%	1.8%	67.5%	12/11	42281	16	24	1804	1230	1.3%	1.3%	40.5%
11/7	42281	0	0	593	539	0.0%	0.0%	47.6%	12/12	42281	0	0	472	385	0.0%	0.0%	44.9%
11/8	42281	4	116	1811	1267	6.4%	0.3%	41.2%	12/13	42281	12	0	924	729	0.0%	1.6%	44.1%
11/9	42281	0	44	1778	1270	2.5%	0.0%	41.7%	12/14	42281	16	108	1955	1400	5.5%	1.1%	41.7%
11/10	42281	16	60	369	1276	16.3%	1.3%	77.6%	12/15	42281	12	84	1854	1282	4.5%	0.9%	40.9%
11/11	42281	8	52	1717	1199	3.0%	0.7%	41.1%	12/16	42281	28	76	1820	1256	4.2%	2.2%	40.8%
11/12	42281	16	160	1817	1398	8.8%	1.1%	43.5%	12/17	42281	20	120	1995	1337	6.0%	1.5%	40.1%
11/13	42281	12	64	1724	1210	3.7%	1.0%	41.2%	12/18	42281	20	164	1780	1342	9.2%	1.5%	43.0%
11/14	42281	0	0	516	549	0.0%	0.0%	51.5%	12/19	42281	4	0	560	408	0.0%	1.0%	42.1%
11/15	42281	8	120	1833	1354	6.5%	0.6%	42.5%	12/20	42281	16	160	1952	1441	8.2%	1.1%	42.5%
11/16	42281	8	40	1683	1301	2.4%	0.6%	43.6%	12/21	42281	16	108	1920	1274	5.6%	1.3%	39.9%
11/17	42281	16	48	1540	1181	3.1%	1.4%	43.4%	12/22	42281	20	52	1981	1301	2.6%	1.5%	39.6%
11/18	42281	4	48	1474	1148	3.3%	0.3%	43.8%	12/23	42281	24	16	1982	1396	0.8%	1.7%	41.3%
11/19	42281	8	120	1947	1342	6.2%	0.6%	40.8%	12/24	42281	16	16	1863	1253	0.9%	1.3%	40.2%
11/20	42281	12	44	1602	1120	2.7%	1.1%	41.1%	12/25	42281	24	0	823	602	0.0%	4.0%	42.2%
11/21	42281	4	0	441	400	0.0%	1.0%	47.6%	12/26	42281	0	0	384	388	0.0%	0.0%	50.3%
11/22	42281	16	64	1705	1262	3.8%	1.3%	42.5%	12/27	42281	12	0	1160	873	0.0%	1.4%	42.9%
11/23	42281	12	52	1677	1227	3.1%	1.0%	42.3%	12/28	42281	4	92	1666	1229	5.5%	0.3%	42.5%
												QoS Metrics					
				NTCHD		NCB		NCS		NHO		PCB		PHD		HO/CP	
				15.23478		41.678261		1581.587		1093.47		2.64%		1.39%		40.88%	
OVERALL KISUMU TOWN GRADE OF SERVICE													2.13%				

Table A2.7 Basic analysis of Operator Two Busy Hour data for Nairobi Town

BASIC ANALYSIS OF OPERATOR TWO BUSY HOUR DATA FOR NAIROBI TOWN																
CI-041NBAD TRAFFIC LOAD 111.4 ERLANGS								CI-048NBBD TRAFFIC LOAD 75.3 ERLANGS								
DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP	DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP
		NCSR	HOR	TTLR	PCB	PHD				NCSR	HOR	TTLR	PCB	PHD	
2/1	10554	4336	6174	10510	0.0%	0.0%	4380	2/1	7134	3558	2814	6372	0.0%	0.0%	4320
2/2	10554	4280	6265	10545	0.0%	0.0%	4289	2/2	7134	3518	2360	5878	0.0%	0.0%	4774
2/3	10554	4517	6481	10998	1.7%	2.4%	4073	2/3	7134	3784	2571	6355	0.0%	0.0%	4563
2/4	10554	4107	6345	10452	0.0%	0.0%	4209	2/4	7134	3720	2460	6180	0.0%	0.0%	4674
2/5	10554	6068	5850	11918	5.8%	5.6%	4704	2/5	7134	1828	1040	2868	0.0%	0.0%	6094
2/6	10554	3423	3479	6902	0.0%	0.0%	7075	2/6	7134	928	617	1545	0.0%	0.0%	6517
2/7	10554	4708	6886	11594	3.6%	5.3%	3668	2/7	7134	3767	2504	6271	0.0%	0.0%	4630
AVER	10554	4491	5926	10417	0.0%	0.0%	4628	AVER	7134	3015	2052	5067	0.0%	0.0%	5081
CI-041NBBD TRAFFIC LOAD 75.7 ERLANGS								CI-049NBCD TRAFFIC LOAD 74.6 ERLANGS								
2/1	7172	4643	4551	9194	11%	11%	2621	2/1	7067	4059	3837	7896	5.4%	5.1%	3230
2/2	7172	4152	4367	8519	7.7%	8.1%	2805	2/2	7067	4011	4282	8293	7.1%	7.6%	2785
2/3	7172	4609	4232	8841	9.8%	9.0%	2940	2/3	7067	4169	4236	8405	7.9%	8.0%	2831
2/4	7172	4204	3794	7998	5.4%	4.9%	3378	2/4	7067	4012	3923	7935	5.5%	5.4%	3144
2/5	7172	3981	3207	7188	0.1%	0.1%	3965	2/5	7067	3250	2593	5843	0.0%	0.0%	4474
2/6	7172	2898	1883	4781	0.0%	0.0%	5289	2/6	7067	2374	1413	3787	0.0%	0.0%	5654
2/7	7172	4333	3943	8276	7.0%	6.4%	3229	2/7	7067	3724	3925	7649	3.7%	3.9%	3142
AVER	7172	4117	3711	7828	4.4%	4.0%	3461	AVER	7067	3657	3458	7115	0.3%	0.3%	3609
CI-042NBAD TRAFFIC LOAD 146.5 ERLANGS								CI-103NBAD TRAFFIC LOAD 77.2 ERLANGS								
2/1	13879	6889	3603	10492	0.0%	0.0%	10276	2/1	7314	5447	1161	6608	0.0%	0.0%	6153
2/2	13879	7324	3335	10659	0.0%	0.0%	10544	2/2	7314	5365	1177	6542	0.0%	0.0%	6137
2/3	13879	6593	2847	9440	0.0%	0.0%	11032	2/3	7314	5300	1184	6484	0.0%	0.0%	6130
2/4	13879	6131	2967	9098	0.0%	0.0%	10912	2/4	7314	4794	1017	5811	0.0%	0.0%	6297
2/5	13879	7816	3796	11612	0.0%	0.0%	10083	2/5	7314	2858	684	3542	0.0%	0.0%	6630
2/6	13879	5994	2663	8657	0.0%	0.0%	11216	2/6	7314	3190	1240	4430	0.0%	0.0%	6074
2/7	13879	9788	3485	13273	0.0%	0.0%	10394	2/7	7314	4263	1233	5496	0.0%	0.0%	6081
AVER	13879	7219	3242	10462	0.0%	0.0%	10637	AVER	7314	4460	1099	5559	0.0%	0.0%	6214
CI-043NBB TRAFFIC LOAD 181 ERLANGS								CI-108NBA TRAFFIC LOAD 174.3 ERLANGS								
2/1	17147	17821	2783	20604	14.5%	2.3%	14364	2/1	16513	13940	1361	15301	0.0%	0.0%	15152
2/2	17147	15863	2508	18371	5.8%	0.9%	14639	2/2	16513	20164	2681	22845	24.5%	3.3%	13832
2/3	17147	10773	2376	13149	0.0%	0.0%	14771	2/3	16513	20691	2961	23652	26.4%	3.8%	13552
2/4	17147	10634	2210	12844	0.0%	0.0%	14937	2/4	16513	18403	2439	20842	18.3%	2.4%	14074
2/5	17147	17887	2323	20210	13.4%	1.7%	14824	2/5	16513	16867	2272	19139	12.1%	1.6%	14241
2/6	17147	17126	1619	18745	7.8%	0.7%	15528	2/6	16513	15314	1797	17111	3.1%	0.4%	14716
2/7	17147	19877	2299	22176	20.3%	2.4%	14848	2/7	16513	15367	2002	17369	4.4%	0.6%	14511
AVER	17147	15712	2303	18014	4.2%	0.6%	14845	AVER	16513	17249	2216	19466	13.4%	1.7%	14296
CI-048NBAD TRAFFIC LOAD 88.3 ERLANGS								CI-379NBBD TRAFFIC LOAD 100.7 ERLANGS								
2/1	8365	4008	2786	6794	0.0%	0.0%	5579	2/1	9540	4931	4069	9000	0.0%	0.0%	5471
2/2	8365	3384	2244	5628	0.0%	0.0%	6121	2/2	9540	4219	5360	9579	0.2%	0.2%	4180
2/3	8365	3686	2677	6363	0.0%	0.0%	5688	2/3	9540	4844	5100	9944	2.0%	2.1%	4440
2/4	8365	3691	2814	6505	0.0%	0.0%	5551	2/4	9540	5232	5288	10520	4.6%	4.7%	4252
2/5	8365	1716	994	2710	0.0%	0.0%	7371	2/5	9540	4007	3484	7491	0.0%	0.0%	6056
2/6	8365	916	534	1450	0.0%	0.0%	7831	2/6	9540	2509	2279	4788	0.0%	0.0%	7261
2/7	8365	3398	2494	5892	0.0%	0.0%	5871	2/7	9540	4048	5087	9135	0.0%	0.0%	4453
AVER	8365	2971	2078	5049	0.0%	0.0%	6288	AVER	9540	4256	4381	8637	0.0%	0.0%	5159

Table A2.8 Basic analysis of Operator Two Busy Hour data for Nakuru Town

BASIC ANALYSIS OF OPERATOR TWO BUSY HOUR DATA FOR NAKURU TOWN															
CI-500NKC(NJORO) TRAFFIC LOAD 53 ERLANGS								CI-576NKC(MOLO) TRAFFIC LOAD 37 ERLANGS							
DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP	DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP
		NCSR	HOR	TTLR	PCB	PHD				NCSR	HOR	TTLR	PCB	PHD	
2/1	4557	1823	357	2180	-91%	-18%	4200	2/1	3354	2768	551	3319	-0.9%	0%	2803
2/2	5788	1876	360	2236	-133%	-26%	5428	2/2	3486	2737	451	3188	-8.0%	-1%	3035
2/3	4263	1619	287	1906	-105%	-19%	3976	2/3	3979	3079	580	3659	-7.4%	-1%	3399
2/4	5409	1829	309	2138	-131%	-22%	5100	2/4	3884	2797	551	3348	-13%	-3%	3333
2/5	5381	1790	236	2026	-146%	-19%	5145	2/5	3022	2491	489	2980	-1.2%	0%	2533
2/6	4813	1723	425	2148	-100%	-25%	4388	2/6	2558	2165	393	2558	0.0%	0%	2165
2/7	5002	1687	383	2070	-115%	-26%	4619	2/7	3969	3028	615	3643	-7.4%	-2%	3354
AVER	5031	1764	337	2101	-117%	-22%	4694	AVER	3465	2724	519	3242	-5.8%	-1%	2946
CI-552NKB(CHEPSIR) TRAFFIC LOAD 41 ERLANGS								CI-584NKC(LITEIN) TRAFFIC LOAD 69 ERLANGS							
2/1	3382	4220	830	5050	27.6%	5.4%	2552	2/1	6783	6295	1337	7632	9%	2%	5446
2/2	3486	4418	703	5121	27.5%	4.4%	2783	2/2	6205	5901	1202	7103	11%	2%	5003
2/3	3761	4795	781	5576	28.0%	4.6%	2980	2/3	6726	6211	1063	7274	6%	1%	5663
2/4	3941	4798	806	5604	25.4%	4.3%	3135	2/4	6215	6315	1150	7465	14%	3%	5065
2/5	4225	5599	834	6433	29.9%	4.4%	3391	2/5	6726	7097	1211	8308	16%	3%	5515
2/6	4547	5978	888	6866	29.4%	4.4%	3659	2/6	6319	6658	1231	7889	17%	3%	5088
2/7	3941	5071	748	5819	28.1%	4.1%	3193	2/7	6480	6480	1168	7648	13%	2%	5312
AVER	3898	4983	799	5781	28.1%	4.5%	3099	AVER	6494	6422	1195	7617	12%	2%	5299
CI-562NKC(ELDAMARAVINE) TRAFFIC LOAD 41 ERLANGS								CI-670KCBD(KERICHO) TRAFFIC LOAD 43 ERLANGS							
2/1	4083	3164	350	3514	-15%	-2%	3733	2/1	3628	1138	2032	3170	-5.2%	-9%	1596
2/2	4102	3314	248	3562	-14%	-1%	3854	2/2	4112	1101	2328	3429	-6.4%	-14%	1784
2/3	4140	3396	239	3635	-13%	-1%	3901	2/3	4263	1280	2390	3670	-5.6%	-11%	1873
2/4	3865	3337	257	3594	-7%	-1%	3608	2/4	5068	1296	2737	4033	-8.3%	-17%	2331
2/5	4064	3386	232	3618	-12%	-1%	3832	2/5	4292	1207	2647	3854	-3.6%	-8%	1645
2/6	3107	2435	137	2572	-20%	-1%	2970	2/6	3193	911	1843	2754	-5.3%	-11%	1350
2/7	4045	3052	262	3314	-20%	-2%	3783	2/7	4254	1144	2333	3477	-7.3%	-15%	1921
AVER	3915	3155	246	3401	-14%	-1%	3669	AVER	4116	1154	2330	3484	-6.0%	-12%	1786

Table A2.9 Basic analysis for Operator Two Busy Hour data for Mombasa

BASIC ANALYSIS OF OPERATOR TWO BUSY HOUR DATA FOR MOMBASA TOWN

CI-004MSA TRAFFIC LOAD 186 ERLANGS

DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP
		NCSR	HOR	TTLR	PCB	PHD	
2/1	9161	7497	4062	11559	13.5%	7%	5099
2/2	13604	3789	4927	8716	-24%	-32%	8677
2/3	9474	6028	3298	9326	-1.0%	-1%	6176
2/4	7380	6223	3442	9665	15.2%	8%	3938
2/5	9474	7230	2717	9947	3.5%	1%	6757
2/6	6423	3253	1376	4629	-27%	-12%	5047
2/7	9474	6584	3964	10548	6.4%	4%	5510
2/8	76045	46798	23786	70584	-5.1%	-3%	52259
AVER	17629	10925	5947	16872	-2.9%	-2%	11683

CI-406MLC TRAFFIC LOAD 56 ERLANG

DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP
		NCSR	HOR	TTLR	PCB	PHD	
2/1	13737	22910	1050	23960	41%	2%	12687
2/2	15158	23850	888	24738	37%	1%	14270
2/3	19989	19370	699	20069	0%	0%	19290
2/4	26432	22970	942	23912	-10%	0%	25490
2/5	34863	25223	920	26143	-32%	-1%	33943
2/6	46042	23537	1036	24573	-84%	-4%	45006
2/7	60821	23278	1004	24282	-144%	-6%	59817
2/8	80242	161138	6539	167677	50%	2%	73703
AVER	7200	40285	1635	41919	79.6%	3%	5565

CI-008MSB TRAFFIC LOAD 78 ERLANGS

DTE	CC	NCSR	HOR	TTLR	PCB	PHD	HO_EFF_CP
2/1	7389	9564	6919	16483	32.0%	23%	470
2/2	11984	10225	7337	17562	18.5%	13%	4647
2/3	9237	6787	3897	10684	8.6%	5%	5340
2/4	6224	8555	4721	13276	34.2%	19%	1503
2/5	7986	8304	4326	12630	24.2%	13%	3660
2/6	7389	5238	2349	7587	1.8%	1%	5040
2/7	7560	8327	5244	13571	27.2%	17%	2316
2/8	19942	57809	35763	93572	48.6%	30%	-15821
AVER	7389	14351	8820	23171	42.2%	26%	-1430

CI-005MSA TRAFFIC LOAD 76 ERLANGS

DTE	CC	NCSR	HOR	TTLR	PCB	PHD	HO_EFF_CP
2/1	6347	12676	3752	16428	47%	14%	2595
2/2	8432	14226	4007	18233	42%	12%	4425
2/3	5400	11958	2949	14907	51%	13%	2451
2/4	9284	13337	3826	17163	36%	10%	5458
2/5	5400	19510	3563	23073	65%	12%	1837
2/6	6442	14048	2927	16975	51%	11%	3515
2/7	6821	15756	3958	19714	52%	13%	2863
2/8	6442	101511	24982	126493	76%	19%	-18540
AVER	5305	25378	6246	31623	67%	16%	-940

CI-005MSA TRAFFIC LOAD 76 ERLANGS

DTE	CC	NCSR	HOR	TTLR	PCB	PHD	HO_EFF_CP
2/1	7200	16672	7465	24137	48.5%	22%	-265
2/2	7200	22774	8770	31544	55.7%	21%	-1570
2/3	7200	19235	5854	25089	54.7%	17%	1346
2/4	7200	13537	5058	18595	44.6%	17%	2142
2/5	7200	10476	4488	14964	36.3%	16%	2712
2/6	7200	4429	1970	6399	-8.7%	-4%	5230
2/7	7200	17103	5709	22812	51.3%	17%	1491
2/8	7200	104226	39314	143540	69.0%	26%	-32114
AVER	7200	26057	9829	35885	58.0%	22%	-2629

Table A2.10 Basic analysis of Operator Two Busy Hour data for Kisumu Town

BASIC ANALYSIS OF OPERATOR TWO BUSY HOUR DATA FOR KISUMU TOWN																	
CI-103KSB(SIAYA) TRAFFIC LOAD 70 ERLANGS									CI-304KSB(KEUMBU) TRAFFIC LOAD 66 ERLANGS								
DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP		DTE	CC	REQUESTS			QoS Metrics		HO_EFF_CP
		NCSR	HOR	TTLR	PCB	PHD				NCSR	HOR	TTLR	PCB	PHD			
2/1	7731	5456	699	6155	-23%	-3%	7032	2/1	5902	4221	982	5203	-11%	-3%	4920		
2/2	7077	5494	603	6097	-14%	-2%	6474	2/2	3467	2333	461	2794	-20%	-4%	3006		
2/3	6783	5131	641	5772	-16%	-2%	6142	2/3	5760	3473	913	4386	-25%	-7%	4847		
2/4	6452	5540	665	6205	-4%	0%	5787	2/4	6859	4649	984	5633	-18%	-4%	5875		
2/5	5902	4807	585	5392	-8%	-1%	5317	2/5	7408	4963	1155	6118	-17%	-4%	6253		
2/6	6594	5502	681	6183	-6%	-1%	5913	2/6	7020	4650	894	5544	-22%	-4%	6126		
2/7	6082	4902	585	5487	-10%	-1%	5497	2/7	7105	4345	1213	5558	-22%	-6%	5892		
AVER	6660	5262	637	5899	-12%	-1%	6023	AVER	6217	4091	943	5034	-19%	-4%	5274		
CI-106KSA(UGUNJA) TRAFFIC LOAD 75 ERLANGS								CI-315KSA(IGEMEBE) TRAFFIC LOAD 62 ERLANGS									
2/1	5940	5474	1055	6529	8%	1%	4885	2/1	6148	5249	227	5476	-12%	-1%	5921		
2/2	6897	5883	1149	7032	2%	0%	5748	2/2	6063	4916	236	5152	-17%	-1%	5827		
2/3	6736	6096	1226	7322	7%	1%	5510	2/3	5315	4598	244	4842	-9%	0%	5071		
2/4	7437	6851	1458	8309	9%	2%	5979	2/4	6054	4945	202	5147	-17%	-1%	5852		
2/5	7863	6608	1547	8155	3%	1%	6316	2/5	5798	4845	221	5066	-14%	-1%	5577		
2/6	7569	6920	1501	8421	8%	2%	6068	2/6	5466	4069	220	4289	-26%	-1%	5246		
2/7	7569	6782	1376	8158	6%	1%	6193	2/7	6082	5100	243	5343	-13%	-1%	5839		
AVER	7145	6373	1330	7704	6%	1%	5814	AVER	5847	4817	228	5045	-15%	-1%	5619		
CI-138BSA(BUSIA LWERO) TRAFFIC LOAD 77 ERLANGS																	
2/1	6698	5946	1409	7355	7%	2%	5289										
2/2	6385	6073	1424	7497	12%	3%	4961										
2/3	6338	5659	1297	6956	7%	2%	5041										
2/4	7901	6406	1457	7863	0%	0%	6444										
2/5	7465	6349	1232	7581	1%	0%	6233										
2/6	8451	7258	1334	8592	1%	0%	7117										
2/7	7645	6314	1170	7484	-2%	0%	6475										
AVER	7269	6286	1332	7618	4%	1%	5937										

Table A2.11 Secondary analysis of Operator Two Busy Hour data

OPERATOR TWO - ANALYSIS OF NAIROBI TOWN AVERAGED DATA									
CELL SPECIFICATION		ANALYSIS OF THE AREA AVERAGES							
CI	CP	TFCL	NCSR	HOR	TTLR	PCB	PHD	GoS	HO_EFF_CP
NAIROBI 041NBAD	1055368.4%	111.4	4491	5926	10417	0.0%	0.0%	0.0%	4628
NAIROBI 041NBBD	717157.9%	75.7	4117	3711	7828	4.4%	4.0%	8.4%	3461
NAIROBI 042NBAD	1387894.7%	146.5	7219	3242	10462	0.0%	0.0%	0.0%	10637
NAIROBI 043NBB	1714736.8%	181	15712	2303	18014	4.2%	0.6%	4.8%	14845
NAIROBI 048NBAD	836526.3%	88.3	2971	2078	5049	0.0%	0.0%	0.0%	6288
NAIROBI 048NBBD	713368.4%	75.3	3015	2052	5067	0.0%	0.0%	0.0%	5081
NAIROBI 049NBCD	706736.8%	74.6	3657	3458	7115	0.3%	0.3%	0.7%	3609
NAIROBI 103NBAD	731368.4%	77.2	4460	1099	5559	0.0%	0.0%	0.0%	6214
NAIROBI 108NBA	1651263.2%	174.3	17249	2216	19466	13.4%	1.7%	15.2%	14296
NAIROBI 379NBBD	954000.0%	100.7	4256	4381	8637	0.0%	0.0%	0.0%	5159
NAIROBI AVER	1046842.1%	**110.5**	6715	**3047**	**9761**	0.0%	0.0%	0.0%	**7422**

OPERATOR TWO - ANALYSIS OF NAKURU TOWN AVERAGED DATA									
CELL SPECIFICATION		ANALYSIS OF THE AREA AVERAGES							
CI	CP	TFCL	NCSR	HOR	TTLR	PCB	PHD	GoS	HO_EFF_CP
500NKC NJORO	5031	53	1764	337	2101	-117%	-22.4%	-139.5%	4694
552NKB CHEPSIR	3898	41	4983	799	5781	28%	4.5%	32.6%	3099
562NKC ELDAMARAVI	3915	41	3155	246	3401	-14%	-1.1%	-15.1%	3669
576NKC MOLO TWN	3465	37	2724	519	3242	-6%	-1.1%	-6.9%	2946
670KCBD LITEIN	6494	69	6422	1195	7617	12%	2.3%	14.7%	5299
670KCBD KERICHO	4116	43	1154	2330	3484	-6%	-12.1%	-18.1%	1786
NAKURU AVERAGE	4486	47	3367	904	4271	-4%	-1.1%	-5.0%	3582

Table A2.11 Secondary analysis of Operator Two Busy Hour data

OPERATOR TWO - ANALYSIS OF MOMBASA TOWN AVERAGED DATA									
CELL SPECIFICATION		ANALYSIS OF THE AREA AVERAGES							
CI	CP	TFCL	NCSR	HOR	TTLR	PCB	PHD	GoS	HO_EFF_CP
MOMBASA 004MSA	17629.34	186.1	10925.25	5947	16872	-2.9%	-1.6%	-4.5%	11683
MOMBASA 008MSB	7389.47	78	14351.125	8820	23171	42.2%	25.9%	68.1%	-1430
MOMBASA 203MSA	7200.00	76	40284.5	1635	41919	79.6%	3.2%	82.8%	5565
MOMBASA 406MLC	5305.26	56	25377.75	6246	31623	66.8%	16.4%	83.2%	-940
MOMBASA 005MSA	7200.00	76	26056.5	9829	35885	58.0%	21.9%	79.9%	-2629
MOMBASA AVERAGE	8944 82	94	23399.025	6495	29894	54.9%	15.2%	70.1%	2450

OPERATOR TWO - ANALYSIS OF KISUMU TOWN AVERAGED DATA									
CELL SPECIFICATION		ANALYSIS OF THE AREA AVERAGES							
CI	CP	TFCL	NCSR	HOR	TTLR	PCB	PHD	GoS	HO_EFF_CP
SIAYA 103KSB	6660	70	5261.7143	637	5899	-11.51%	-1.39%	-12.91%	6023
UGUNJA 106KSA	7145	75	6373.4286	1330	7704	6.01%	1.25%	7.26%	5814
BUSIA 138BSA	7269	77	6286.4286	1332	7618	3.78%	0.80%	4.58%	5937
KEUMBU 304KSB	6217	66	4090.5714	943	5034	-19.11%	-4.41%	-23.52%	5274
IGEMBE 315KSA	5847	62	4817.4286	228	5045	-15.17%	-0.72%	-15.89%	5619
KSM AVERAGE	6628	70	5365.9143	894	6260	-5.03%	-0.84%	-5.87%	5734

Table A2.12 Basic analysis of Operator Three Busy Hour Data for Nairobi Town

Basic analysis of Operator Three Busy Hour Data for Nairobi Town																			
CI-NBI0521 CELL CAPACITY 27 TCH										CI-NBI1201 CELL CAPACITY 27 TCH									
LD		REQUESTS			AV CP	QoS ANALYSIS			LD		REQUESTS			AV CP	QoS ANALYSIS				
ERL	DTE	NCS	HO	TTL		PCB	PHD	GoS	ERL	DTE	NCS	HO	TTL		PCB	PHD	GoS		
27	2/7	1928	724	2652	2558	2.6%	1.0%	3.5%	26	2/7	1576	1093	2669	2558	2.5%	1.7%	4.2%		
27	2/8	2008	756	2764	2558	5.4%	2.4%	7.5%	24	2/8	1411	1150	2561	2558	0.1%	0.1%	0.1%		
26	2/9	1748	712	2460	2558	-2.8%	-1.1%	-4%	24	2/9	1811	749	2560	2558	0.1%	0.0%	0.1%		
25	2/10	1748	696	2444	2558	-3.3%	-1.2%	-5%	22	2/10	1793	1123	2916	2558	7.6%	4.7%	12%		
28	2/11	2016	776	2792	2558	6.1%	2.8%	8.4%	20	2/11	1597	1165	2762	2558	4.3%	3.1%	7.4%		
26		1890	733	2622	2558	1.8%	0.7%	2.5%	23		1638	1056	2694	2558	3.1%	2.0%	5.0%		
CI- NBI2261 CELL CAPACITY 28 TCH										CI-NBI3371 CELL CAPACITY 28 TCH									
29	2/7	1924	980	2904	2653	5.7%	2.9%	8.7%	27	2/7	1921	756	2677	2653	0.7%	0.3%	0.9%		
31	2/8	1728	972	2700	2653	1.1%	0.6%	1.8%	28	2/8	2310	832	3142	2653	11%	4.1%	16%		
27	2/9	1660	960	2620	2653	-0.8%	-0.5%	-1%	27	2/9	1875	921	2796	2653	3.4%	1.7%	5.1%		
28	2/10	1572	936	2508	2653	-3.6%	-2.2%	-6%	25	2/10	1981	833	2814	2653	4.0%	1.7%	5.7%		
28	2/11	1716	1004	2720	2653	1.6%	0.9%	2.5%	24	2/11	1739	959	2698	2653	1.1%	0.6%	1.7%		
29		1720	970	2690	2653	0.9%	0.5%	1.4%	26		1965	860	2825	2653	4.3%	1.9%	6.1%		
CI-NBI0082 CELL CAPACITY 26 TCH										CI-NBI2312 CELL CAPACITY 28 TCH									
22	2/7	2112	810	2572	2463	3.5%	0.8%	4.2%	27	2/7	1721	956	2677	2653	0.6%	0.3%	0.9%		
24	2/8	1780	798	2228	2463	-8.4%	-2.1%	-0.11	27	2/8	1934	887	2821	2653	4.1%	1.9%	6.0%		
19	2/9	1948	794	2392	2463	-2.4%	-0.6%	-0.03	29	2/9	1748	1180	2928	2653	5.6%	3.8%	9.4%		
21	2/10	2148	954	2752	2463	8.2%	2.3%	0.10	25	2/10	1860	821	2681	2653	0.7%	0.3%	1.1%		
20	2/11	1948	910	2508	2463	1.4%	0.4%	0.02	29	2/11	1732	992	2724	2653	1.7%	1.0%	2.6%		
21		1987	853	2490	2463	0.9%	0.4%	0.01	27		1799	967	2766	2653	2.7%	1.4%	4.1%		
CI-NBI2071CELL CAPACITY 26 TCH										CI-NBI0911 CELL CAPACITY 29 TCH									
25	2/7	1760	815	2575	2463	1.1%	0.8%	4.3%	31	2/7	1912	1208	3120	2747	7.3%	4.6%	12%		
23	2/8	1960	863	2823	2463	3.7%	2.3%	13%	29	2/8	2212	1493	3705	2747	15%	10%	26%		
25	2/9	1492	599	2091	2463	-3.1%	-2.1%	-18%	28	2/9	1917	1253	3170	2747	8.1%	5.3%	13%		
21	2/10	1876	827	2703	2463	2.4%	1.6%	8.9%	30	2/10	1673	1090	2763	2747	0.3%	0.2%	1%		
20	2/11	1892	799	2691	2463	2.4%	1.4%	8.5%	31	2/11	1713	1101	2814	2747	1.4%	0.9%	2%		
23		1796	781	2577	2463	3.1%	1.3%	4.4%	30		1885	1229	3114	2747	7.1%	4.7%	12%		
CI-NBI0673 CELL CAPACITY 29 TCH										CI-NBI2503 CELL CAPACITY 28 TCH									
27	2/7	1264	1572	2836	2747	1.4%	1.7%	3.1%	30	2/7	1611	1104	2715	2653	1.4%	0.9%	2.3%		
25	2/8	1322	1316	2638	2747	-2.1%	-2.1%	-4%	32	2/8	1574	1148	2722	2653	1.5%	1.1%	2.5%		
23	2/9	1500	1380	2880	2747	2.4%	2.2%	5%	32	2/9	1835	876	2711	2653	1.5%	0.7%	2.2%		
23	2/10	1562	1156	2718	2747	-0.6%	-0.5%	-1%	24	2/10	1723	876	2599	2653	-1.4%	-0.7%	-2.1%		
26	2/11	1674	1124	2798	2747	1.1%	0.7%	1.8%	24	2/11	1464	1369	2833	2653	3.3%	3.1%	6.4%		
25		1464	1310	2774	2747	0.5%	0.5%	1.0%	28		1641	1075	2716	2653	1.4%	0.9%	2.3%		

Table A2.13 Basic analysis of Operator Three Busy Hour Data for KSM, MSA and NKU.

BASIC ANALYSIS OF OPERATOR THREE BUSY HOUR DATA FOR KISUMU TOWN

TO 3 DATA FOR CI-KMU0101 CP 29 TCH NYAMASARIA_1

DTE	ERL LD	REQUESTS NCS	HO	TTL	AV CP	QoS ANALYSIS PCB	PHD	GoS
7/2	7	258	564	822	2747	-1	0	-2
8/2	6	257	570	827	2747	-1	0	-2
9/2	7	219	590	809	2747	-1	0	-2
10/2	8	304	563	867	2747	-1	0	-2
11/2	8	293	614	907	2747	-1	0	-2
AVER	7	266	580	846	2747	-1	0	-2

TO 3 DATA FOR CI-KMU0103-NYAMASARIA_3 CP29 TCH

DTE	ERL LD	REQUESTS NCS	HO	TTL	AV CP	QoS ANALYSIS PCB	PHD	GoS
7/2	9.1	253	340	593	2747	-155%	-10%	-363%
8/2	5.3	373	337	710	2747	-151%	-9%	-287%
9/2	6.5	279	269	548	2747	-204%	-8%	-401%
10/2	6.7	366	301	667	2747	-171%	-8%	-312%
11/2	6.4	199	216	415	2747	-270%	-7%	-562%
AVEF	6.8	294	293	587	2747	-185%	-8%	-368%

TCH MIGINGO 3

DTE	ERL LD	NCS	HO	TTL	AV CP	PCB	PHD	GoS
7/2	7	118	77	195	1232	-3	0	-5.3
8/2	7	591	207	798	1232	0	0	-0.5
9/2	8	229	122	351	1232	-2	0	-2.5
10/2	7	583	172	755	1232	0	0	-0.6
11/2	8	595	199	794	1232	0	0	-0.6
AVER	7	423	155	579	1232	-1	0	-1.1

TO DATA FOR CI-NYDOO32-AHERO_2 CP 29

DTE	ERL LD	NCS	HO	TTL	AV CP	PCB	PHD	GoS
7/2	5.6	403	167	570	2747	-270%	0	-382%
8/2	5.3	420	173	593	2747	-257%	0	-363%
9/2	7.4	246	142	388	2747	-386%	0	-608%
10/2	7.5	697	329	1026	2747	-114%	0	-168%
11/2	7.6	261	167	428	2747	-331%	0	-542%
AVEF	6.7	405	196	601	2747	-2.4	0	-3.6

TO 3 DATA FOR CI-KMU0191 CP 20 TCH KIBOSWA_1

DTE	ERL LD	NCS	HO	TTL	AV CP	PCB	PHD	GoS
7/2	8	177	83	260	1895	-4.3	-4%	-6.3
8/2	5.1	12	10	22	1895	-46.4	-1%	-85
9/2	5.7	160	65	225	1895	-5.3	-3%	-7.4
10/2	6.6	162	59	221	1895	-5.6	-3%	-7.6
11/2	5	415	129	544	1895	-1.9	-5%	-2.5
AVER	5.4	185	69	254	1895	-4.7	-3%	-6.4

TO 3 DATA FOR CI-NYDOO91_MIGINGO-1 CP 13

DTE	ERL LD	NCS	HO	TTL	AV CP	PCB	PHD	GoS
7/2	5.2	312	324	636	1232	-46%	-13%	-94%
8/2	4.7	372	306	678	1232	-45%	-11%	-82%
9/2	5.9	211	153	364	1232	-138%	-9%	-238%
10/2	5.7	386	371	757	1232	-32%	-12%	-63%
11/2	5.3	396	311	707	1232	-42%	-11%	-74%
AVER	5.4	335	293	628	1232	-0.5	-12%	-1.0

BASIC ANALYSIS OF OPERATOR THREE BUSY HOUR DATA FOR MOMBASA TOWN

TO 3 DATA FOR CI-KFI0033-MTWAPA_3 CP 45 TCH

DTE	ERL LD	REQUESTS NCSR	HOR	TTL	AV CP	QoS ANALYSIS PCB	PHD	GoS
7/2	29	1085	217	1302	4263	-190%	-4%	-227%
8/2	31.1	1152	261	1413	4263	-165%	-4%	-202%
9/2	30.4	1082	317	1399	4263	-158%	-5%	-205%
10/2	28.6	971	309	1280	4263	-177%	-5%	-233%
11/2	27	2035	381	2416	4263	-64%	-4%	-77%
AVER	29.2	1265	297	1562	4263	-140%	-4%	-173%

TO 3 DATA FOR CI-KFI0031-MTWAPA_1 CP 45 TCH

DTE	ERL LD	REQUESTS NCSR	HOR	TTL	AV CP	QoS ANALYSIS PCB	PHD	GoS
7/2	34.4	1192	236	1428	4263	-166%	-4%	-199%
8/2	29.7	2347	401	2748	4263	-47%	-3%	-55%
9/2	30	1083	247	1330	4263	-180%	-4%	-221%
10/2	30.9	2337	360	2697	4263	-50%	-3%	-58%
11/2	28.2	271-1	470	3181	4263	-29%	-3%	-34%
AVEF	30.6	1934	343	2277	4263	-74%	-4%	-87%

TO 3 DATA FOR CI-MSA0302-BOMBOLULU_2 CP 45 TCH

DTE	ERL LD	NCSR	HOR	TTL	AV CP	PCB	PHD	GoS
7/2	28.5	2266	821	3087	4263	-28%	-5%	-38%
8/2	30.3	2508	735	3243	4263	-24%	-4%	-32%
9/2	31.2	1231	536	1767	4263	-98%	-7%	-141%
10/2	32.6	2621	780	3401	4263	-20%	-4%	-25%
11/2	30.3	2519	716	3235	4263	-25%	-4%	-32%
AVER	30.6	2229	718	2947	4263	-34%	-5%	-45%

TO 3 DATA FOR CI-MSA0191-DIGO_1 CP 29 TCH

DTE	ERL LD	NCSR	HOR	TTL	AV CP	PCB	PHD	GoS
7/2	30.8	2230	492	2722	2747	-1%	0%	-1%
8/2	28.4	2094	436	2530	2747	-7%	-1%	-9%
9/2	27.6	1994	441	2435	2747	-11%	-2%	-13%
10/2	30.2	2125	564	2689	2747	-2%	0%	-2%
11/2	28.3	2005	452	2457	2747	-10%	-2%	-12%
AVEF	29.1	2090	477	2567	2747	-6%	-1%	-7%

Table A2.13 Basic analysis of Operator Three Busy Hour Data for KSM, MSA and NKU.

BASIC ANALYSIS OF OPERATOR THREE BUSY HOUR DATA FOR MOMBASA TOWN																	
TO 3 DATA FOR CI-MSA0491-CHAANI 1 CP 28 TCH									TO 3 DATA FOR CI-MSA0021-MAKADARA_1 CP 43 TCH								
DTE	ERL	REQUESTS				QoS ANALYSIS				ERL	REQUESTS				QoS ANALYSIS		
	LD	NCSR	HOR	TTL	AV CP	PCB	PHD	GoS	DTE	LD	NCSR	HOR	TTL	AV CP	PCB	PHD	GoS
7/2	27.7	614	459	1073	2652.6	-84%	-9%	-147%	7/2	31.9	2212	921	3133	4074	-21%	-5%	-30%
8/2	28.1	722	481	1203	2652.6	-72%	-9%	-121%	8/2	30	2086	965	3051	4074	-23%	-6%	-34%
9/2	28.8	745	460	1205	2652.6	-74%	-9%	-120%	9/2	32.7	2239	1071	3310	4074	-16%	-5%	-23%
10/2	24	764	398	1162	2652.6	-84%	-8%	-128%	10/2	32	2269	948	3217	4074	-19%	-5%	-27%
11/2	29.3	821	501	1322	2652.6	-63%	-9%	-101%	11/2	30.2	2210	879	3089	4074	-23%	-5%	-32%
AVER	27.6	733	460	1193	2652.6	-75%	-9%	-122%	AVER	31.4	2203	957	3160	4074	-20%	-5%	-29%
TO 3 DATA FOR CI-MSA0131-AIRPORT_1 CP 36 TCH																	
7/2	31	1096	488	1584	3410.5	-80%	-8%	-115%									
8/2	29.2	1061	380	1441	3410.5	-101%	-6%	-137%									
9/2	28.2	974	365	1339	3410.5	-113%	-7%	-155%									
10/2	26.2	1715	552	2267	3410.5	-38%	-5%	-50%									
11/2	27	1847	559	2406	3410.5	-32%	-5%	-42%									
AVER	28.3	1339	469	1807	3410.5	-66%	-7%	-89%									

BASIC ANALYSIS OF OPERATOR THREE BUSY HOUR DATA FOR NAKURU TOWN																	
TCH									TO 3 DATA FOR CI-NRU0723-PRISON 3 CP 30 TCH								
	ERL	REQUESTS				QoS ANALYSIS			DTE	ERL	REQUESTS			AV	QoS ANALYSIS		
DTE	LD	NCSR	HOR	TTL	AV CP	PCB	PHD	GoS		LD	NCSR	HOR	TTL	CP	PCB	PHD	GoS
7/2	40.9	1309	533	1842	4168.4	-90%	-7%	-126%	7/2	33.2	651	365	1016	2842	-115%	-8%	-180%
8/2	41.7	1187	560	1747	4168.4	-94%	-8%	-139%	8/2	36	249	464	713	2842	-104%	-12%	-299%
9/2	39.5	1329	564	1893	4168.4	-84%	-7%	-120%	9/2	38	208	449	657	2842	-105%	-12%	-333%
10/2	35.9	1141	468	1609	4168.4	-113%	-7%	-159%	10/2	28	684	358	1042	2842	-113%	-8%	-173%
11/2	32	1308	403	1711	4168.4	-110%	-6%	-144%	11/2	28.4	656	332	988	2842	-125%	-8%	-188%
AVER	38	1255	506	1760	4168.4	-98%	-7%	-137%	AVER	32.7	490	394	883	2842	-123%	-10%	-222%
TCH									TO 3 DATA FOR CI-NRU0691-LANGA 1 CP 29 TCH								
7/2	24.6	1734	361	2095	2652.6	-22%	-3%	-27%	7/2	26.4	615	538	1153	2747	-74%	-11%	-138%
8/2	26.4	1697	415	2112	2652.6	-21%	-3%	-26%	8/2	29.1	653	651	1304	2747	-55%	-12%	-111%
9/2	26.2	1730	395	2125	2652.6	-20%	-3%	-25%	9/2	24.5	276	377	653	2747	-136%	-11%	-321%
10/2	23.3	1662	323	1985	2652.6	-28%	-3%	-34%	10/2	21.3	507	538	1045	2747	-79%	-12%	-163%
11/2	25.6	1636	368	2004	2652.6	-26%	-3%	-32%	11/2	18.6	248	373	621	2747	-137%	-11%	-342%
AVER	25.2	1692	372	2064	2652.6	-23%	-3%	-29%	AVER	24	460	495	955	2747	-90%	-12%	-188%
TO 3 DATA FOR CI-NRU0693-LANGA 3 CP 29 TCH									TO 3 DATA FOR CI-NRU0053-RWY STN 3 CP 29 TCH								
7/2	21.8	840	294	1134	2747	-105%	-6%	-142%	7/2	25.7	1958	472	2430	2747	-11%	-2%	-13%
8/2	24	747	180	927	2747	-158%	-4%	-196%	8/2	25.7	1833	432	2265	2747	-17%	-3%	-21%
9/2	26.3	689	194	883	2747	-165%	-5%	-211%	9/2	25	1706	487	2193	2747	-20%	-4%	-25%
10/2	23.1	837	210	1047	2747	-130%	-5%	-162%	10/2	24.4	1785	391	2176	2747	-22%	-3%	-26%
11/2	20.1	850	219	1069	2747	-125%	-5%	-157%	11/2	22.9	1583	430	2013	2747	-29%	-4%	-37%
AVER	23.1	840	294	1134	2747	-105%	-6%	-142%	AVER	24.7	1773	442	2215	2747	-19%	-3%	-24%

Table A2.14 Secondary analysis of Operator Three data for NKU, MSA and KSM.

OPERATOR THREE -NAKURU SECONDARY DATA ANALYSIS									
ELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
NRU0691	29	23.98	459.8	495.4	955.2	2747.4	-90.3%	-11.8%	-187.6%
NRU0053	29	24.74	1773	442.4	2215.4	2747.4	-19.2%	-3.1%	-24.0%
NRU0693	29	23.06	840	294	1134	2747.4	-105.4%	-6.3%	-142.3%
NRU0041	28	25.22	1691.8	372.4	2064.2	2652.6	-23.4%	-3.1%	-28.5%
NRU0723	30	32.72	489.6	393.6	883.2	2842.1	-123.0%	-9.6%	-221.8%
NRU0043	44	38	1254.8	505.6	1760.4	4168.4	-97.5%	-7.0%	-136.8%
Town Aver	32	28.7	1209.8	401.6	1611.4	3031.6	-66.2%	-6.2%	-88.1%

OPERATOR THREE -MOMBASA SECONDARY DATA ANALYSIS									
ELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
KFI0033	45	29.22	1265	297	1562	4263.2	-140.1%	-4.4%	-172.9%
KFI0031	45	30.64	1934	342.8	2276.8	4263.2	-74.1%	-3.8%	-87.2%
MSA0191	29	29.06	2089.6	477	2566.6	2747.4	-5.7%	-1.1%	-7.0%
MSA0491	28	27.58	733.2	459.8	1193	2652.6	-75.2%	-9.5%	-122.4%
MSA0131	36	28.32	1338.6	468.8	1807.4	3410.5	-65.7%	-6.5%	-88.7%
MSA0021	43	31.36	2203.2	956.8	3160	4073.7	-20.2%.	-5.3%	-28.9%
MSA0302	45	30.58	2229	717.6	2946.6	4263.2	-33.8%	-5.2%	-44.7%
Town Aver	36.2	29.38	1718.7	616	2334.7	3429.5	-34.5%	-5.7%	-46.9%

OPERATOR THREE -KISUMU SECONDARY DATA ANALYSIS									
ELL DETAILS		ERLANG	REQUESTS			AV	QoS ANALYSIS		
AREA	CP(TCH)	LOAD	NCS	HO	TTL	CP	PCB	PHD	GoS
KMU0101	29	7.22	266.2	580.2	846.4	2747.4	-70.6%	-14.6%	-224.6%
NYD0093	13	7.14	423.2	155.4	578.6	1231.6	-82.5%	-6.7%	-112.9%
KMU0191	20	5.36	185.2	69.2	254.4	1894.7	-469.4%	-3.2%	-644.8%
KMU0103	29	6.8	294	292.6	586.6	2747.4	-184.6%	-8.4%	-368.4%
NYD0032	29	6.68	405.4	195.6	601	2747.4	-240.9%	-5.6%	-357.1%
NYD0091	13	5.36	335.4	293	628.4	1231.6	-51.2%	-11.7%	-96.0%
Town Aver	13	6.268	328.6	201.2	529.8	1231.6	-82.2%	-9.3%	-132.5%

Erlang B-Table for 1 to 50 channels, 0.7% - 40%

n	Loss probability (E)										n
	0.007	0.008	0.009	0.01	0.02	0.03	0.05	0.1	0.2	0.4	
1	.00705	.00806	.00908	.01010	.02041	.03093	.05263	.11111	.25000	.66667	1
2	.12600	.13532	.14416	.15259	.22347	.28155	.38132	.59543	1.0000	2.0000	2
3	.39664	.41757	.43711	.45549	.60221	.71513	.89940	1.2708	1.9299	3.4798	3
4	.77729	.81029	.84085	.86942	1.0923	1.2589	1.5246	2.0454	2.9452	5.0210	4
5	1.2362	1.2810	1.3223	1.3608	1.6571	1.8752	2.2185	2.8811	4.0104	6.5955	5
6	1.7531	1.8093	1.8610	1.9090	2.2759	2.5431	2.9603	3.7584	5.1086	8.1907	6
7	2.3149	2.3820	2.4437	2.5009	2.9354	3.2497	3.7378	4.6662	6.2302	9.7998	7
8	2.9125	2.9902	3.0615	3.1276	3.6271	3.9865	4.5430	5.5971	7.3692	11.419	8
9	3.5395	3.6274	3.7080	3.7825	4.3447	4.7479	5.3702	6.5464	8.5217	13.045	9
10	4.1911	4.2889	4.3784	4.4612	5.0840	5.5294	6.2157	7.5106	9.6850	14.677	10
11	4.8637	4.9709	5.0691	5.1599	5.8415	6.3280	7.0764	8.4871	10.857	16.314	11
12	5.5543	5.6708	5.7774	5.8760	6.6147	7.1410	7.9501	9.4740	12.036	17.954	12
13	6.2607	6.3863	6.5011	6.6072	7.4015	7.9667	8.8349	10.470	13.222	19.598	13
14	6.9811	7.1155	7.2382	7.3517	8.2003	8.8035	9.7295	11.473	14.413	21.243	14
15	7.7139	7.8568	7.9874	8.1080	9.0096	9.6500	10.633	12.484	15.608	22.891	15
16	8.4579	8.6092	8.7474	8.8750	9.8284	10.505	11.544	13.500	16.807	24.541	16
17	9.2119	9.3714	9.5171	9.6516	10.656	11.368	12.461	14.522	18.010	26.192	17
18	9.9751	10.143	10.296	10.437	11.491	12.238	13.385	15.548	19.216	27.844	18
19	10.747	10.922	11.082	11.230	12.333	13.115	14.315	16.579	20.424	29.498	19
20	11.526	11.709	11.876	12.031	13.182	13.997	15.249	17.613	21.635	31.152	20
21	12.312	12.503	12.677	12.838	14.036	14.885	16.189	18.651	22.848	32.808	21
22	13.105	13.303	13.484	13.651	14.896	15.778	17.132	19.692	24.064	34.464	22
23	13.904	14.110	14.297	14.470	15.761	16.675	18.080	20.737	25.281	36.121	23
24	14.709	14.922	15.116	15.295	16.631	17.577	19.031	21.784	26.499	37.779	24
25	15.519	15.739	15.939	16.125	17.505	18.483	19.985	22.833	27.720	39.437	25
26	16.334	16.561	16.768	16.959	18.383	19.392	20.943	23.885	28.941	41.096	26
27	17.153	17.387	17.601	17.797	19.265	20.305	21.904	24.939	30.164	42.755	27
28	17.977	18.218	18.438	18.640	20.150	21.221	22.867	25.995	31.388	44.414	28
29	18.805	19.053	19.279	19.487	21.039	22.140	23.833	27.053	32.614	46.074	29
30	19.637	19.891	20.123	20.337	21.932	23.062	24.802	28.113	33.840	47.735	30
31	20.473	20.734	20.972	21.191	22.827	23.987	25.773	29.174	35.067	49.395	31
32	21.312	21.580	21.823	22.048	23.725	24.914	26.746	30.237	36.295	51.056	32
33	22.155	22.429	22.678	22.909	24.626	25.844	27.721	31.301	37.524	52.718	33
34	23.001	23.281	23.536	23.772	25.529	26.776	28.698	32.367	38.754	54.379	34
35	23.849	24.136	24.397	24.638	26.435	27.711	29.677	33.434	39.985	56.041	35
36	24.701	24.994	25.261	25.507	27.343	28.647	30.657	34.503	41.216	57.703	36
37	25.556	25.854	26.127	26.378	28.254	29.585	31.640	35.572	42.448	59.365	37
38	26.413	26.718	26.996	27.252	29.166	30.526	32.624	36.643	43.680	61.028	38

39	27.272	27.583	27.867	28.129	30.081	31.468	33.609	37.715	44.913	62.690	39
40	28.134	28.451	28.741	29.007	30.997	32.412	34.596	38.787	46.147	64.353	40
41	28.999	29.322	29.616	29.888	31.916	33.357	35.584	39.861	47.381	66.016	41
42	29.866	30.194	30.494	30.771	32.836	34.305	36.574	40.936	48.616	67.679	42
43	30.734	31.069	31.374	31.656	33.758	35.253	37.565	42.011	49.851	69.342	43
44	31.605	31.946	32.256	32.543	34.682	36.203	38.557	43.088	51.086	71.006	44
45	32.478	32.824	33.140	33.432	35.607	37.155	39.550	44.165	52.322	72.669	45
46	33.353	33.705	34.026	34.322	36.534	38.108	40.545	45.243	53.559	74.333	46
47	34.230	34.587	34.913	35.215	37.462	39.062	41.540	46.322	54.796	75.997	47
48	35.108	35.471	35.803	36.109	38.392	40.018	42.537	47.401	56.033	77.660	48
49	35.988	36.357	36.694	37.004	39.323	40.975	43.534	48.481	57.270	79.324	49
50	36.870	37.245	37.586	37.901	40.255	41.933	44.533	49.562	58.508	80.988	50
	0.007	**0.008**	**0.009**	**0.01**	**0.02**	**0.03**	**0.05**	**0.1**	**0.2**	**0.4**	
n	**Loss probability (E)**										**n**

Erlang B-Table for 1 to 50 channels, 0.001% - 0.6%

n	**Loss probability (E)**										**n**
	0.00001	**0.00005**	**0.0001**	**0.0005**	**0.001**	**0.002**	**0.003**	**0.004**	**0.005**	**0.006**	
1	.00001	.00005	.00010	.00050	.00100	.00200	.00301	.00402	.00503	.00604	1
2	.00448	.01005	.01425	.03213	.04576	.06534	.08064	.09373	.10540	.11608	2
3	.03980	.06849	.08683	.15170	.19384	.24872	.28851	.32099	.34900	.37395	3
4	.12855	.19554	.23471	.36236	.43927	.53503	.60209	.65568	.70120	.74124	4
5	.27584	.38851	.45195	.64857	.76212	.89986	.99446	1.0692	1.1320	1.1870	5
6	.47596	.63923	.72826	.99567	1.1459	1.3252	1.4468	1.5421	1.6218	1.6912	6
7	.72378	.93919	1.0541	1.3922	1.5786	1.7984	1.9463	2.0614	2.1575	2.2408	7
8	1.0133	1.2816	1.4219	1.8298	2.0513	2.3106	2.4837	2.6181	2.7299	2.8266	8
9	1.3391	1.6595	1.8256	2.3016	2.5575	2.8549	3.0526	3.2057	3.3326	3.4422	9
10	1.6970	2.0689	2.2601	2.8028	3.0920	3.4265	3.6480	3.8190	3.9607	4.0829	10
11	2.0849	2.5059	2.7216	3.3294	3.6511	4.0215	4.2661	4.4545	4.6104	4.7447	11
12	2.4958	2.9671	3.2072	3.8781	4.2314	4.6368	4.9038	5.1092	5.2789	5.4250	12
13	2.9294	3.4500	3.7136	4.4465	4.8306	5.2700	5.5588	5.7807	5.9638	6.1214	13
14	3.3834	3.9523	4.2388	5.0324	5.4464	5.9190	6.2291	6.4670	6.6632	6.8320	14
15	3.8559	4.4721	4.7812	5.6339	6.0772	6.5822	6.9130	7.1665	7.3755	7.5552	15
16	4.3453	5.0079	5.3390	6.2496	6.7215	7.2582	7.6091	7.8780	8.0995	8.2898	16
17	4.8502	5.5583	5.9110	6.8782	7.3781	7.9457	8.3164	8.6003	8.8340	9.0347	17
18	5.3693	6.1220	6.4959	7.5186	8.0459	8.6437	9.0339	9.3324	9.5780	9.7889	18
19	5.9016	6.6980	7.0927	8.1698	8.7239	9.3515	9.7606	10.073	10.331	10.552	19
20	6.4460	7.2854	7.7005	8.8310	9.4115	10.068	10.496	10.823	11.092	11.322	20
21	7.0017	7.8834	8.3186	9.5014	10.108	10.793	11.239	11.580	11.860	12.100	21
22	7.5680	8.4926	8.9462	10.180	10.812	11.525	11.989	12.344	12.635	12.885	22
23	8.1443	9.1095	9.5826	10.868	11.524	12.265	12.746	13.114	13.416	13.676	23
24	8.7298	9.7351	10.227	11.562	12.243	13.011	13.510	13.891	14.204	14.472	24

25	9.3240	10.369	10.880	12.264	12.969	13.763	14.279	14.673	14.997	15.274	25
26	9.9265	11.010	11.540	12.972	13.701	14.522	15.054	15.461	15.795	16.081	26
27	10.537	11.659	12.207	13.686	14.439	15.285	15.835	16.254	16.598	16.893	27
28	11.154	12.314	12.880	14.406	15.182	16.054	16.620	17.051	17.406	17.709	28
29	11.779	12.976	13.560	15.132	15.930	16.828	17.410	17.853	18.218	18.530	29
30	12.417	13.644	14.246	15.863	16.684	17.606	18.204	18.660	19.034	19.355	30
31	13.054	14.318	14.937	16.599	17.442	18.389	19.002	19.470	19.854	20.183	31
32	13.697	14.998	15.633	17.340	18.205	19.176	19.805	20.284	20.678	21.015	32
33	14.346	15.682	16.335	18.085	18.972	19.966	20.611	21.102	21.505	21.850	33
34	15.001	16.372	17.041	18.835	19.743	20.761	21.421	21.923	22.336	22.689	34
35	15.660	17.067	17.752	19.589	20.517	21.559	22.234	22.748	23.169	23.531	35
36	16.325	17.766	18.468	20.347	21.296	22.361	23.050	23.575	24.006	24.376	36
37	16.995	18.470	19.188	21.108	22.078	23.166	23.870	24.406	24.846	25.223	37
38	17.669	19.178	19.911	21.873	22.864	23.974	24.692	25.240	25.689	26.074	38
39	18.348	19.890	20.640	22.642	23.652	24.785	25.518	26.076	26.534	26.926	39
40	19.031	20.606	21.372	23.414	24.444	25.599	26.346	26.915	27.382	27.782	40
41	19.718	21.326	22.107	24.189	25.239	26.416	27.177	27.756	28.232	28.640	41
42	20.409	22.049	22.846	24.967	26.037	27.235	28.010	28.600	29.085	29.500	42
43	21.104	22.776	23.587	25.748	26.837	28.057	28.846	29.447	29.940	30.362	43
44	21.803	23.507	24.333	26.532	27.641	28.882	29.684	30.295	30.797	31.227	44
45	22.505	24.240	25.081	27.319	28.447	29.708	30.525	31.146	31.656	32.093	45
46	23.211	24.977	25.833	28.109	29.255	30.538	31.367	31.999	32.517	32.962	46
47	23.921	25.717	26.587	28.901	30.066	31.369	32.212	32.854	33.381	33.832	47
48	24.633	26.460	27.344	29.696	30.879	32.203	33.059	33.711	34.246	34.704	48
49	25.349	27.206	28.104	30.493	31.694	33.039	33.908	34.570	35.113	35.578	49
50	26.067	27.954	28.867	31.292	32.512	33.876	34.759	35.431	35.982	36.454	50
	0.00001	**0.00005**	**0.0001**	**0.0005**	**0.001**	**0.002**	**0.003**	**0.004**	**0.005**	**0.006**	
n	**Loss probability (E)**										n