# From 3g to lte: the feasibility of the transition for zimbabwe mobile operators

BY

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# Abstract

Mobile telecoms industry has become a key element of productivity across economies and societies worldwide. The rigorous demand for delivery of services of uncompromising quality in the highly competitive cellular industry has challenged the operators to constantly upgrade their networks. In Zimbabwe we have witnessed a significant transformation within this sector because of the impact it has on the economy with LTE being the latest technology to be considered by most mobile operators.

While LTE is the fastest-growing cellular technology in history in terms of subscription-number growth, it is still very much a new technology both in terms of the total number of subscriptions and also the maturity of the service proposition. This report aims at researching on the feasibility for Zimbabwean operators to migrate from 3G to 4G LTE by analyzing the current state of the mobile telecom industry in Zimbabwe.

# DECLARATION

I, Artwell Magadzire hereby declare that I am the sole author of this thesis. I authorize the Midlands State University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

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# APPROVAL

This dissertation/thesis entitled "FROM 3G TO LTE:THE FEASIBILITY OF THE TRANSITION FOR ZIMBABWEAN MOBILE OPERATORS" by Artwell Magadzire meets the regulations governing the award of the degree of BSC TELECOMMUNICATIONS HONOURS of the Midlands State University, and is approved for its contribution to knowledge and literal presentation.

Supervisor …………………………………………………...

Date ………………………………………………………….

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I would also like to thank my wife and children who endured my long absence while I was away attending lessons or even when I was at home but not reachable to their needs because of the demands of this programme. I would like to acknowledge my immediate family members and friends for the support they rendered during the three years of this programme. My gratitude also goes to my workmates for holding fort during my absence.

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May the good Lord richly and abundantly bless you all.

# Contents

# Abbreviations

| | |
|---|---|
| LTE | Long Term Evolution |
| 3G | Third generation of mobile telecommunications technology |
| GSM | Global System for Mobile Communications, originally Group Spécial Mobile |
| ITU | International Telecommunication Union |
| IMT | International Mobile Telecommunications |
| 3GPP | Third Generation Partnership Project |
| CDMA | Code Division Multiple Access |
| UMTS | Universal Mobile Telecommunications System |
| FDMA | Frequency Division Multiple Access |
| TDMA | Time Division Multiple Access |
| EDGE | Enhanced Data rates for GSM Evolution |
| ISDN | Integrated Services Digital Network |
| HDR | High Data Rate |
| RAN | Radio Access Network |
| ATM | Asynchronous Transfer Mode |
| CID | Channel Identifier |
| RNC | Radio Network Controller |
| UDP | User Datagram Protocol |
| MSC | Mobile Switching Centre |
| RAB | Radio Access Bearer |
| RNS | Radio Network Subsystem |
| SCCP | Signaling Connection Control Part |

| | |
|---|---|
| SCH | Synchronization Channel |
| TDD | Time Division Duplex |
| UE | User Equipment |
| UTRAN | UMTS Terrestrial Radio Access Network |

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# Chapter One

## 1.1. Introduction

This research investigates the most influential factors contributing towards the growth of the telecommunication Industry in Zimbabwe in a bid to determine the feasibility of the transition from 3G to 4G LTE. An in depth analysis of the nature and effect of these factors was conducted.

The prime objective of this study is to explore the comparisons of LTE and 3G on data performance. It has often been noted that information technology has revolutionized the ways in which organizations perform. IT has been used widely as a tool for organizational transformation rather than a mere tool for helping in the day to day functions of the organization.

The data collected is further used to discuss the impact of these factors and to determine if it is the right time to launch 4G LTE and the deployment strategies that best suit telecom operators in Zimbabwe.

## 1.2. Background of the Problem

LTE is a market driven technology (through operators), which offers higher data rate (100Mbit/s downlink and 50Mbit/s uplink) with low latency and short call set up delay that aim to improve end-user throughput, increase sector capacity, reduce user plane latency, and consequently offer superior user experience with full mobility.

Globally, existing 2G-3G mobile wireless operators, including AT&T, China Telecom, China Mobile, NTT DoCoMo, Telecom Italia, T-Mobile Germany and USA, Verizon and Vodafone, have all made announcements indicating LTE as their preferred wireless technology for the future [1]

By August 2013, a total of 204 LTE networks in 77 countries were commercially operating [2]. Thus the world over there is a rapid increase in LTE network trials and commercial launches. However, it is worth noting that a considerable number of mobile operators have taken a cautious approach to LTE deployment. This may be due to their negative experiences with initial 3G deployments, which were characterized by low consumer demand and an immature environment (expensive, power hungry devices and complex, unstable networks) [3].

In Zimbabwe, one mobile operator, Econet Wireless has already reportedly launched an LTE network and the other mobile operators are still to do so [4]. Effective deployment of an evolutionary technology such as LTE requires a paradigm shift in that, evolution in technical infrastructure only is just but the beginning. There are challenges awaiting mobile operators such as, the marketing, the transformation of operations and business models and the policing and regularization particularly in the Zimbabwe market.

## 1.3. Problem Statement

Long Term Evolution abbreviated (LTE), is designed to provide multimegabit bandwidth and with it more efficient use of the radio network, latency reduction, and improved mobility [5]. This combination aims to enhance the user's interaction with the network and further increase the demand for mobile multimedia services.

Changes in technology in mobile communications have always been evolutionary, and the deployment of LTE is envisaged to be the same. The deployment of LTE will be a transition from 3G UMTS to 4G over a period of several years, as was the case and still is the case with the transition from 2G to 3G [6]. As a result the challenge for mobile operators in Zimbabwe is to look for strategies and solutions that, whilst enhancing their existing 3G UMTS networks, will address their LTE deployment requirements without involving a "forklift" upgrade.

## 1.3 .Aims and Objectives of the research

### 1.3.1 Aim

The aim of this research document is to determine the feasibility of the transition from 3G to 4G LTE for operators in Zimbabwe and also how they can effectively prepare their networks to move over to Long Term Evolution technology, so that they can improve user experience and yield new revenue opportunities.

### 1.3.2 Objectives

The Objectives of the project are:

1. To document the current state of 3G and LTE technologies in Zimbabwe telecoms industry.
2. To research on the potential benefits and challenges that can be realised with LTE technology deployment in Zimbabwe.
3. To investigate the deployment strategies for LTE Technology that can be employed in the Zimbabwe Mobile telecoms Industry

## 1.5 .Significance of Study

Zimbabwe is considered to be having a fast growing mobile telecoms market. The rigorous demand for delivery of services of uncompromising quality in the highly competitive Cellular industry implies there is need for continuous study of new developments in mobile telecommunications and implementing the developments so as to improve and transform the business investments into profitable revenue streams.

The main reason for this research is for the in-depth understanding of the current technology and compare it with the latest technology in an attempt to come to a conclusion of which technology can be best fit the Zimbabwe market

This thesis, by applying the theoretical framework of Porter model in deriving the industrial competitiveness of Zimbabwe market, aim at developing recommendations that will improve industrial performances.

This study will make clear knowledge about the competitiveness of Zimbabwe telecom industry. This knowledge will help in realizing the current telecom business environment in Zimbabwe while on the other hand the study findings will serve as lessons to be shared in future studies on the same subject. Therefore, the author recommends the findings of this thesis for researchers, academicians and practitioners.

## 1.4.Limitations of the study

Due to the time constraints, scope of the study was restricted to focus only on primary cellular mobile companies as representatives of the industry, which could result an overlook on certain industrial elements like the fixed network services from companies like Telone.

The other limitations were:

1. There was lack of enough funding for a more comprehensive study and to incorporate more respondents. This was overcome by triangulating various methods of research.
2. Due to confidentiality clauses in the company policy most respondents were unwilling to provide information about their views. This led to the researcher explaining to them that the research was purely for academic purposes and information given was not published.
3. Some people were reluctant to take part in the study due to lack of time and therefore the use of questionnaires enabled the researcher to gain information from these respondents.

## 1.5 .Scope

This project is going to focus on the LTE already at installed at a particular organization. In a bid to fully analyze and compare with the 3G, the project will also investigate the operations of an already existing 3G network.

## 1.6.Ethical Considerations

As part of ethical considerations the researcher did not expose participants to unnecessary physical or psychological harm. This was done through ensuring that participation was optional and not mandatory. Even after initially agreeing to participate in the research if participants fell that they need to withdraw they were allowed to do so at any stage during the research. The right to privacy was also critical in a study; therefore, the identity of the respondents remained strictly private and confidential and the participants were be informed of this prior to their participation in the research. Participants also where reserved the right to withdraw information which they felt violated their own beliefs and or principles

# Chapter Two

# Literature Review

## 2.1 .Introduction

This section will introduce the reader to the main areas that were applied in this research project. It is taken to be true that the reader has no knowledge of these areas so this part of the report is quite important as the chapters to follow shall be referring to these areas frequently.

At the end of this chapter the reader should be able to appreciate that LTE deployment in Zimbabwe is imposing a new set of challenges

## 2.2 Mobile Telecommunications Technologies

The mobile communication industry in Zimbabwe has seen a significant growth due to the high demand for both voice and data services. The mobile telephone subscriber data base, as well as the usage, has grown considerably. The operators have been upgrading their networks with advanced technologies in order to deploy both high-quality voice services and innovative data services. Service providers and equipment vendors are driving innovations with the latest wireless technologies to improve the efficiency of spectrum used, getting more capacity out of a given spectral bandwidth.

The rampant increase of mobile data usage and the introduction of new applications such as Multimedia Online Gaming, mobile TV and video calling have motivated the 3rd Generation Partnership Project (3GPP) to introduce Long-Term Evolution (LTE). LTE is the latest standard in the mobile network technology tree that encompasses the previously defined GSM/EDGE and UMTS/HSPA standards, accounting for over 86% of all mobile subscribers worldwide. LTE will ensure 3GPP's competitive edge over other cellular and mobile broadband technologies; however, it does not preclude the use of LTE in conjunction with other cellular technologies, e.g. 3GPP2, WiMAX and other non-3GPP technologies.

The 3GPP market is currently served by two technologies: GSM (with GPRS, EDGE, and Evolved EDGE) and UMTS (with HSDPA, HSUPA, and HSPA+). The evolution and key technical aspects of these technologies are summarized in table 2.1 below:

| TECHNOLOGY | DESCRIPTION |
|---|---|
| GSM | A voice-centric FDD TDM based mobile architecture using an 8-timeslot 200 kHz carrier structure. Core network based on ISDN with mobility enhancements. |
| GPRS | Introduces a packet overlay to GSM. GSM air-interface timeslots carry shared packet data channels. GPRS added to the existing GSM RAN equipment via the PCU and a standardized Gb interface using frame-relay. Separate packet core network from CS, with optional coordination of mobility between the CS & PS domains. |
| EDGE | High-speed enhancement to GPRS timeslots |
| E-EDGE | Proposed higher-speed enhancement to EDGE |
| UMTS (R99) | The network technology based on a FDD wideband-CDMA on a 5 MHz carrier. Separate network to GSM, with efficient handover between GSM and UMTS. Supports CS and PS services via dynamic dedicated channels to each terminal. Core network equipment may be an upgrade from GSM. Uses ATM and now IP transmission. The split of responsibilities between RAN and core at the Iu interface is different to GSM's A/Gb interface. |
| HSDPA/ HSUPA | Adds new high-speed packet shared packet channels to the existing R99 UMTS system, and works within the R99 frequencies. Shared channels do not use soft handover, and air-interface management functions for these channels moved from RNC to NodeB. |
| HSPA+ | Enhancement of HSDPA/HSUPA to exploit available radio technologies as well as the option of 'flattening' the existing complex architecture. |

**Table 2.1 Mobile telecommunications technologies and description**

### 2.2.1 Importance of GSM

GSM has been an overwhelmingly successful technology and has an unsurpassed installed base of infrastructure and subscribers. GSM is perceived to continue servicing customers for a long time supporting roamers and providing coverage while eventually migrating to LTE.

GSM has remained an attractive option economically addressing the needs of many consumers due to the availability of low cost GSM handsets with longer battery lifetimes in the mass market [7].

### 2.2.2 .GSM OVERVIEW

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz

GSM was devised as a cellular system specific to the 900 MHz band, called The Primary Band. The primary band includes two sub bands of 25 MHz each, 890 to 915 MHz and 935 MHz to 960 MHz GSM-PLMN has allocated 124 duplex carrier frequencies over the following bands of operation: [7]

Uplink frequency band: 890 to 915 MHz (MS transmits, BTS receives) [8].

Downlink frequency band: 935 to 960 MHz (BTS transmits, MS receives) [8].

Carrier spacing: - 200 KHz.

#### 2.2.2.1 GSM Architecture

A GSM network is composed of several functional entities, whose functions and interfaces are specified. Figure 2.1 shows the layout of a generic GSM network. The GSM network can be divided into three broad parts. The Mobile Station which constitutes the subscriber. The Base Station Subsystem which controls the radio link with the Mobile Station. The Network Subsystem, the main part of which is the Mobile services Switching Center (MSC), performs the switching of calls between the mobile users, and between mobile and fixed network users. The MSC also handles the mobility management operations [9]. The Mobile Station and the Base Station Subsystem communicate across the Um interface, also known as the air interface or radio link. The Base Station Subsystem communicates with the Mobile services Switching Center across the A interface.

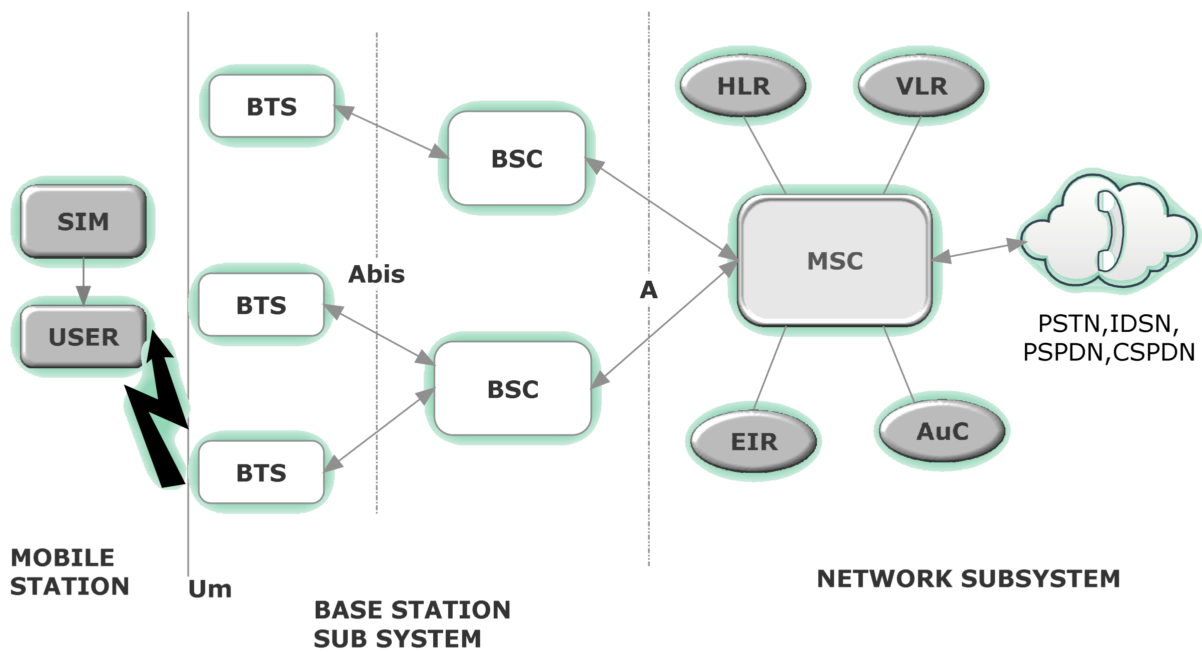



**Figure 1.1 Simplified GSM Network overview**

<u>KEY</u>

| | |
|---|---|
| SIM | Subscriber Identity Module |
| BSC | Base Station Controller |
| MSC | Mobile Services Switching Center |
| HLR | Home Location Register |
| EIR | Equipment Identity Register |
| BTS | Base Transceiver Station |
| VLR | Visitor Location Register |
| AuC | Authentication Center |

**Mobile Station**

The mobile station (MS) consists of the mobile equipment (the terminal) and the Subscriber Identity Module (SIM). The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal. By inserting the SIM card into another GSM terminal, the user is able to receive calls at that terminal, make calls from that terminal, and receive other subscribed services.

The mobile equipment is uniquely identified by the International Mobile Equipment Identity (IMEI). The SIM card contains the International Mobile Subscriber Identity (IMSI) used to identify the subscriber to the system, a secret key for authentication, and other information. The IMEI and the IMSI are independent, thereby allowing personal mobility. The SIM card may be protected against unauthorized use by a password or personal identity number [9].

**Base Station Subsystem**

The Base Station Subsystem is composed of two parts, the Base Transceiver Station (BTS) and the Base Station Controller (BSC). These communicate across the standardized Abis interface, allowing (as in the rest of the system) operation between components made by different suppliers.

The Base Transceiver Station houses the radio transceivers that define a cell and handles the radio-link protocols with the Mobile Station. In a large urban area, there will potentially be a large number of BTSs deployed, thus the requirements for a BTS are ruggedness, reliability, portability, and minimum cost [9].

The Base Station Controller manages the radio resources for one or more BTSs. It handles radio-channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile station and the Mobile service Switching Center (MSC).

**Network Subsystem**

The central component of the Network Subsystem is the Mobile services Switching Center (MSC). It acts like a normal switching node of the PSTN or ISDN, and additionally provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. The MSC provides the connection to the fixed networks (such as the PSTN or ISDN). Signaling between functional entities in the Network Subsystem uses Signaling System Number 7 (SS7), used for trunk signaling in ISDN and widely used in current public networks [7].

The Home Location Register (HLR) and Visitor Location Register (VLR), together with the MSC, provide the call-routing and roaming capabilities of GSM. The HLR contains all the administrative information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile. The location of the mobile is typically in the form of the signaling address of the VLR associated with the mobile station. There is logically one HLR per GSM network, although it may be implemented as a distributed database.

The Visitor Location Register (VLR) contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently located in the geographical area controlled by the VLR. The geographical area controlled by the MSC corresponds to that controlled by the VLR. Note that the MSC contains no information about particular mobile stations --- this information is stored in the location registers [10].

The other two registers are used for authentication and security purposes. The Equipment Identity Register (EIR) is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by its International Mobile Equipment Identity (IMEI). An IMEI is marked as invalid if it has been reported stolen or is not type approved. The Authentication Center (AuC) is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and encryption over the radio channel.

### 2.2.3 .3G Network Overview

3G is also called third generation. The name comes from the fact that it is the third generation of the standards of telecommunication hardware. It is also the general technology for mobile networking, passing the recent 2.5G. The technology is founded on the ITU or International Telecommunication Union group of standards which belongs to the IMT-2000.

3G networks history allow network operators to provide users a bigger range of the latest services, as it gets bigger network capacity via heightened spectral efficiency. The included services are video calls, wide-area wireless voice telephone and broadband wireless information, all included within the mobile environment. More features included are HSPA data transmission capacities that can send data rates reaching 14.4 Mbit/s on the downlink and the uplink at 5.8 Mbit/s. Figure 2.2 above shows 3G overview. [11]

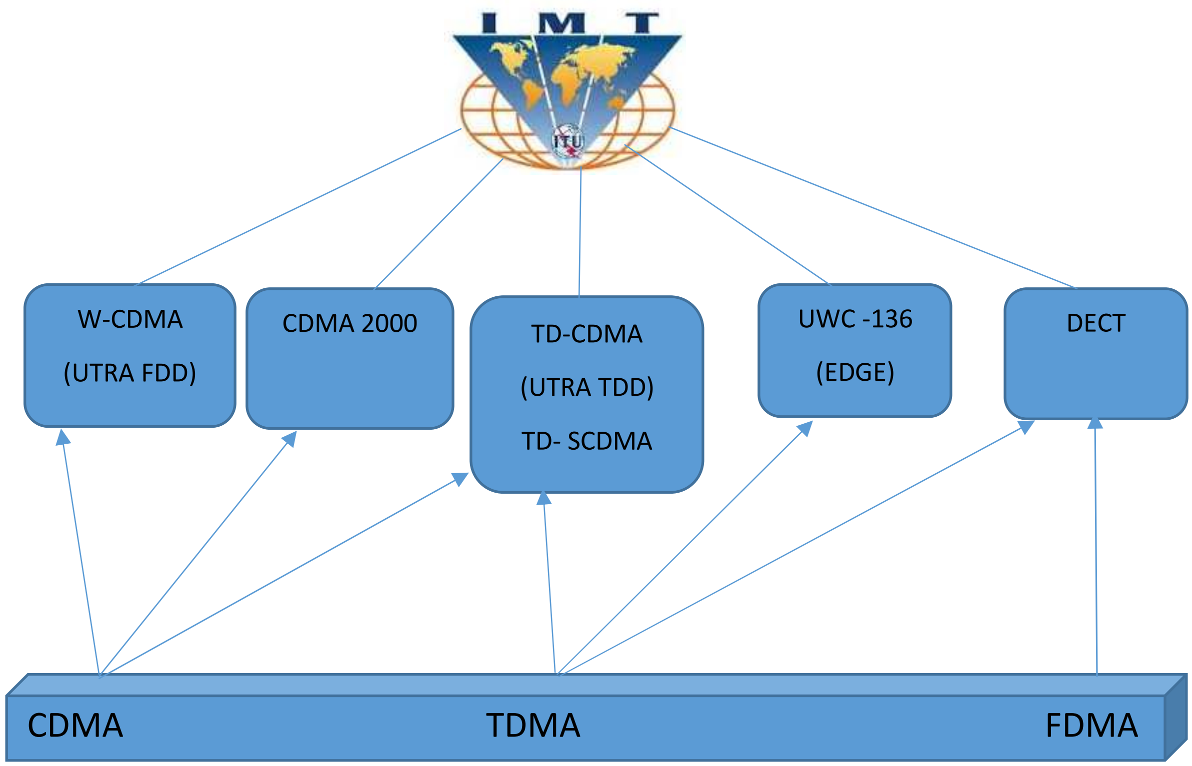



**Figure 2.2 3G Overview**

### 2.2.3.1 Evolution of 3G from 2G

The Evolution to 3G elaborate the upgrading of cellular mobile telecommunications networks to use new 3G technologies. This process has been taking place over the period 1999 to 2010. Japan is the first country having introduced 3G nationally, and in Japan the transition to 3G was largely completed during 2005/2006. 3G technologies enable network operators to offer users a wider range of more advanced services, while achieving greater network capacity through improved spectral efficiency. The evolution process is illustrated in figure 2.3

The International Telecommunication Union (ITU) has defined the demands for third generation mobile networks with the IMT-2000 standard. An organization called 3GPP has continued that work by defining a mobile system that fulfils the IMT-2000 standard. This system is called Universal Mobile Telecommunications System (UMTS). The evolution of the system will move forward with so called releases. In each release new features will be introduced [7].

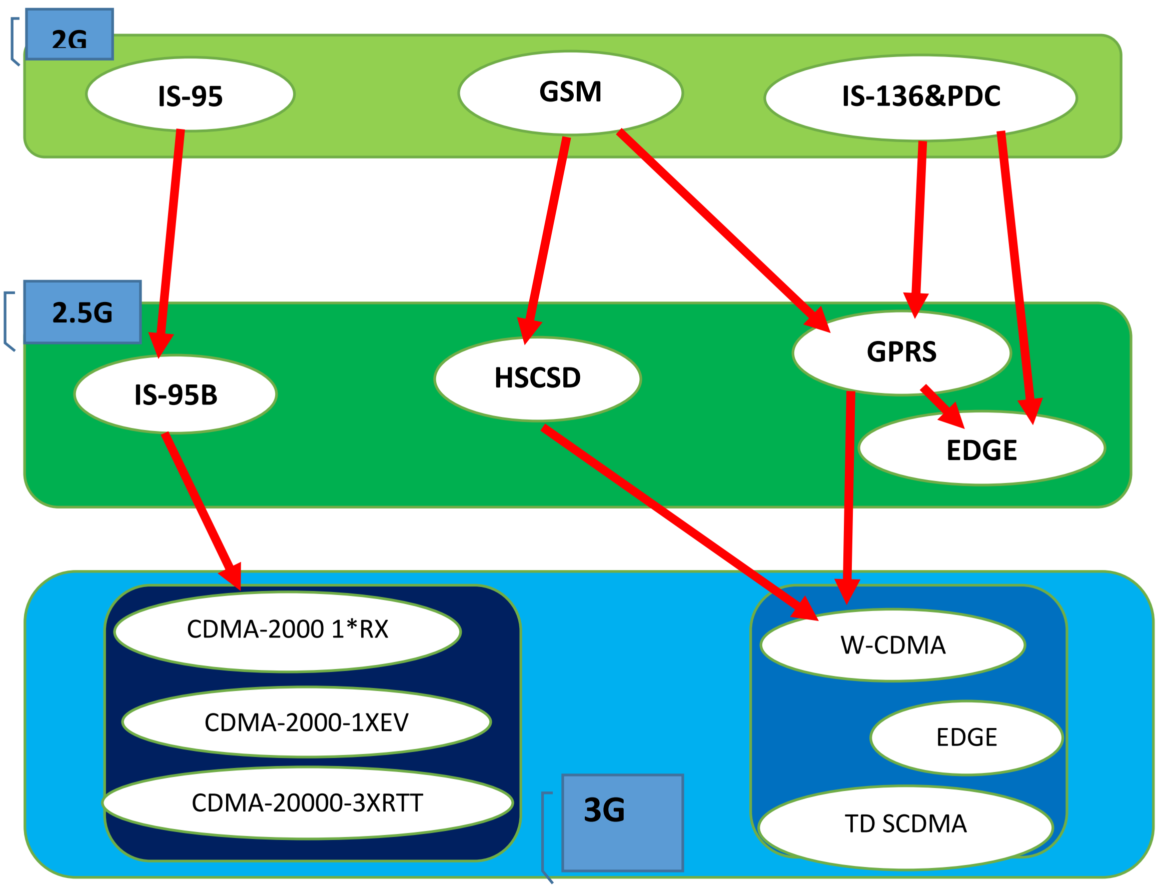



**Figure 2.3 3G Evolution**

There are several different paths from 2G to 3G as seen in figure 2.3. In Europe the main path starts from GSM when GPRS is added to a system. From this point it is possible to go to the

UMTS system. In North America the system evolution will start from TDMA going to EDGE and from there to UMTS.

The first new technology when going from GSM towards UMTS is General Packet Radio Service (GPRS). It is the trigger to 3G services. The main point is that the network connection is always on, so the subscriber is online all the time. From the operator's point of view, it is important that GPRS investments are re-used when going to UMTS. Also capitalizing on GPRS business experience is very important [12].

From GPRS, operators could go directly to UMTS, but they could also invest in an EDGE system. One advantage of EDGE is that there is no new license needed as in UMTS. The frequencies will also be re-used and no new antennas are needed. The main issue is that subscribers will have to buy new EDGE terminals.

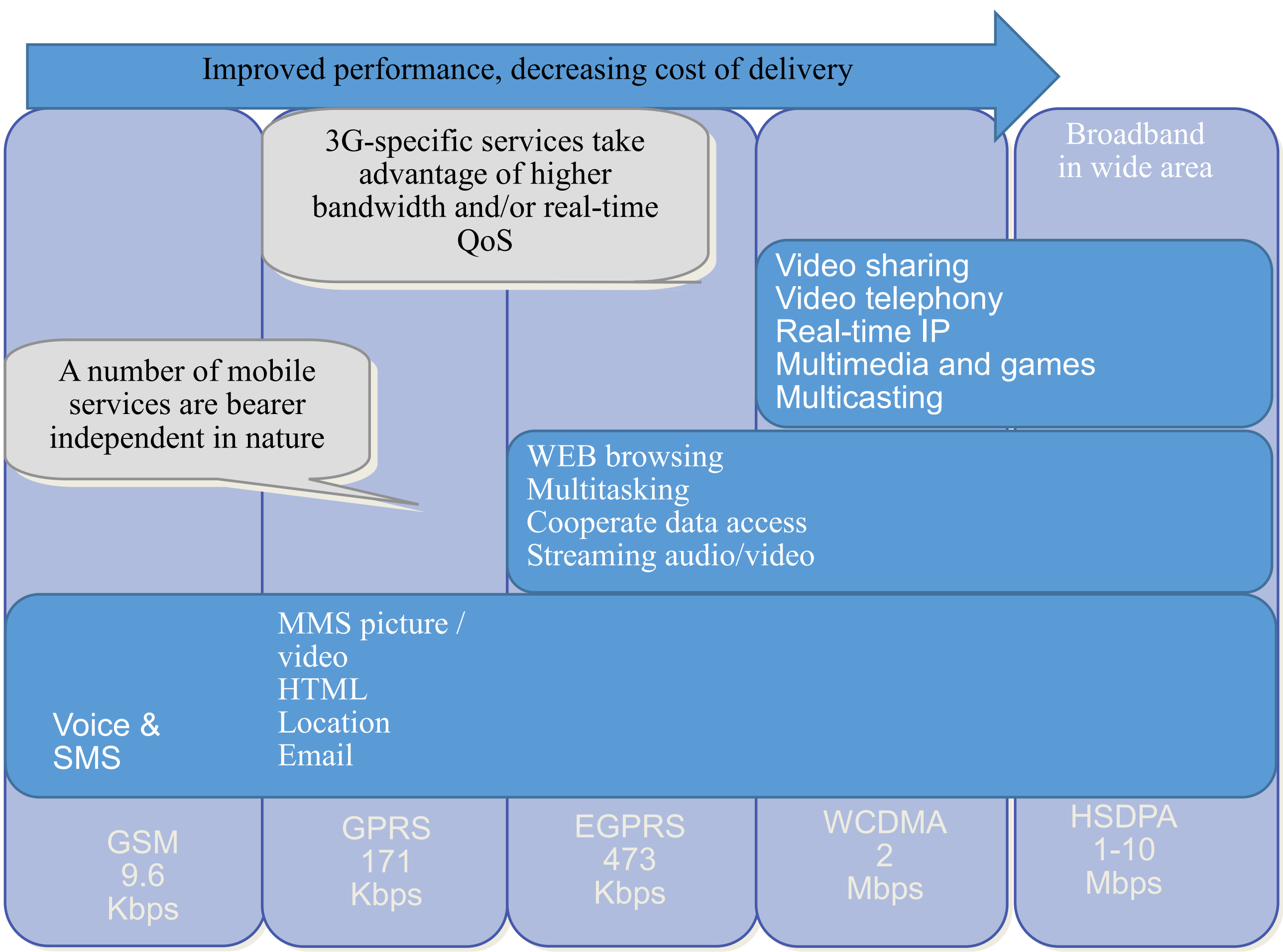



**Figure 2.4 Service roadmap [7]**

## 2.2.4 UMTS Network Architecture

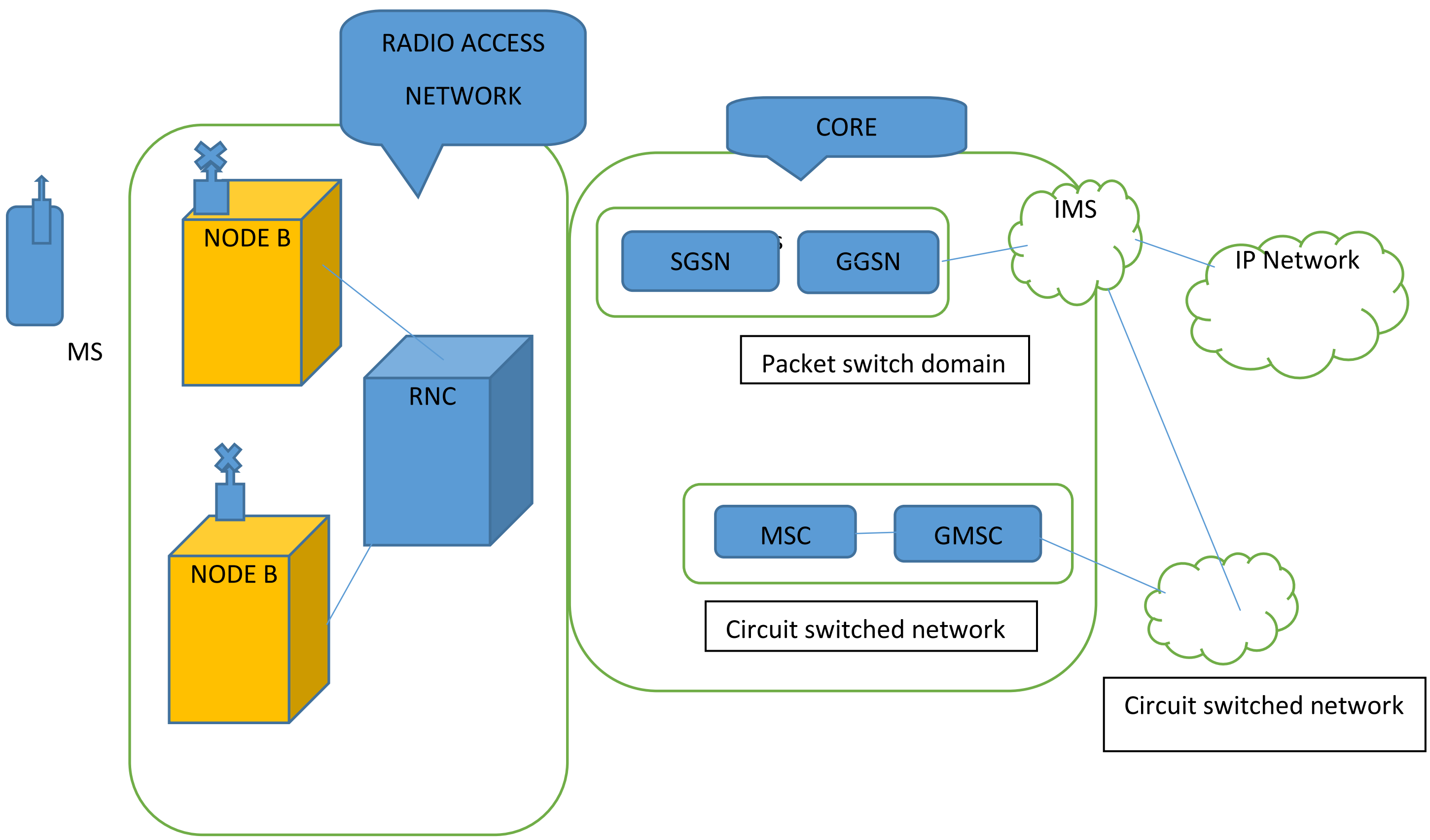



**Figure 2.5 UMTS Network architecture [12]**

<u>KEY</u>

| | |
|---|---|
| MSC | Mobile switching center |
| GMSC | Gateway Mobile switching center |
| SGSN | Service GPRS service network |
| GGSN | Gateway GPRS support network |
| IMS | IP Multimedia Subsystem |

UMTS network architecture shown in figure 2.5 consists of three domains

- Core Network (CN): Provide switching, routing and transit for user traffic
- UMTS Terrestrial Radio Access Network (UTRAN): Provides the air interface access method for user equipment.
- User Equipment (UE): Terminals work as air interface counterpart for base stations. The various identities are: IMSI, TMSI, P-TMSI, TLLI, MSISDN, IMEI, IMEISV

Base stations are referred to as Node-B and the controlling equipment for all Node-Bs is called as Radio Network Controller (RNC).

Functions of Node-B are

- Air Interface Tx/Rx
- Modulation/Demodulation

Functions of RNC are:

- Radio Resource Control
- Channel Allocation
- Power Control Settings
- Handover Control
- Ciphering
- Segmentation and reassembly

### 2.2.5 3.5G (HSPA)

High Speed Packet Access (HSPA) is an amalgamation of two mobile telephony protocols, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) that extends and improves the performance of existing WCDMA protocols [12].

3.5G introduces many new features that will enhance the UMTS technology in future. 1xEV-DV already supports most of the features that will be provided in 3.5G. These include:

- Adaptive Modulation and Coding
- Fast Scheduling
- Backward compatibility with 3G
- Enhanced Air Interface

### 2.2.6 4G (LTE)

LTE stands for Long Term Evolution and is the next Generation mobile broadband technology with promised data transfer rates of 100 Mbps. It is based on UMTS 3G technology and is optimized for All-IP traffic.

#### 2.2.6.1 Advantages of LTE

For Network operators the advantages of LTE include:

- High network throughput
- Low latency
- Plug and play architecture
- Low operating costs
- All IP network
- Simplified upgrade path from 3G networks

For End users the advantages include:

- Faster data downloads or uploads
- Improved response for applications
- Improved end-user experience

### 2.2.6.2 Comparison of Theoretical LTE speeds

| | **2G** | **2.5G** | **3G** | **LTE** | **4G** |
|---|---|---|---|---|---|
| Download speed | 14.4 Kbps | 384 Kbps | 14.4 Mbps | 115 Mbps | 1 Gbps |
| | | | | | |

### 2.2.6.3 Major LTE Radio Technologies

- Uses Orthogonal Frequency Division Multiplexing (OFDM) for downlink
- Uses Single Carrier Frequency Division Multiple Access (SC-FDMA) for uplink
- Uses Multi-input Multi-output(MIMO) for enhanced throughput
- Reduced power consumption
- Higher RF power amplifier efficiency which implies less battery power used by handsets

### 2.2.6.4 LTE Architecture

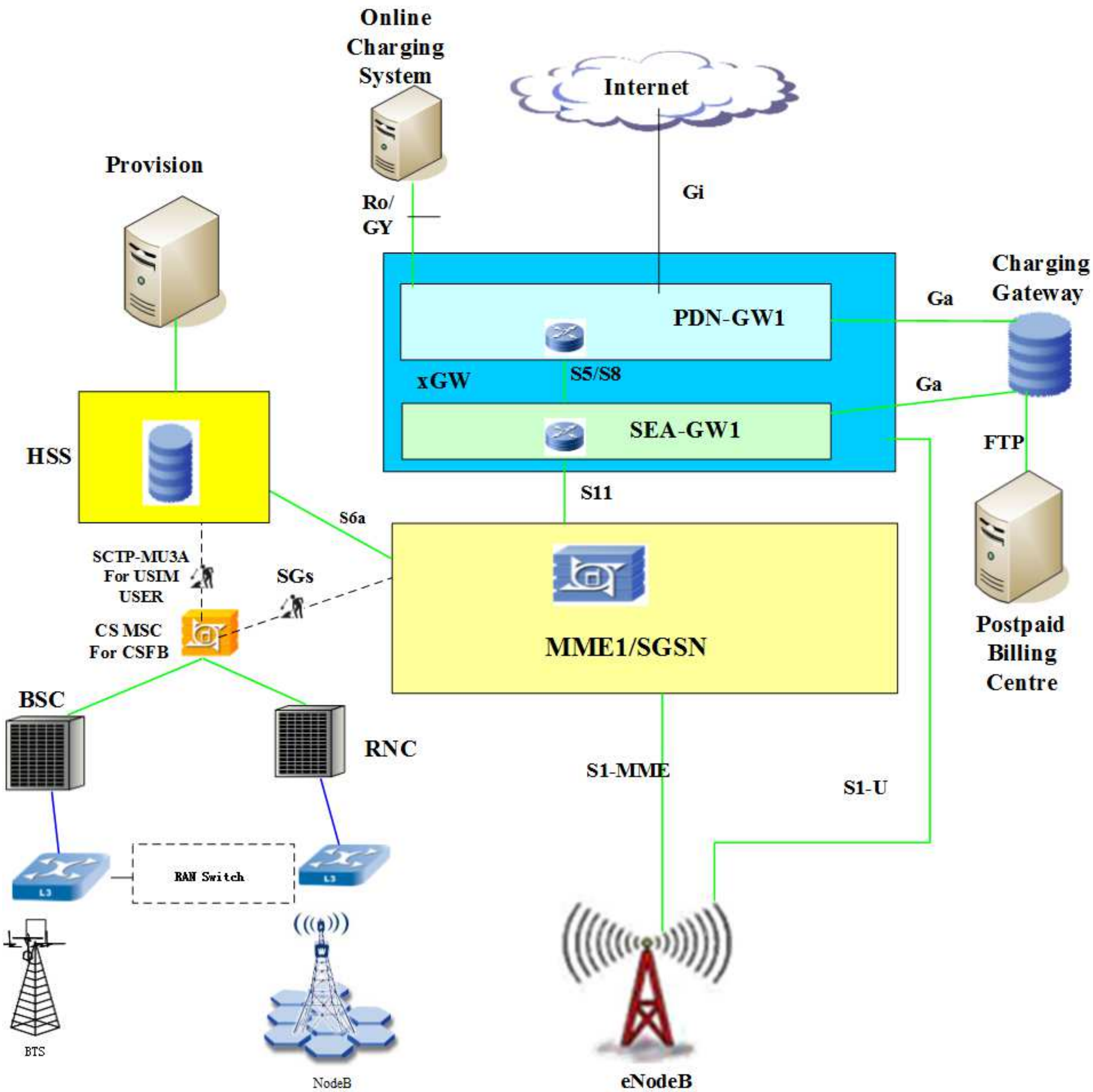



**Figure 2.6 LTE architecture**

### 2.2.6.5 LTE vs. UMTS functional comparison

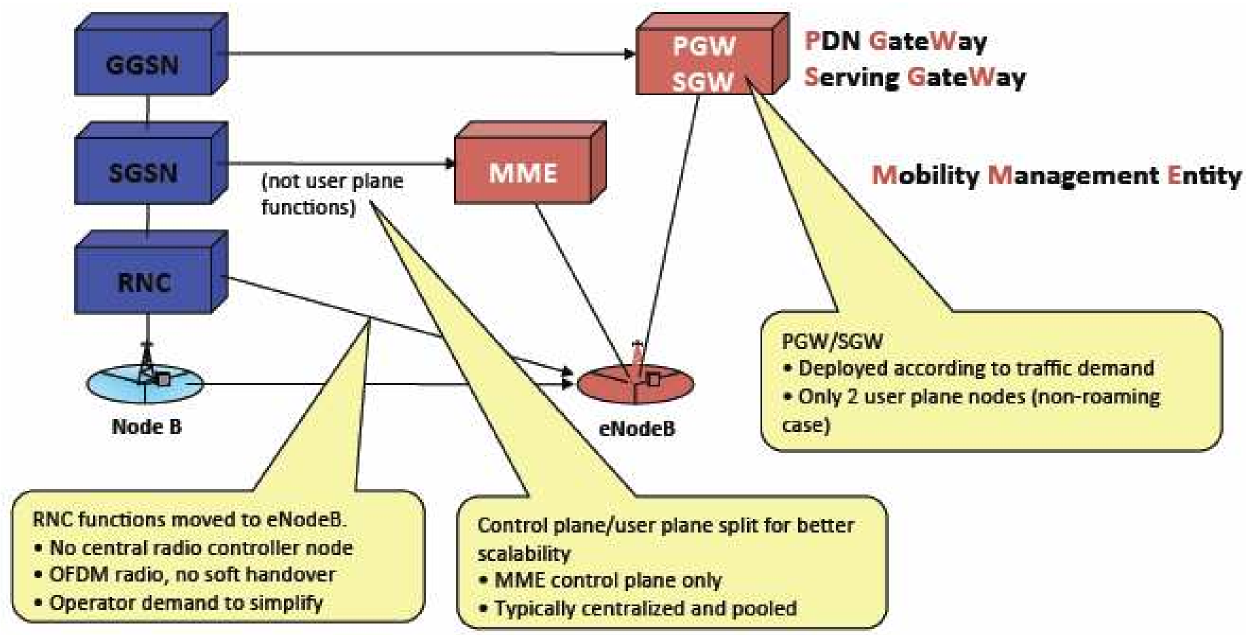



**Figure 2.7 LTE vs. UMTS**

Figure 2.7 shows a comparison between LTE and UMTS networks.

## 2.3 Telecom Industry Growth in Zimbabwe

Telecommunication in simpler terms is the transmission of signals over a distance for the purpose of communication. The technology involved in communicating has evolved significantly over the years. Like telecommunications itself, the telecommunications industry is broader than it was in the past. Telecommunication has a significant social, cultural and economic impact on the modern society.

According to the Postal and Telecommunications Regulatory Authority of Zimbabwe Postal and Telecommunications Sector Performance Report for the 2013 third quarter, total mobile subscribers increased by 5, 6 percent, rising to 13,518,887 from 12,796,118 subscribers recorded in the previous quarter [13].

In contrast to the mobile sector the report said that fixed telephone subscribers declined by 2 percent to reach 307,202 subscribers from 314,622 recorded in the previous period [13].

At the end of the quarter under review, the population under mobile coverage stood at 74,9 percent against a land coverage of 70,1 percent [13]. This marked a 1,8 percent growth in the population covered by mobile networks and a 1,5 percent growth in land coverage compared to the previous quarter.

POTRAZ said the sector was largely driven by mobile telephony [13]. This is evidenced by the continuous growth of mobile subscribers and the increasing traffic volumes for both national and international calls.

This growth is likely to continue and will be characterized by stiff competition and product diversification aimed at sustaining or increasing revenues and market share, the authority added.

Growth in the mobile data and internet segment was the main driver in the upward trend recorded in the data/internet market.

## 2.4 .Policy and Regulation Issues

The telecommunications policy is a framework of law directed by government and the regulatory commissions [14]. The Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) was established in terms of the Postal and Telecommunications Act [Chapter 12:05] of 2000 and is mandated by law to issue licenses in the postal and telecommunications sectors. In pursuance of this responsibility, POTRAZ performs numerous functions which include, allocating the radio frequency spectrums in Zimbabwe. Ensuring that the quality of postal and telecommunication services meet acceptable standards. Promoting and encouraging the innovative development of postal and telecommunication services. Monitoring tariffs charged for services to ensure affordability. And promoting the interests of consumers in terms of quality, variety and availability of services.

## 2.5 .The Future of Telecommunications

Communication is a crucial basis for the development of each individual's social identity as well as for intellectual and commercial exchange and economic development [15].

Therefore, the question is not whether telecommunications industries have a future but what kind of future old and new players will have, given the dynamic changes in technologies and markets with various opportunities, challenges, and discontinuities.

Telecommunications has been and will continue to be an important foundation for innovative new industries that use telecommunications as a primary technological enabler and foundation. That being said, one should know that "not everything that glitters is gold". For example, the emerging markets face lacking of talented resources and intense competition in order to sustain the growth that has been observed over the past few years [16].

The importance of regulatory and policy changes are stressed upon in order to adapt to the future and maintain the growth rate of the telecom industry in all countries.

# Chapter Three

# Methodology

## 3.1 .Introduction

This Chapter describes the methods that were adopted and the various data collection techniques that were employed in an attempt to address the critical question on the feasibility for Zimbabwe telecommunications operators to migrate to LTE widely marketed as 4G LTE.

The design of the methodology was more based on the research objectives of this paper. As a result the research was both qualitative and quantitative in trying to determine the critical factors contributing towards the revenue of Zimbabwe telecommunications industries.

In qualitative approach the main focus is on getting a deeper understanding and discovering the experiences and perspectives of the active participants. In this method the approach is flexible and informal. The techniques employed ranges from unstructured interviews, document analysis, and particular observation to case studies. The responses are explanatory and give depth but the outcome exposes danger of subjective interpretation.

On the other hand quantitative research method is centered on maximizing objectivity, replicability and generalizability of findings. The major interest is on prediction. In this method the approach is formal and structured. It is advised to know in advance the questions to ask and the areas to be covered. The sample size is usually large. The techniques may involve the following; structured interviews, questionnaires, non-participant observation, experiments or tests. The responses are not explanatory and lack depth. The responses are mainly numerical and often coding and data processing tools like Microsoft excel may be employed to analyze the data. The outcome is in form of results and can be quantified. The interpretation is more objective.

## 3.2 .Research approach

This research project presents a case where strategies where employed to bring together or integrate qualitative and quantitative so that the combined outcomes and strengths accomplished more than what was possible with a single method.

The approach used in this research document became a pragmatic approach because of the mixed methods that were used to meet the research objectives. This choice helped in overcoming the limitations of each single method and the limitations of the project time. The benefits also include an improved quality of research because of the combination of research methods.

## 3.3 .Choosing between the Observation and Questioning Approach

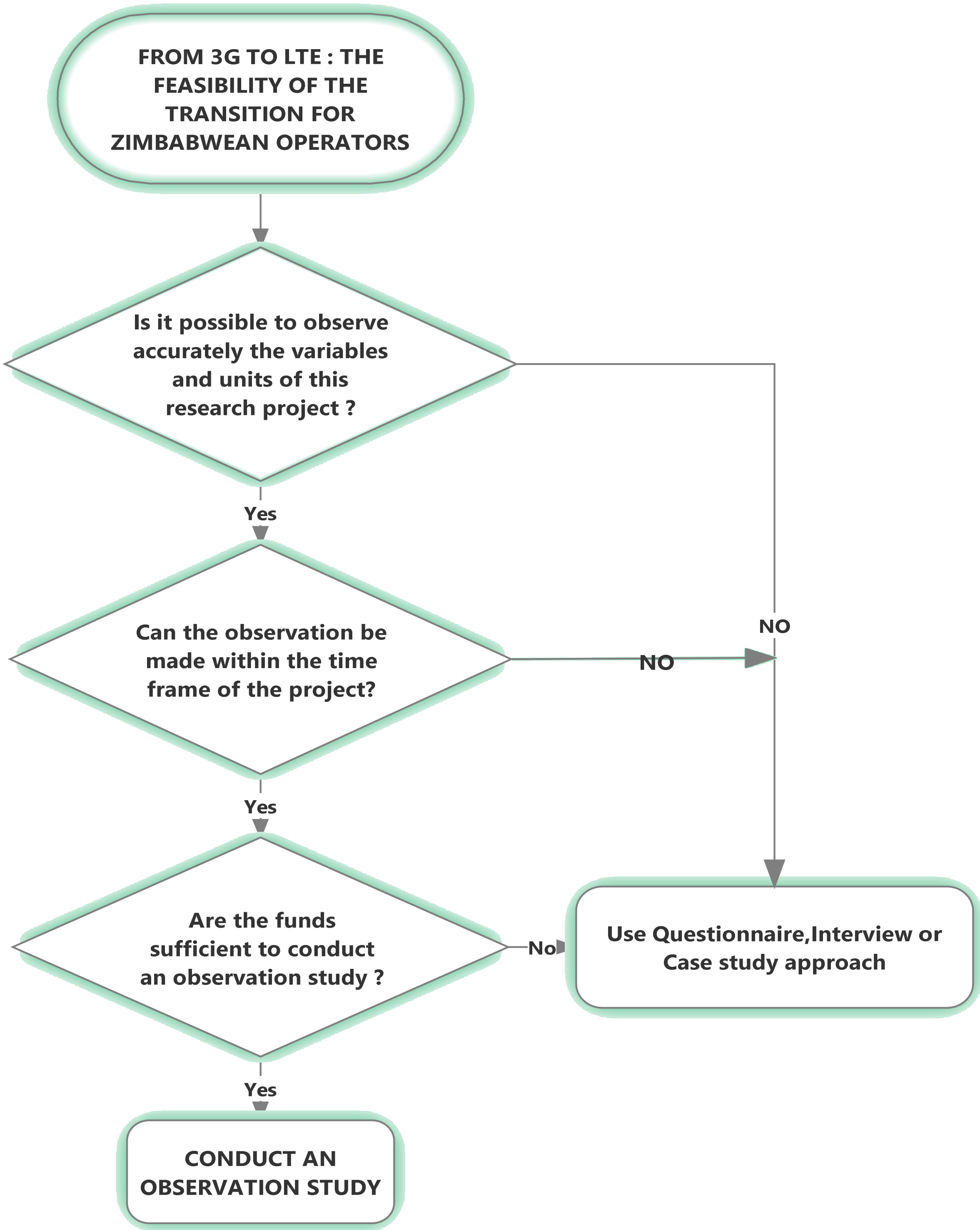



Figure 3.1 Choosing between the Observation and Questioning Approach

The flow chart of figure 3.1 shows how the decision between which approaches to use was conducted.

In most cases the observation approach was preferred because most of the essential data involved interaction with the actual equipment.

## 3.4 .Data Collection

Data was classified according to figure 3.2.

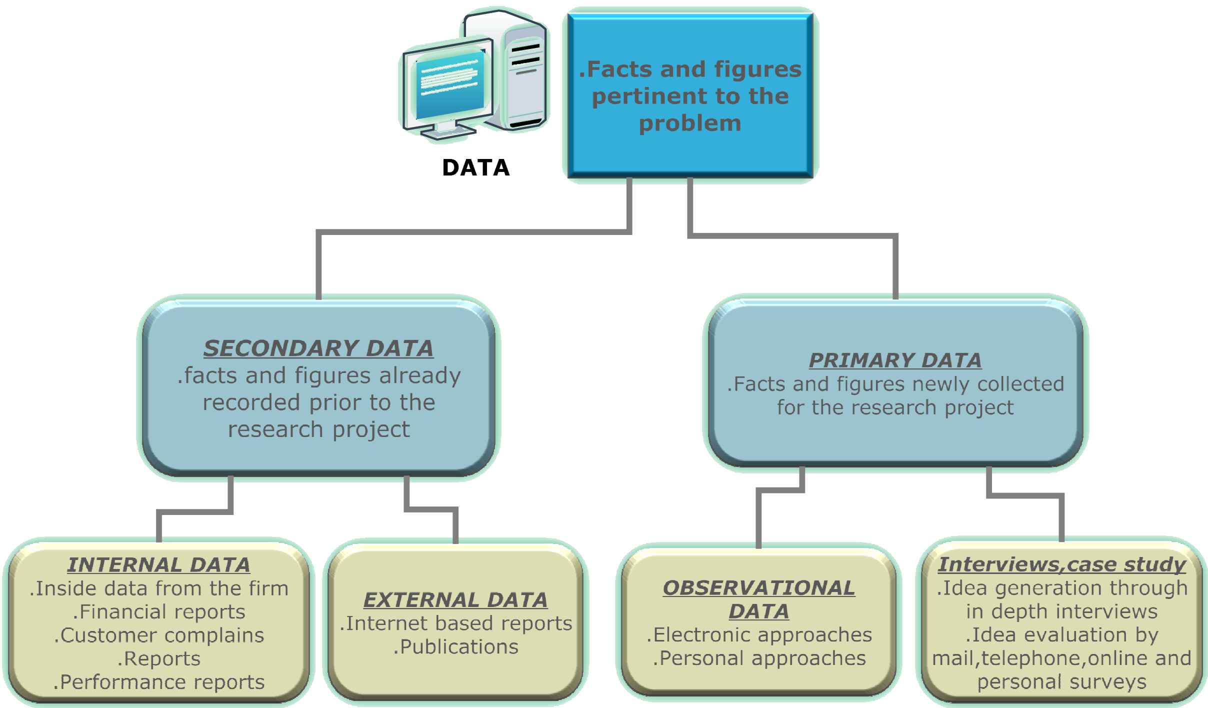



**Figure 3.2 Data classification**

PRIMARY DATA: This is data that was collected through the author`s own measurements and observations in the field.

The primary information formed the basis of the investigations

SECONDARY DATA: This is information obtained from sources that have already been published and is in statistical or mapped forms. In this research secondary information will supplement primary information but must only play a small part in the investigation.

To meet the objectives of this research project the following were some the major points that were looked at in the data extraction process.

- Government regulation or licensing
- Market uptake
- Mobile revenue
- Number of subscribers
- Expansion of subscribers
- Mobile network costs
- Monthly active users for most popular applications

The research structure overview is shown in Figure 3.3 employs a three-level approach aiming to develop an experimental model to study the empirical findings.

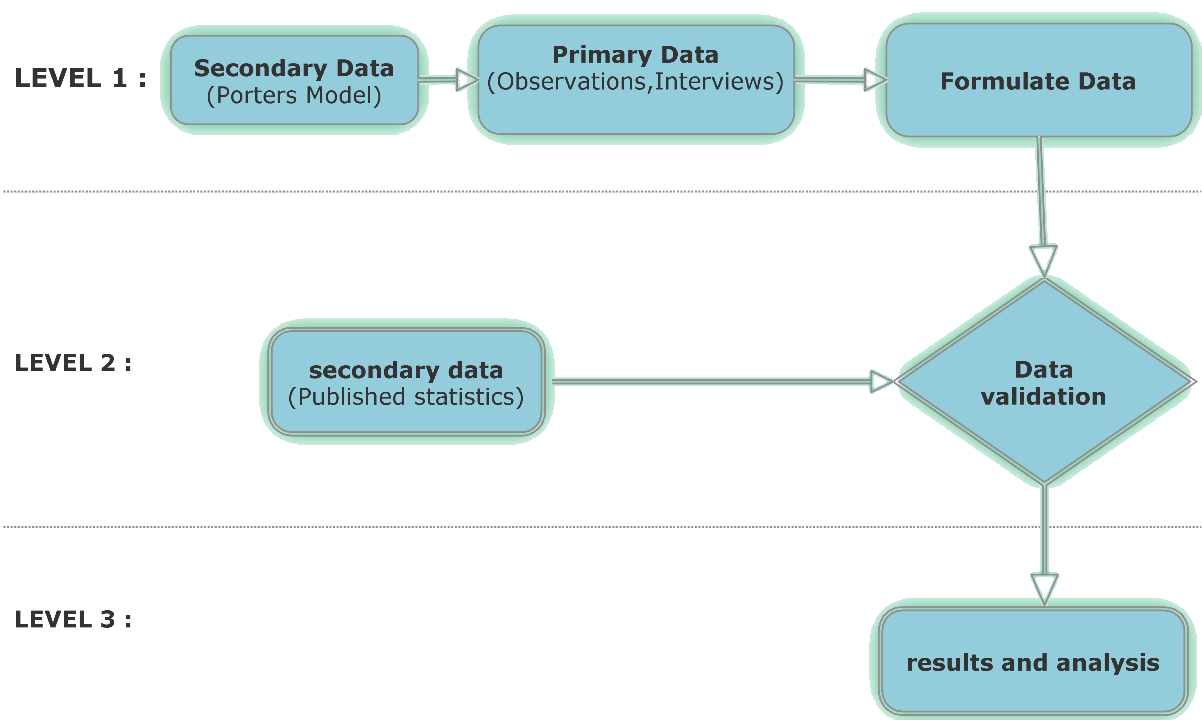



**Figure 3.3 research overview**

To study the determinant factors of the Zimbabwe telecom industry revenue the author adopted Porter`s Five forces model which systematically accommodates industry analysis. The Porter`s Five forces model was modified to suit this research and is shown in figure 3.4. It shows competition from both internal threats and external resources to determine the intensity of the existing completion in the telecoms industry and the resultant profitability of the telecoms market.

The Porter`s model was therefore adopted as the conceptual framework to analyze the influencing factors of the revenue growth in Zimbabwe telecom industry.

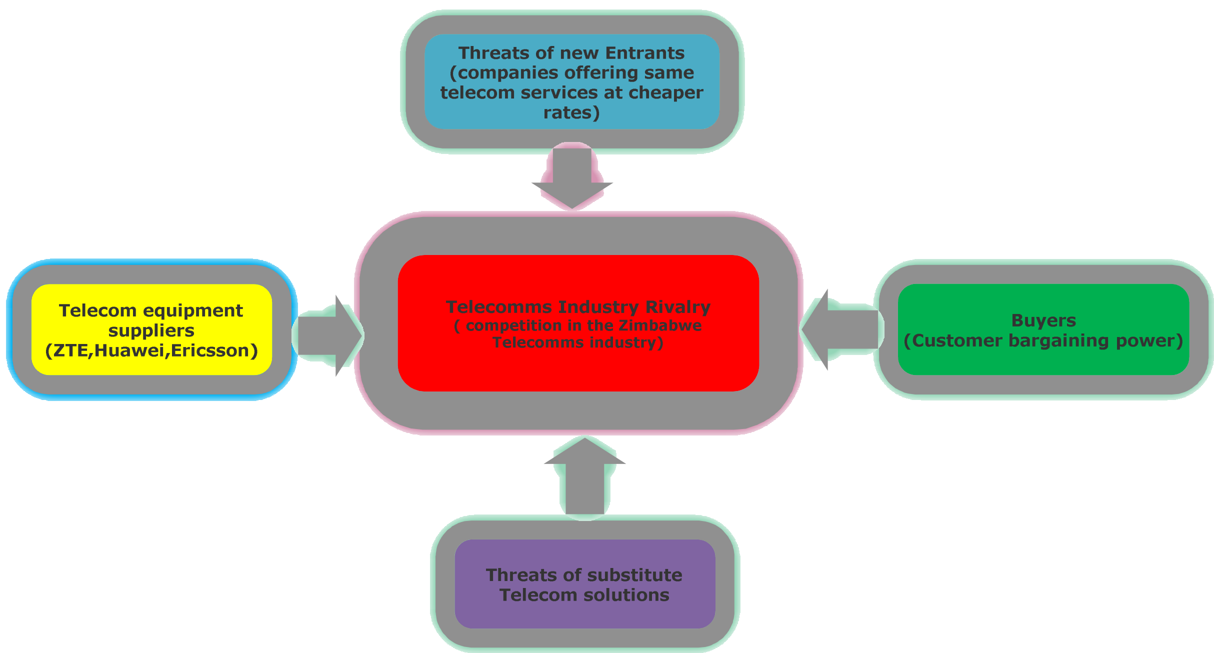



**Figure 3.4 Porter`s modified Five forces model to determine nature of competition**

From the modified Porter's Five Forces model the author aimed at obtaining the widest data range possible and took into account factors from various dimensions such as customers, suppliers and other stakeholders who are relevant to the industry analysis.

### 3.4.1. Primary Data Collection

This section will describe the steps that were followed to extract information from the equipment. The author having a strong background in telecoms had to interact directly with the actual equipment and therefore the data in this section represents the author's observations and experiment findings. Two main methods were employed which are:

- Script coding
- Mobile Network Element Management System

#### 3.4.1.1 .Script Coding

In brief scripting language is a programming language that supports scripts. These programs are written for special run-time environments that can interpret and automate the execution of tasks that could alternatively be executed one-by-one by a human operators

For purposes of this research this method was preferred to extract subscriber information from the Home Location Register (HLR). The HLR is a master database of all subscribers in the network. The data it contains is remotely accessed by all the Mobile Switching Centers(MSCs ) and the visitor location registers(VLRs) in the network and, although the network may contain more than one HLR, there is only one database record per subscriber each HLR is therefore handling a portion of the total subscriber database.

The subscriber data may be accessed by either the International Mobile Subscriber Identity (IMSI) or the Mobile Station International Subscriber Directory Number (MSISDN).

**I. EXTRACTING ALL TYPES OF HANDSETS IN THE NETWORK**

To determine the types of handsets in the network the code snippet below was used.

```
if (not null sub.msisdn) ->
count key: "Count for all Subscribers ",
output text:
sub.msisdn "|"
sub.imei "|"
dev.brand "|"
dev.model " "
end
```

## II. EXTRACTING 3G HANDSETS IN THE NETWORK

To extract only 3G handsets the following script code was used:

```
if (dev.hardware_umts == true and dev.hardware_hsdpa == true ) ->
count key: "Count for all  Subscribers ",
output text:
sub.msisdn " "
dev.brand " "
dev.model " "
end
```

## III. EXTRACTING LTE HANDSETS ONLY

```
if (dev.hardware_lte == true) ->
output text:
" IMSI: " sub.imsi
" IMEI: " sub.imei
" MSISDN: " sub.msisdn
" Handset manufacturer and model: " dev.brand " " dev.model,
 count key: "lte capable devices"
end
```

The outputs from the script codes were text files .The sample output is shown in figure 3.5. As can be seen form the output text file the data needed further processing to have a meaning. The methods that were employed to process the data shall be discussed in the results section.

```
Samsung I9500 263[redacted]9140 Apple iPhone 5 263[redacted]200 Samsung I9100 263[redacted]260 SonyEricsson X10i
[redacted] Huawei P2-6011 263[redacted]355 HTC Status (PH06110) 263[redacted]9510 Sony Xperia E C1504 263[redacted]
Samsung S5660 263[redacted]03 Nokia N95 263[redacted]27[redacted]93 Samsung S5300 263[redacted]5662[redacted] BlackBerry 9300 263[redacted]
6 Samsung SC-04D 263[redacted]66640 Nokia E5-00 263[redacted]37[redacted]9 Nokia Lumia 520 263[redacted]249 Samsung S5300 26
ng S5270K 263[redacted]5962 Samsung S5300 26[redacted]6073 Samsung I9100 263[redacted]8004 Samsung S5301 263[redacted]589
300 263[redacted]09 Samsung SM-N9005 263[redacted]605 SonyEricsson Naite J105i 263[redacted]83 BlackBerry 9000
E63 263[redacted]83 Samsung SHW-M110S 263[redacted]85 Nokia E71 263[redacted]386 Samsung S5300 26[redacted]685 Bl
Samsung S5300 263[redacted]71290 LG LG-P768 263[redacted]71344 LG LG-E455 263[redacted]1453 Nokia N97mini 263[redacted]47148
ng S5301 263[redacted]19567 Samsung S5300 26[redacted]74328 Apple iPhone 3G 263[redacted]669 Nokia 3030 263[redacted]370
263[redacted]9914 Samsung S6102 26[redacted]9976 Samsung S5300 26[redacted]09981 Samsung B5330 263[redacted]10213 Samsun
7550 Samsung E3210 26[redacted]217 Motorola V1100 [redacted]2328 Apple iPad 2 263[redacted]756 Apple iPhone 4
263[redacted]706 Samsung I9003 263[redacted]189 Nokia 3020 263[redacted]858 Samsung S5301 263[redacted]8190 Samsung S
Samsung S6102 263[redacted]341 Samsung S5300 263[redacted]0364 Nokia 3110 263[redacted]06 SonyEricsson Xperia X1
Berry 9300 26[redacted]688632 BlackBerry 9300 263[redacted]78144 Nokia 3020 26[redacted]814104 Nokia 5230 263[redacted]94
00 263[redacted]723 Samsung S5300 263[redacted]433 Huawei U8150-D IDEOS 263[redacted]291 Samsung B5510 263[redacted]75
30i 263[redacted]281 ZTE E821 263[redacted]297 Nokia E63 263[redacted]878 Nokia C6-00 263[redacted]4156 Samsung S5300
[redacted]609 Samsung I9300 263[redacted]631 Samsung S5360 263[redacted]183 BlackBerry 9700 263[redacted]088 Samsung I9
GS 263[redacted]138 Samsung I9100 263[redacted]50721 Nokia E51 263[redacted]85542 Samsung S5301 263[redacted]809 Nokia C
[redacted]3821 HTC Desire (PB99200) 263[redacted]693 SonyEricsson Xperia X10 Mini pro U20i 263[redacted]03542 Nokia
amsung P1000 263[redacted]355 Samsung S5570 263[redacted]875 Samsung S5360T 263[redacted]628 BlackBerry 9360 263
[redacted]88 HTC Titan (PI39120) 263[redacted]95 Nokia 5230 263[redacted]374 Samsung S5300 263[redacted]800 Nokia C5-0
2[redacted]9445 Samsung S5830 263[redacted]913 Samsung S5301 263[redacted]024 Samsung S5360 263[redacted]295 HTC Desire
essMusic 263[redacted]1 Peiker CIB eCall US Mexiko-NAD 6200 US 263[redacted]988 Apple iPhone 4 263[redacted]772
263[redacted]1166 Samsung S6500D 263[redacted]755 Samsung S5360 263[redacted]856 Nokia 3110 263[redacted]211 Samsung
6710 Navigator 263[redacted]525 Samsung S5300 263[redacted]605 Apple iPhone 4 263[redacted]279 Samsung S5360 263
ckBerry 9720 263[redacted]761 Nokia E66 263[redacted]30 Samsung S5830 263[redacted]24 Samsung I9082 263[redacted]60
46 Nokia E51 263[redacted]21 Samsung I9300 263[redacted]609 Nokia E63 263[redacted]70 HTC Flyer Tablet (PG4110
5 26[redacted]76 Samsung I5801 263[redacted]045 Samsung I9500 263[redacted]407 Nokia 6700 Classic 263[redacted]467
[redacted]858 Nokia E75 263[redacted]977 Samsung I9500 26[redacted]784 Samsung S5830i 263[redacted]1812 Samsung I580
I747 263[redacted]66682 Nokia E5-00 26[redacted]893634 Samsung S5300 263[redacted]82624 BlackBerry 9530 263[redacted]286 S
BlackBerry 9000 263[redacted]509 Samsung I8190 263[redacted]978 Nokia X3-02 263[redacted]268 BlackBerry 9700 263
01 263[redacted]09 Nokia 3030 263[redacted]394 Nokia 3020 263[redacted]9008 Samsung I9300 263[redacted]19291 Nokia C7-
3[redacted]891 Nokia E5-00 263[redacted]8909 Nokia 3020 263[redacted]923 BlackBerry 9300 263[redacted]975 Nokia 3000
6[redacted]19 Nokia E63 263[redacted]225 Nokia 3110 263[redacted]162 HTC Radar (PI06100) 263[redacted]3206 Tethin S
```

**Figure 3.5 Screen capture of a sample output from a script code for determining 3G handsets in a network**

### 3.4.2. Mobile Network Element Management System (Net Numen M31 (RAN))

ZTE Net Numen U31 element management system (EMS) is an integrated network operation and maintenance system that controls different interconnected networks and performs integrated network fault management, fault location, and performance analysis of WCDMA, LTE, and GSM networks.

This software was employed to get performance related data. Steps below will provide information on how system management functions were performed on Net Numen.

**<u>Querying Performance Data</u>**

i. The screen capture shown in figure 3.6 shows the ways to navigate performance data on Net Numen after a successful log in.

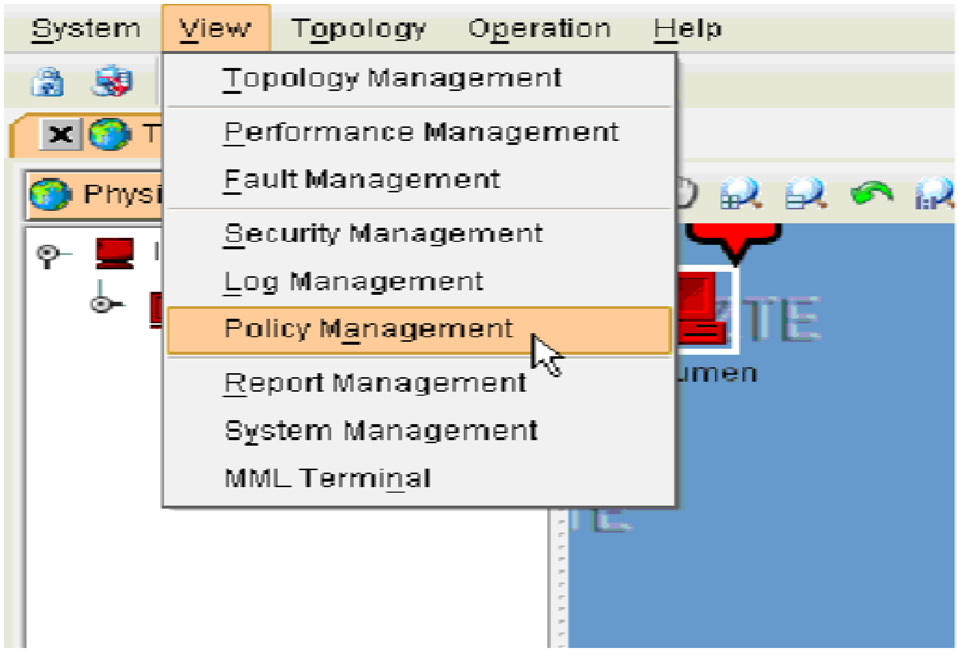



**Figure 3.6 Screen capture showing how to navigate to performance management**

ii. The Query dialog box appears in the Data query interface opting the user to select the NE type and the object type, as shown in screen capture of figure 3.7.

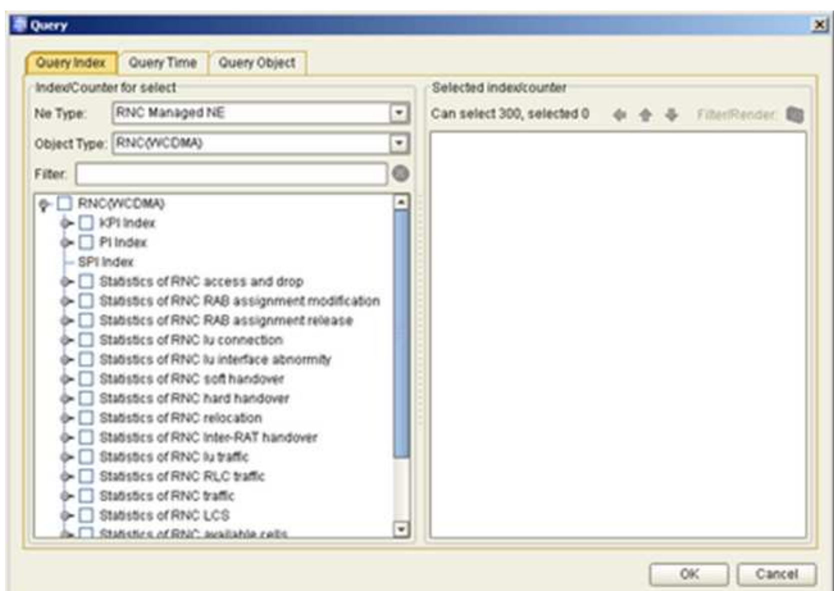
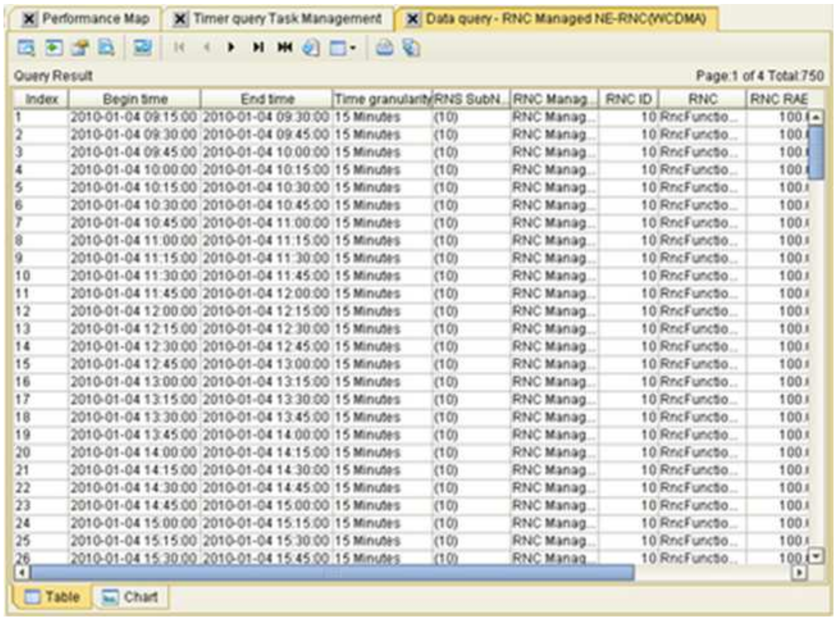



**Figure 3.7 selecting the NE type and Object type**

The object tree lists all indices and counters related to the selected object type. The user can tick the indices and counters to be queried. After this step the query time tab pops up and the user can input the time intervals.

A sample query result is as shown in figure 3.8


Performance Map | Timer query Task Management | Data query - RNC Managed NE-RNC(WCDMA)

Query Result — Page:1 of 4 Total:750

| Index | Begin time | End time | Time granularity | RNS SubN... | RNC Manag... | RNC ID | RNC | RNC RAE |
|---|---|---|---|---|---|---|---|---|
| 1 | 2010-01-04 09:15:00 | 2010-01-04 09:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 2 | 2010-01-04 09:30:00 | 2010-01-04 09:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 3 | 2010-01-04 09:45:00 | 2010-01-04 10:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 4 | 2010-01-04 10:00:00 | 2010-01-04 10:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 5 | 2010-01-04 10:15:00 | 2010-01-04 10:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 6 | 2010-01-04 10:30:00 | 2010-01-04 10:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 7 | 2010-01-04 10:45:00 | 2010-01-04 11:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 8 | 2010-01-04 11:00:00 | 2010-01-04 11:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 9 | 2010-01-04 11:15:00 | 2010-01-04 11:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 10 | 2010-01-04 11:30:00 | 2010-01-04 11:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 11 | 2010-01-04 11:45:00 | 2010-01-04 12:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 12 | 2010-01-04 12:00:00 | 2010-01-04 12:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 13 | 2010-01-04 12:15:00 | 2010-01-04 12:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 14 | 2010-01-04 12:30:00 | 2010-01-04 12:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 15 | 2010-01-04 12:45:00 | 2010-01-04 13:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 16 | 2010-01-04 13:00:00 | 2010-01-04 13:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 17 | 2010-01-04 13:15:00 | 2010-01-04 13:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 18 | 2010-01-04 13:30:00 | 2010-01-04 13:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 19 | 2010-01-04 13:45:00 | 2010-01-04 14:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 20 | 2010-01-04 14:00:00 | 2010-01-04 14:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 21 | 2010-01-04 14:15:00 | 2010-01-04 14:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 22 | 2010-01-04 14:30:00 | 2010-01-04 14:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 23 | 2010-01-04 14:45:00 | 2010-01-04 15:00:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 24 | 2010-01-04 15:00:00 | 2010-01-04 15:15:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 25 | 2010-01-04 15:15:00 | 2010-01-04 15:30:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |
| 26 | 2010-01-04 15:30:00 | 2010-01-04 15:45:00 | 15 Minutes | (10) | RNC Manag... | 10 | RncFunctio... | 100 |

Table | Chart

**Figure 3.8 Query result**

## <u>Configuring Reports on Net Numen</u>

The steps are shown in figure 3.9.

i. Configuring report main menu
ii. Configuring report tool bar
iii. System topology tree
iv. Generated configuration report

Configuration report helps provide statistical information on the configuration data of the selected object, such as the total number of RNCs/ BBUs/ RRUs/ cells.

Via the configuration reports, system administrators can get NE configuration information and output uniform data.

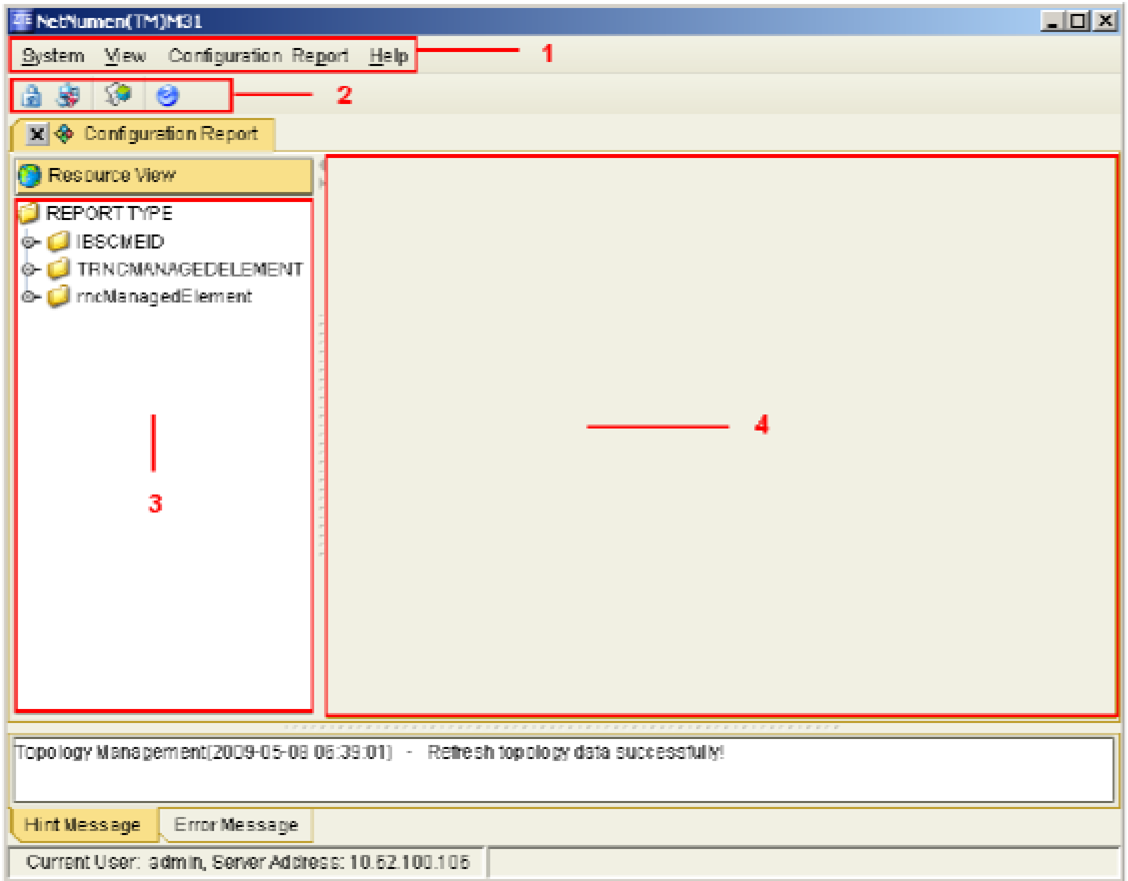



Figure 3.9 configuring report interface-overview

**MML TERMINAL**

A **man-machine language** or *MML* is a specification language. MML typically are defined to standardize the interfaces for managing a telecommunications or network device from a console.

MML terminal facilitates users by providing graphical user interface (GUI) based command inputs. MML terminal also provides command line inputs to execute commands that are not available in GUI such as internal commands that are not available for customers.

Figure 3.10 shows panes in MML terminal interface.

i. MML message area
ii. Topology tree
iii. System message area
iv. MML commands tree
v. Commands input area (text)

vi. Command parameters pane

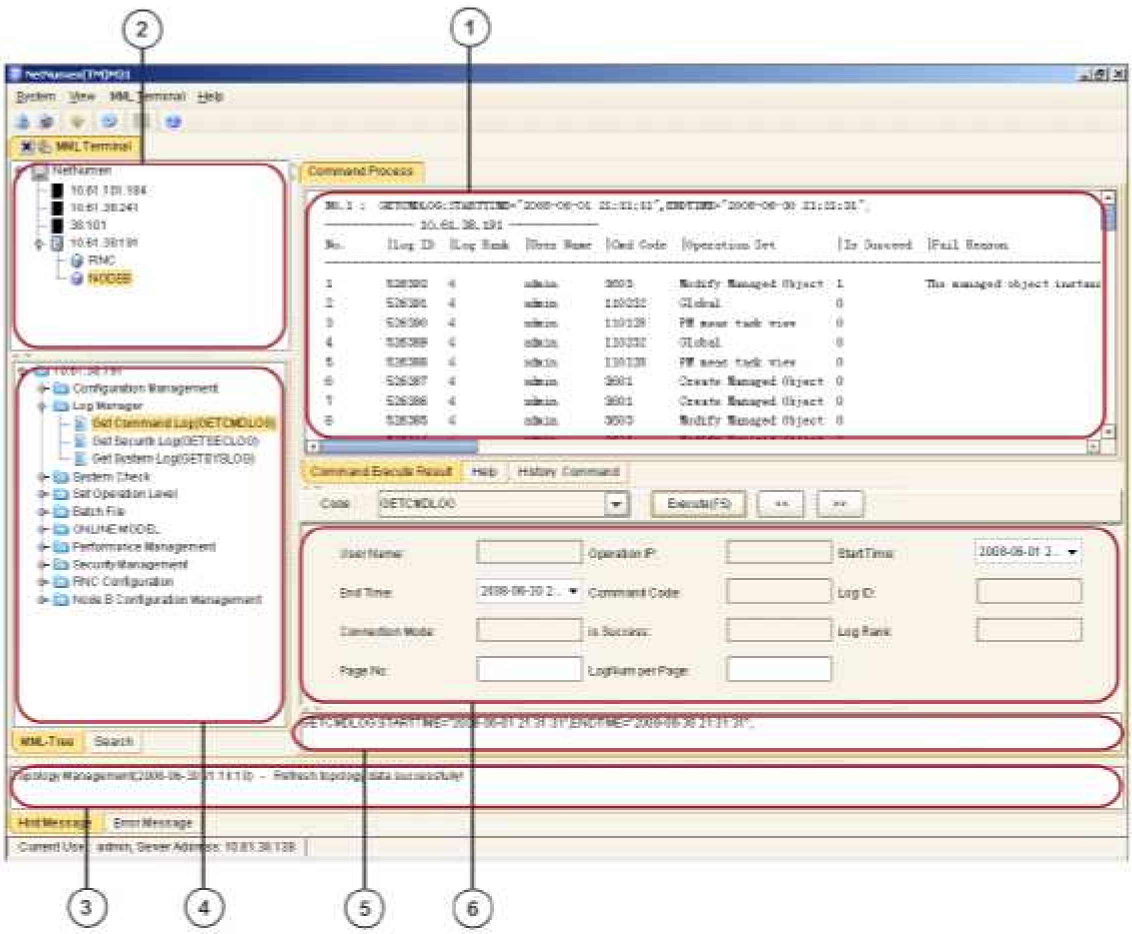



**Figure 3.11 MML terminal interface overview**

### 3.4.2 .Secondary Data Collection

Secondary data was collected making reference to some of the factors from the Porters five forces model.

The role of POTRAZ was looked at and in particular the pricing model for spectrum fee calculation.

From the Porters Five forces model and the Primary collected data it was evident that there are three broad factors that needed to be analyzed which are:

- Technology Innovation
- Government Regulations and Policing

- Number of subscribers

Data related to number of subscribers is already covered in the Primary data collection.

These factors are key to the hypothesis testing to find a relationship to the telecoms industry revenue. Additionally the author collected statistics on:

- Annual revenue of telecom industry
- The annual data figures

This data was categorized under secondary data in the sense that it is data that is already in the public domain.

The stiff completion in the telecoms industry was also taken into consideration as another factor contributing to the future of telecoms industry. To address this issue marketing teams were engaged to gather data on the following:

- Price wars and the role of POTRAZ
- Effect of promotions and the regulations
- Challenges of launching new products
- Strategies to predict customer response to new products.

This data was obtained through interviews and publications.

### 3.4.3 Analysis of Collected Data

The various methods that were used in collecting data for the key factors affecting telecoms revenue posed a challenge in the methods to carry out data analysis. Multiple methods were employed.

#### 3.4.3.1 Microsoft Excel

Excel is a powerful instrument for research as a support for data sets. It has some basic statistical analysis tool. This was employed to analyze data from text files as shown in figure 3.5 to make it readable and understandable. The excel feature to import data from text file is shown in figure 3.12

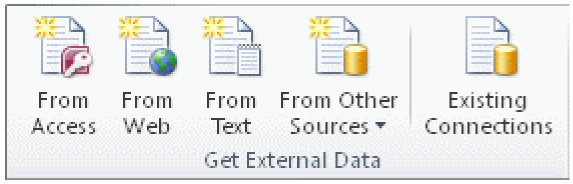



**Figure 3.12 Screen capture showing importation of data from different sources in excel**

The analysis ToolPak in excel made the complex statistical and engineering analyses easy. The steps involved providing the data and parameters for each analysis, and the tool uses the appropriate statistical or engineering macro functions to calculate and display the results in an output table

### 3.4.4 .Validity and Reliability

This research document consists of both primary data and secondary data in attempting to address the research objectives of determining the feasibility of the migration to LTE for Zimbabwe telecoms operators and id based on a profound theory and observations made through interaction with the actual equipment.

The use of highly accurate data analysis tools like excel eliminate all sources of errors in the data analysis.

The major weakness of this research is that the data is based on published statistics which might not reflect the actual state of the telecom industry and the author only got limited access to some vital information which was critical for this research project. The other telecoms operators could not let their information for security and competition reasons therefore the data does not represent the whole telecoms industry in Zimbabwe. However the data having come from one of the biggest telecoms companies still represent a significant proportion for the overall telecom industry in Zimbabwe.

# Chapter Four

# Results and Analysis

## 4.1 .Introduction

This study investigated the feasibility for Zimbabwe telecom operators to migrate to 4G LTE. The study consisted of an in depth telecom industry analysis from observer point of view and a comparison to other successful mobile telecom operators worldwide.

The purpose of the industry analysis was to determine all the factors that contribute to telecom revenue and to analyze the current systems performance.

The study also examined the top three factors that emerged as key drivers of telecom revenue in Zimbabwe which are: Number of subscribers, Technology Innovation and Government Regulation and Policies against the collected data. The goal was to determine if there exist a relationship between the following:

- number of subscribers and Zimbabwe telecom revenue
- government policies and the telecom revenue
- Technology innovation and the telecom revenue.

## 4.2. Total Mobile Subscribers

The official mobile phone subscriber statistics obtained from the Post and Regulatory Authority of Zimbabwe (POTRAZ) as at 31 Dec 2013 are as shown in table 4.1 [17]. The results suggest Econet to be the largest mobile operator in terms of subscriptions and resultantly by network coverage followed by Telecel and with Netone trailing. This is illustrated in figure 4.1.

The official statistics also indicated an increase in mobile penetration rate to 103.5% which indicates a brighter future for mobile telecommunications in Zimbabwe. Mobile penetration rate counts the number of mobile SIM cards on the market at a given time and not actual unique individuals compared to the total population.

| TOTAL MOBILE SUBSCRIBERS AS AT 31 DEC 2013 | |
|---|---|
| **OPERATOR** | **NUMBER OF SUBSCRIPTIONS** |
| ECONET | 8522941 |
| TELECEL | 2544339 |
| NETONE | 2451607 |
| TOTAL SUBSCRIBERS | **13518887** |

**Table 4.1 Statistics from POTRAZ (December 2013) [17]**

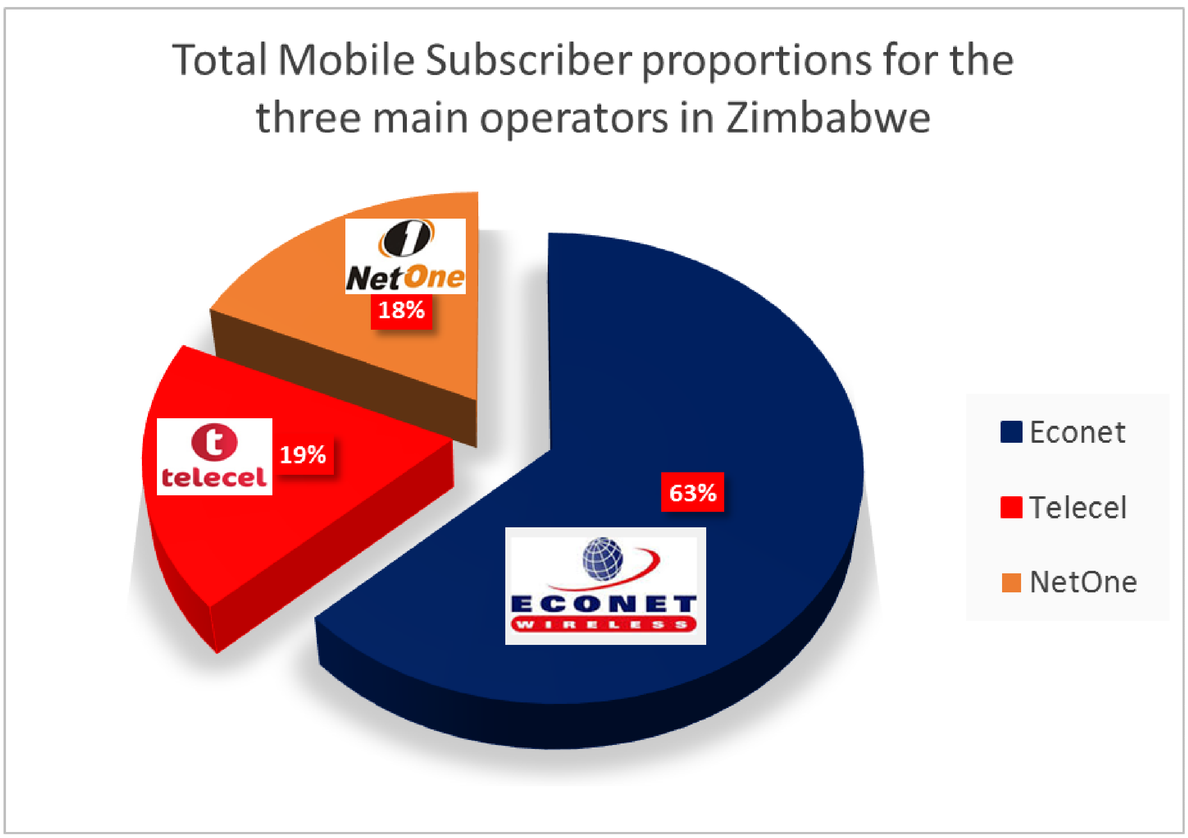



**Figure 4.1 Zimbabwe mobile telecommunications subscriber statistics (December 2013) [17]**

Social Networks like Facebook, Twitter, Whatsapp and Skype have played a major role in data penetration as most Zimbabweans have adapted to the new digital trend as a formidable manner to communicate, cutting revenues for the traditional voice operators. This comes as POTRAZ has also released the figures of data subscribers to be 5 202 993 up from 3.8 million recorded in august 2012.The ratio of voice subscribers to data subscribers is shown in Table 4.2 and figure 4.2.

| Total voice subscribers compared to Total data subscribers as at 31 Dec 2013 | |
|---|---|
| Voice subscribers | 8315894 |
| Data subscribers | 5202993 |

**Table 4.2 Voice subscribers to data subscribers [17]**

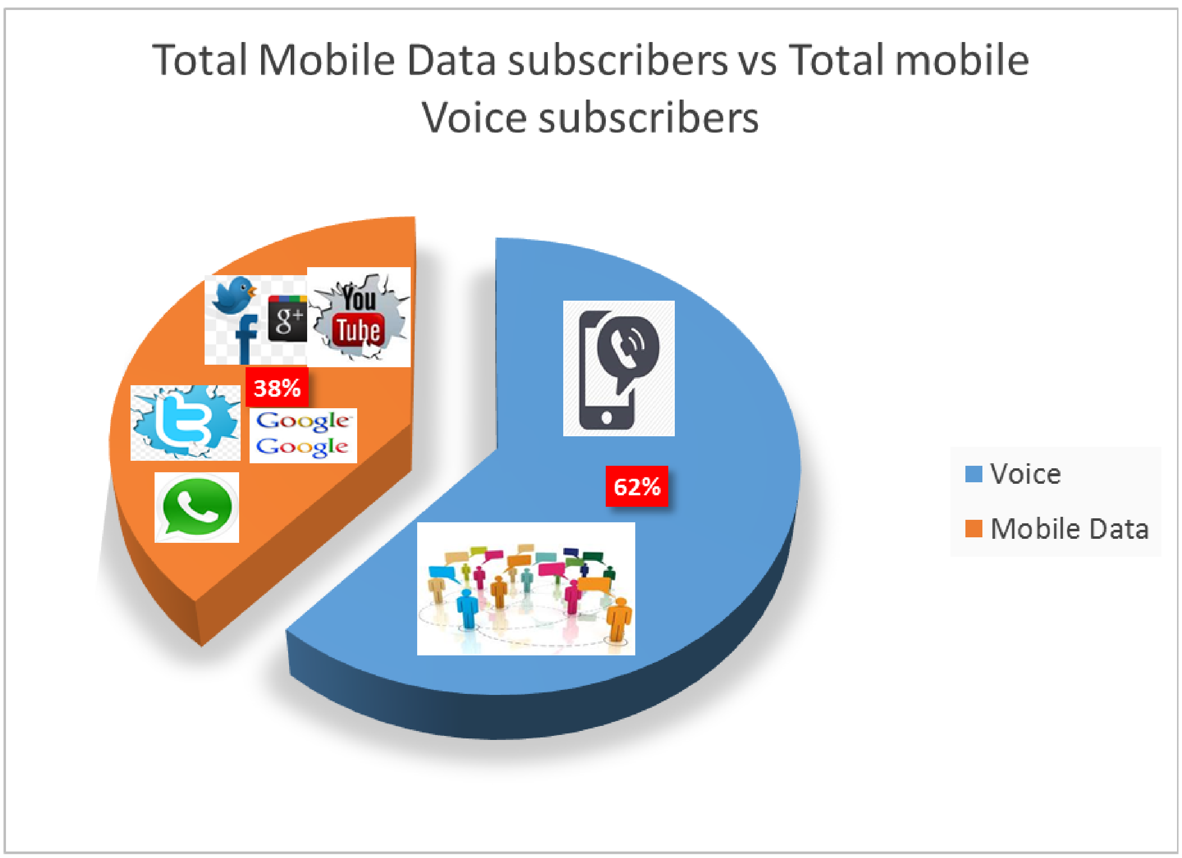



**Figure 4.2 Mobile Data to Mobile voice proportions**

This information shows significant evidence to the rapid adoption of mobile phone technology by Zimbabweans taking into consideration the fact that in June 2011, the country's tele-density was at 56,6 percent.

The surge in data and internet has been driven by enhancement of broadband connectivity via fiber and wireless communication which are greatly competing for market share.

## 4.3 .Status of the Network by Operator

As shown in figure 4.1, Econet constitutes about 63 % of the market share. For this reason the analyses to follow shall mainly focus on the statistics obtained from this operator. Also Econet is the only operator that has made significant advances towards launching 4G LTE services.

### 4.31. Subscribers analysis for the biggest operator

The results collected show that 2G dominate the network with about 92 % of the subscribers. Only 8% of the subscribers are on 3G. The results are shown in the pie chart of figure 4.3

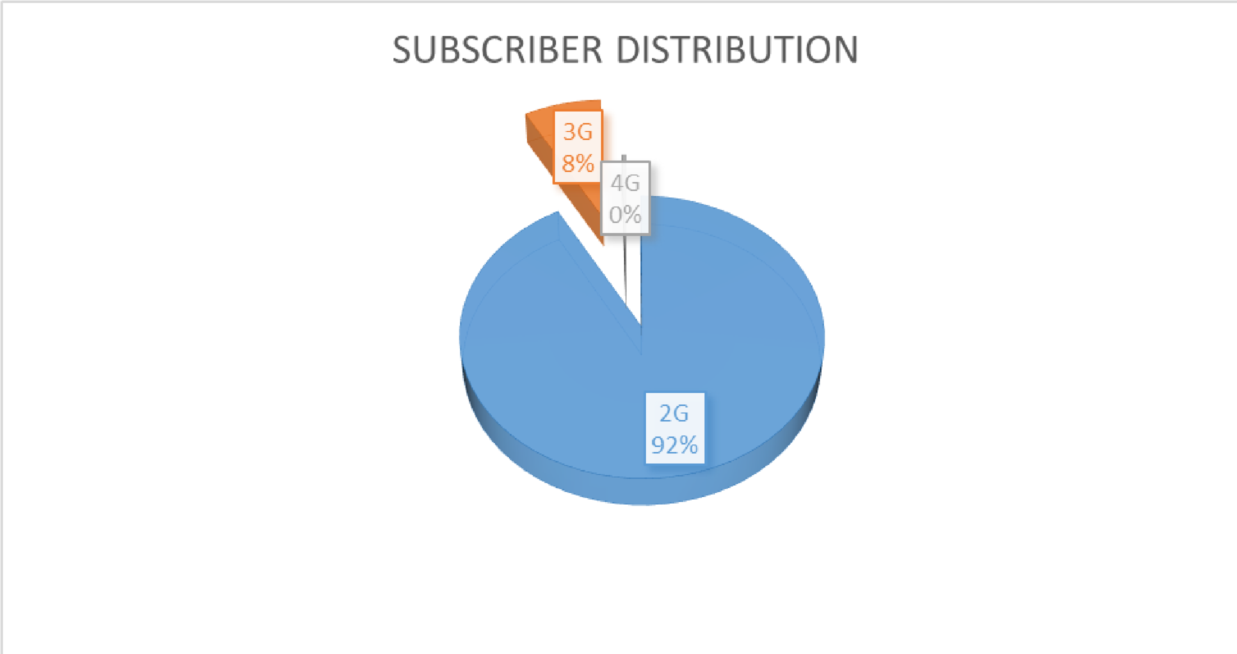



**Figure 4.3 Subscriber distributions**

Further analysis on the rate of adoption of the technologies by customers as they are launched was necessary and the collected results are as shown in figure 4.4

| Technology | Jan-14 | Dec-13 | Dec-12 | Dec-11 | Dec-10 | Dec-09 | Dec-08 | Dec-07 | Dec-06 | Dec-05 | Dec-04 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4G | 35000 | 30000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3G | 654100 | 632500 | 455000 | 245000 | 125000 | 40000 | 0 | 0 | 0 | 0 | 0 |
| 2G | 7850900 | 7660441 | 6032100 | 5080400 | 4723000 | 3523000 | 1645000 | 910,047 | 789,000 | 500,000 | 200,000 |
| Total | 8540000 | 8322941 | 6487100 | 5325400 | 4848000 | 3563000 | 1645000 | 910047 | 789,000 | 500,000 | 200,000 |

**Figure 4.4 Subscribers by technology from Dec 04 to Jan 14**

To further analyze the trend the results are plotted in on the graph in figure 4.5.

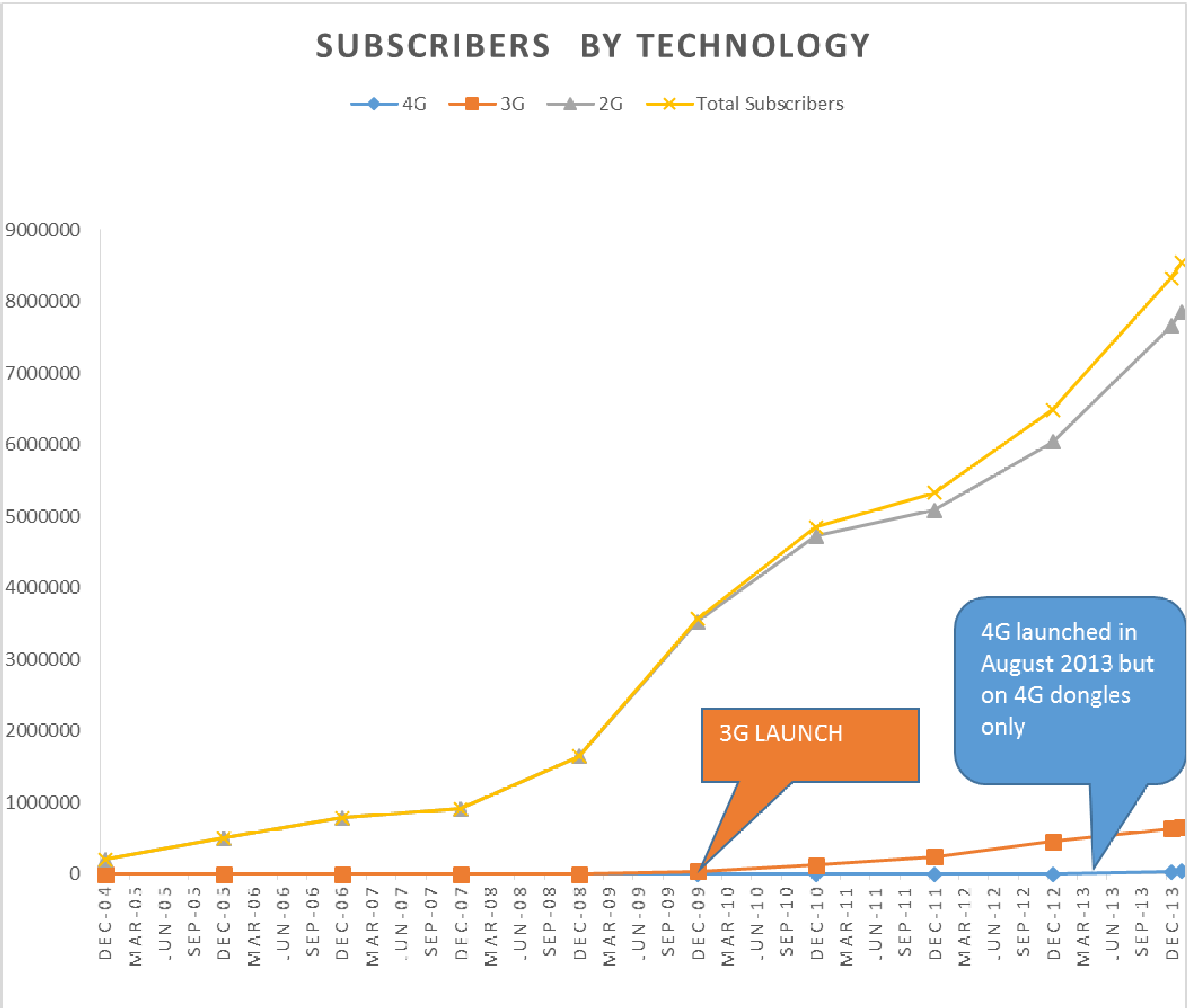



**Figure 4.5 Graph of subscribers by technology over time**

## 4.4.Number of Active Devices

The subscriber statistics obtained from POTRAZ included devices that not active in the network. The statistics are largely based on the number of SIM cards sold. In a country where people have multiple phones and dual SIM phones and the extremely cheap price for SIM cards this means an individual can afford to buy a line that he might never use.

The author identified this factor as a potential distortion to the analysis of subscribers and collected the statistics of active devices on a network. The results are shown in table 4.3 and figure 4.6

| Number of active Devices | |
|---|---|
| 2G | 5941960 |
| 3G | 654 155 |
| 4G | 35 946 |
| TOTAL | **5941960** |

**Table 4.3 Number of active devices**

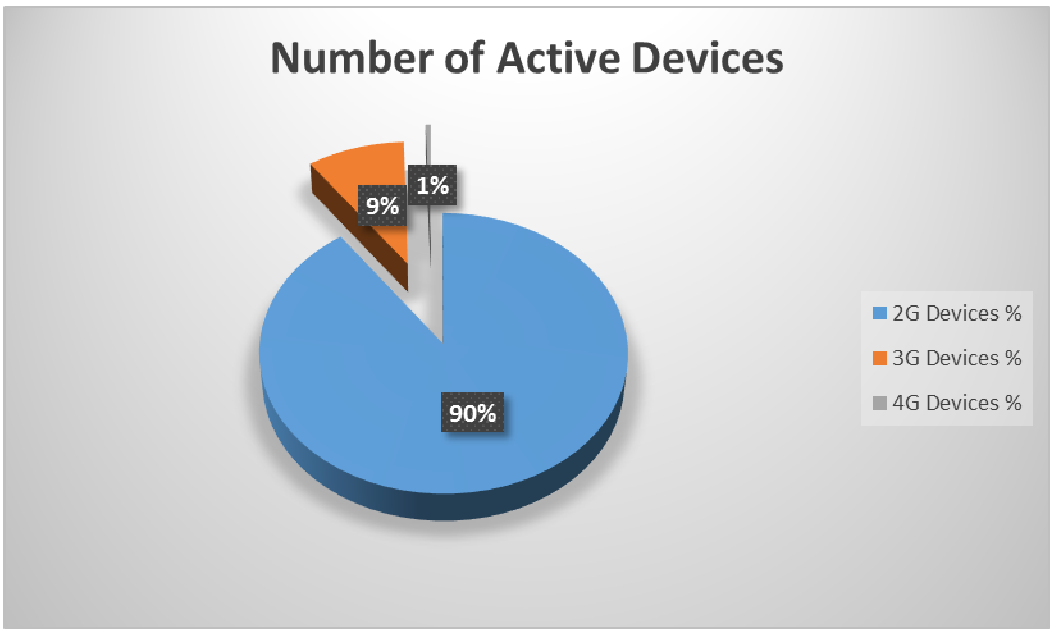



**Figure 4.6 Number of active devices**

## 4.5 .Bandwidth Utilization

Bandwidth Utilization reports are based on the calculation of data that is passed through from one end of a link you wish to measure to the other side. For the purposes of this research project bandwidth will be defined as the average data, for the selected protocols, that is transferred from one side of the bandwidth link to the other. The reports were intended to give a general picture of bandwidth usage on various protocols over a selected time period from 18 January 2014 at 12:00

AM to 28 January 2014 at 23:45 PM. The results were tabulated in excel .The graph shown in Figure 4.7 was a result of the collected data.

Monitoring how bandwidth is used is one of the most critical aspects of network management. In this research measuring bandwidth utilization was key to give pertinent information as to how network resources are being used. The comprehensive insight into the traffic type and bandwidth utilization would enable us to rate the current system performance and challenges.

As an example critical business applications might not receive enough bandwidth, while applications like video streaming and torrent downloading can hog bandwidth. This may result in loss of business applications related customers. This information was critical to gauge if the current system performance is satisfying the various customer types.

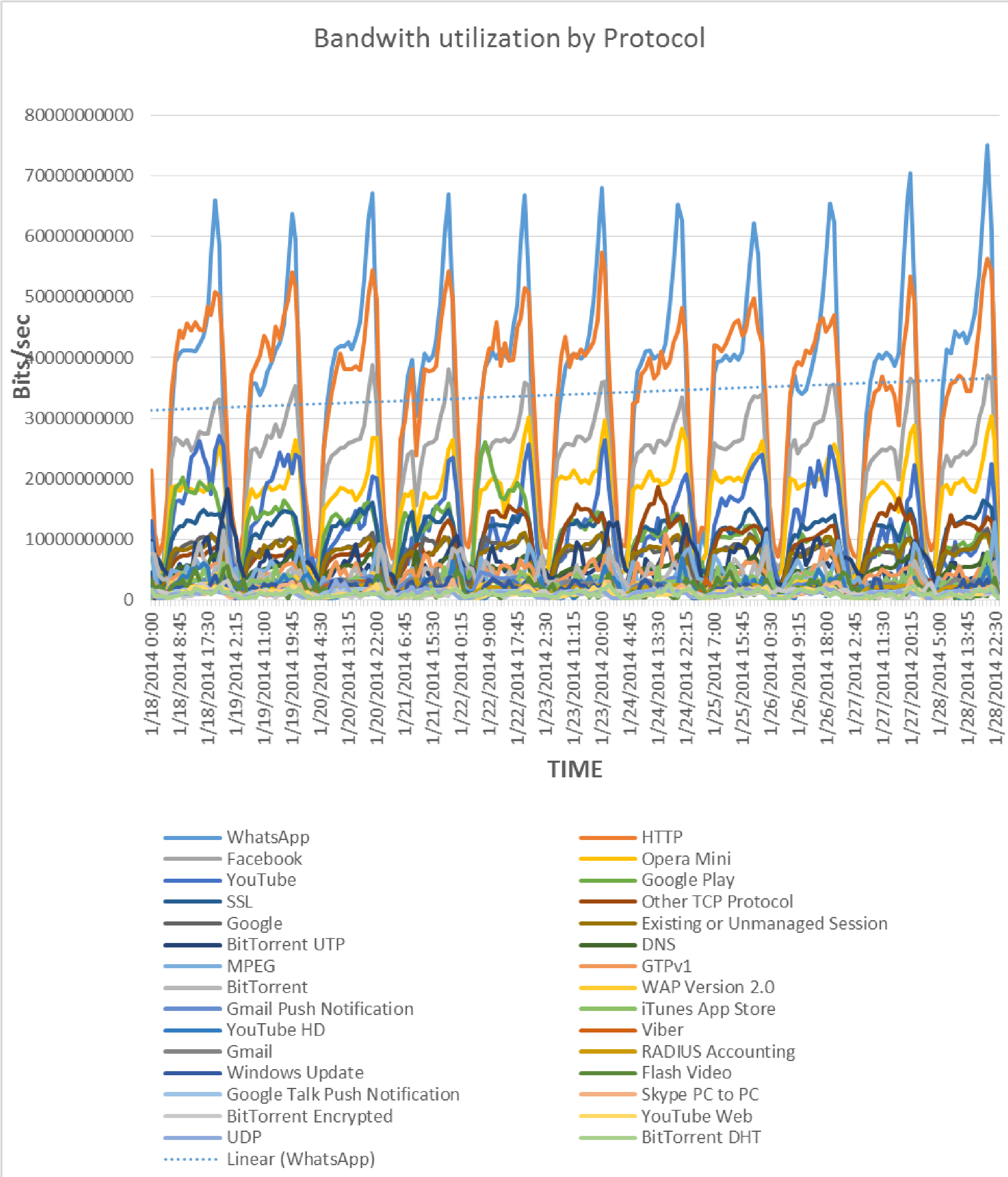



**Figure 4.7 Bandwidth utilization by protocol**

An analysis of the graph shows that the bulk of the bandwidth is occupied by Whatsapp and Facebook which are social networking platforms. To further prove the claim the weekly data consumption for different data ranges was collected and the results shown in table 4.4.

| Bandwidth Range | # of Subs | % of Subscriber | Total Bandwidth (B) | % of Bandwidth | Avg Bw/Sub (B) | Avg BW/Sub (bps) |
|---|---|---|---|---|---|---|
| 0 - 500 MB | 1501622 | 99.57 | 266306000000000 | 72.73 | 17734567.53 | 234.58 |
| 500 - 1000 MB | 4125 | 0.27 | 28112000000000 | 7.68 | 681503735.4 | 9014.6 |
| 1000 - 1500 MB | 1069 | 0.07 | 12840500000000 | 3.51 | 1201172402 | 15888.52 |
| 1500 - 2000 MB | 383 | 0.03 | 654984000000 | 1.79 | 1710139927 | 22620.9 |
| 2000 - 2500 MB | 229 | 0.02 | 508778000000 | 1.39 | 2221739200 | 29388.08 |
| 2500 - 3000 MB | 144 | 0.01 | 390727000000 | 1.07 | 2713380224 | 35891.27 |
| 3000 - 3500 MB | 93 | 0.01 | 299846000000 | 0.82 | 3224150281 | 42647.49 |
| 3500 - 4000 MB | 60 | 0 | 225351000000 | 0.62 | 3755852931 | 49680.59 |
| 4000 - 4500 MB | 48 | 0 | 204861000000 | 0.56 | 4267947876 | 56454.34 |
| 4500 + MB | 300 | 0.02 | 3603880000000 | 9.84 | 12012932719 | 158901.23 |
| | | | | | | |

**Table 4.4 weekly data consumption for the week ending 03 Apr 2014**

**KEY**

| | |
|---|---|
| Avg | Average |
| BW | Bandwidth |
| B | Bytes |
| Bps | bits per second |
| Sub | subscribers |
| # | Number |

The data was represented in a pie chart shown in figure 4.8 below. The trend shows that the bulk of the subscribers' falls in the 0 – 500 Mb range weekly. This further proves that low bandwidth applications are the ones contributing more to the data revenue.

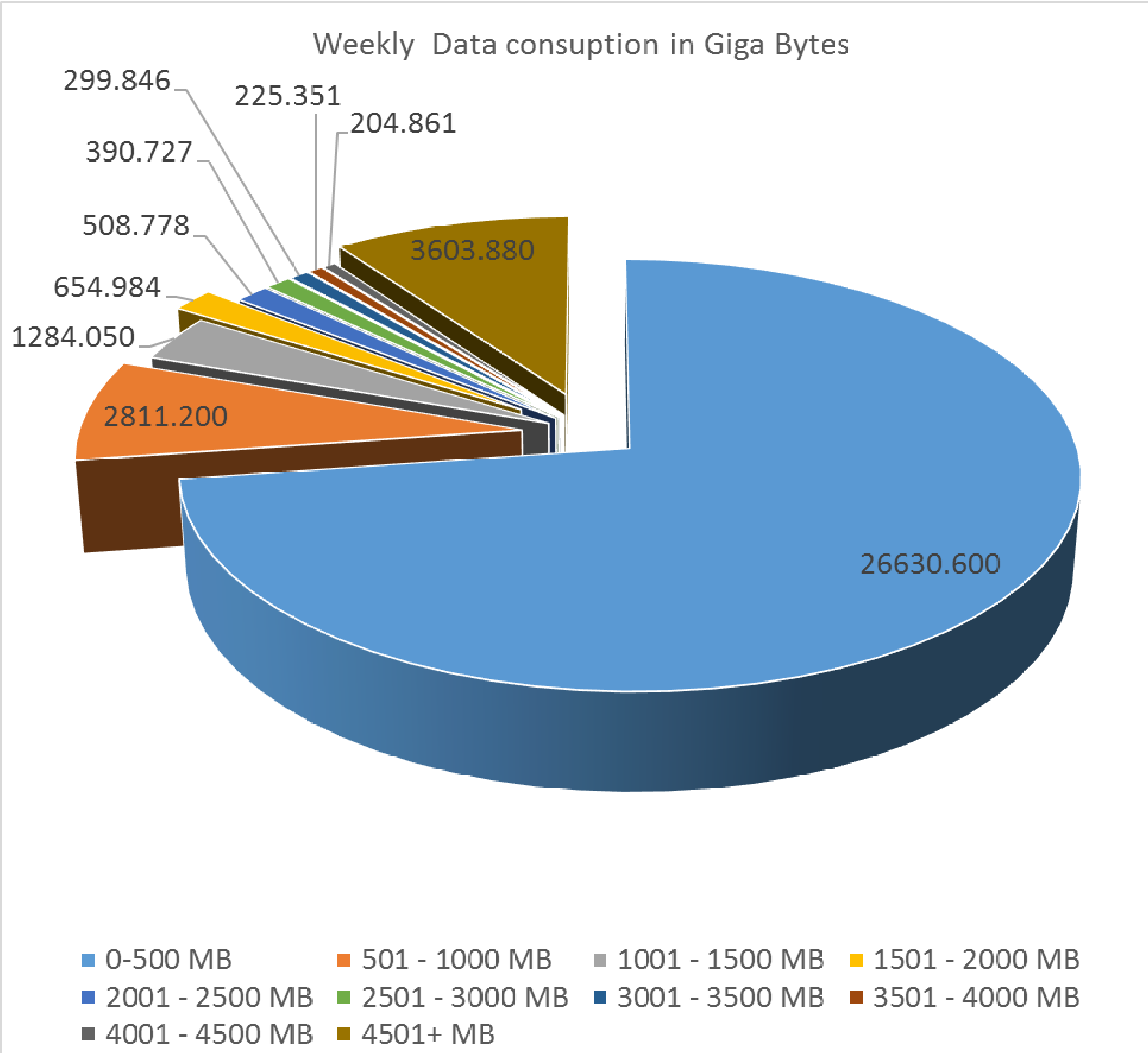



**Figure 4.8 Weekly data consumption for different data ranges**

Examining the number of subscribers connecting per day enabled us to come up with estimations for daily user requirements. This was achieved through examining the connections made through the three switching centers for one of the biggest telecoms operator. The results obtained are graphed in figure 4.9.

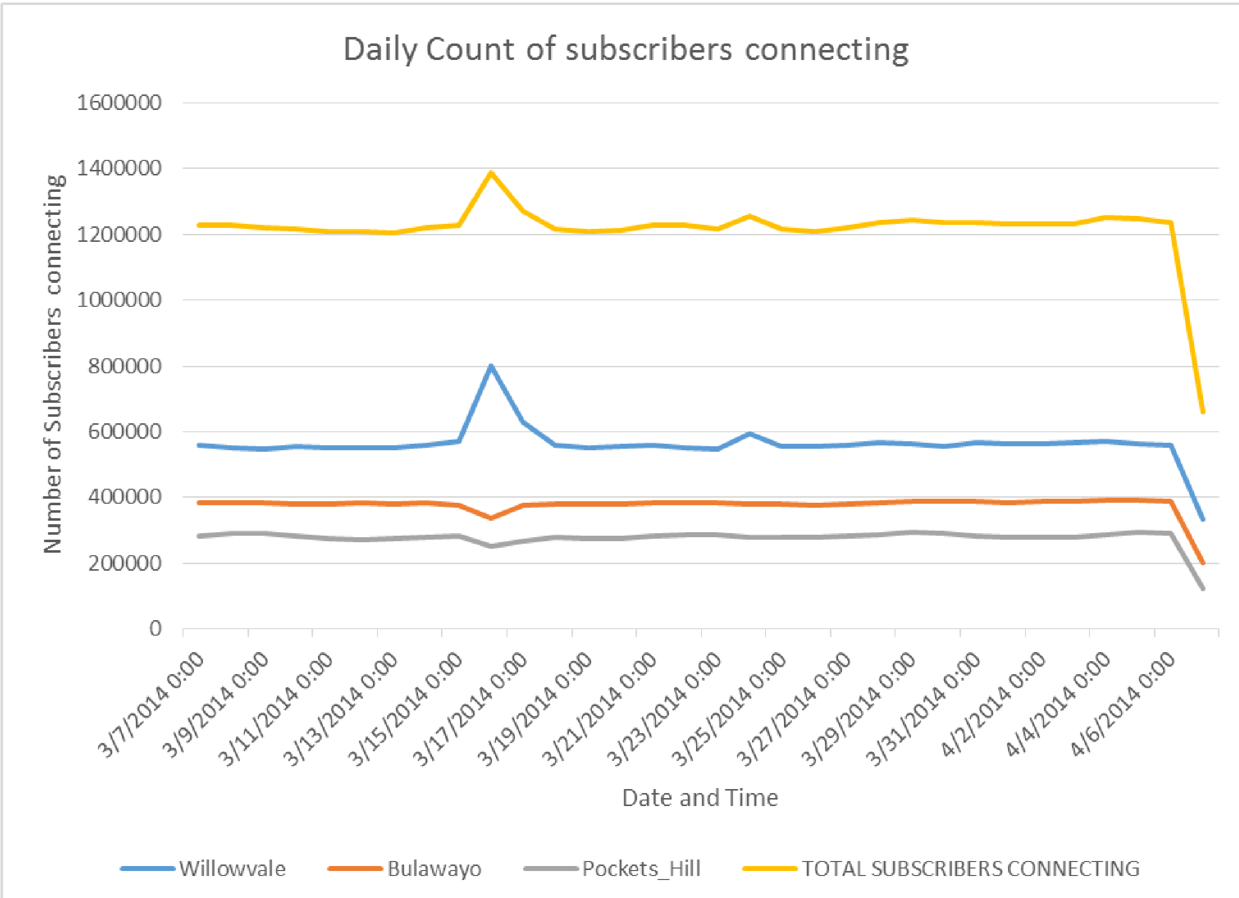



**Figure 4.9 Daily count of subscribers connecting per day**

## 4.6. Telecom Revenue

With the increasing internet user base in Zimbabwe and the smart phones playing a wider role to the increase in mobile data usage, it was critical to also compare the revenue generated from voice services to the revenue generated by data services and the results are as shown in the graph shown in figure 4.9. As can be seen from the graphs voice services contribute more by a wide margin to the total monthly telecom revenue.

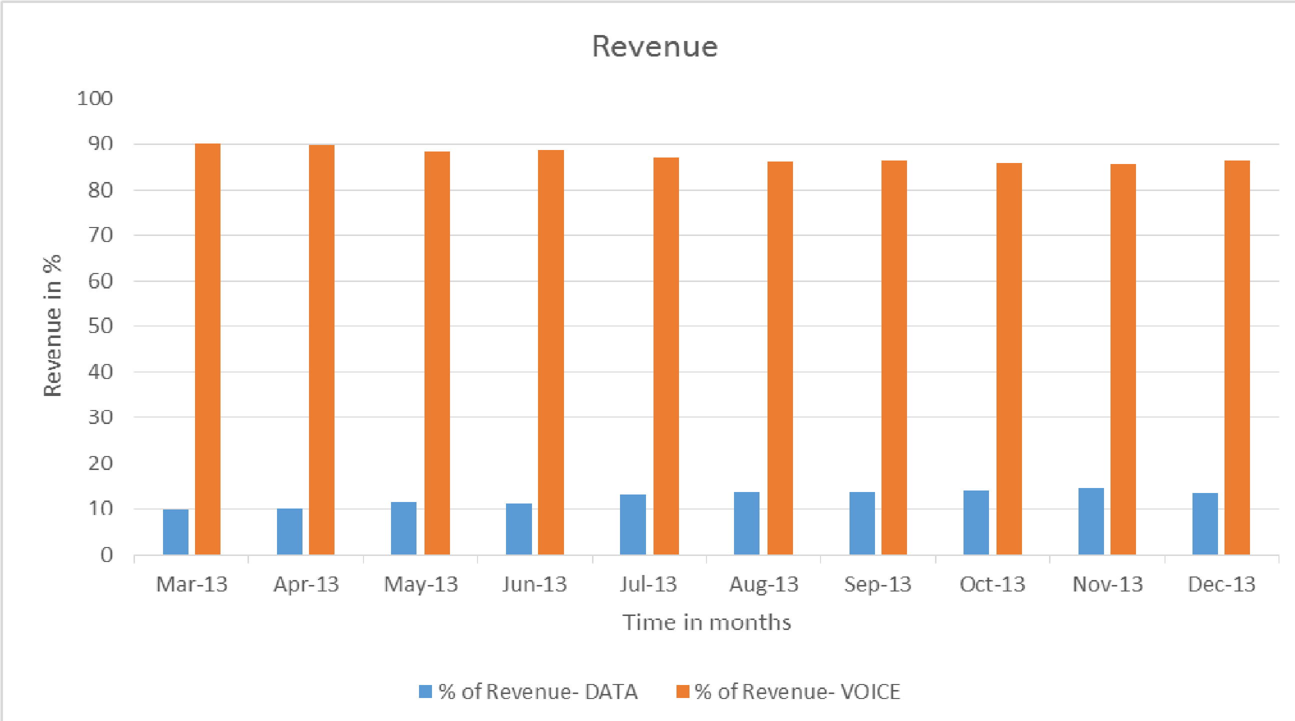



**Figure 4.9 Revenue trend**

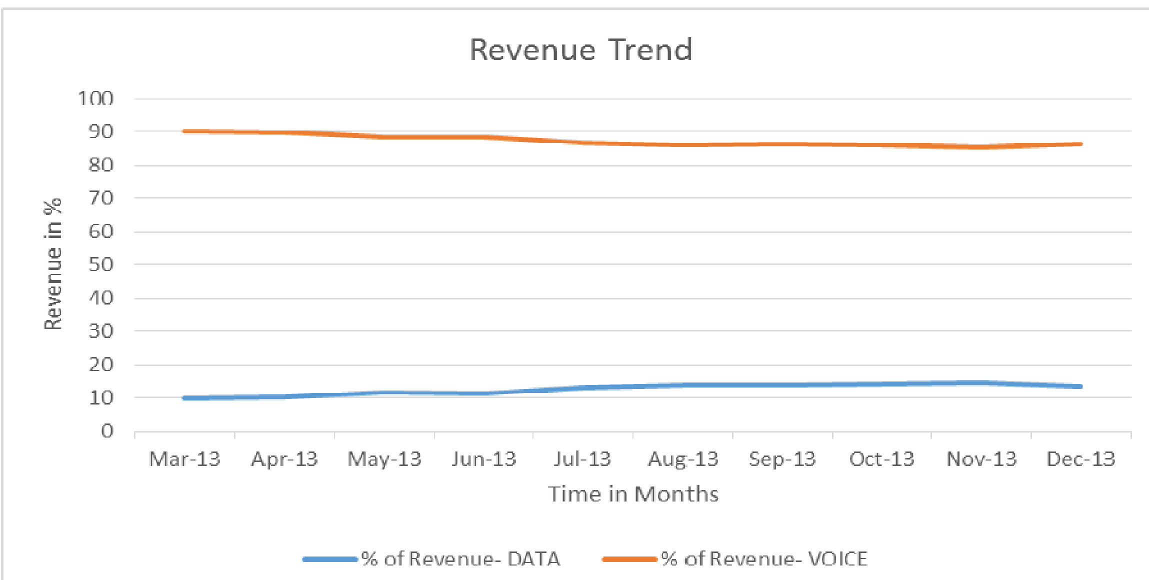



**Figure 4.10 Revenue trend**

*Disclaimer: These results are a representation only and should not be taken as the actual data. For official data, contact the responsible company officials

# Chapter Five

# Discussion and Implications

The main objective of this chapter is to discuss the results presented in the previous chapter. It shall focus on the major factors that are key to the success of the telecom industry. Also to be discussed is the relationship of these factors to the telecom revenue in a bid to derive a conclusion on the potential benefits of 4G LTE to Zimbabwe telecom industry

## 5.1 Number Subscribers Factor:

An increase in number of subscribers stimulates the development of the telecom industry and the related industries. An example would be the growing number of mobile phone users, which results directly on the demand for both hardware and software products. Results show a significant increase in number of mobile telecom subscribers.

### 5.1.1 Reasons for the increase in Number of subscribers

There are a combination of factors that have contributed to the dramatic increase in the number of subscribers in Zimbabwe. Chief among these factors in the increase in affordability.

I. **Increase in affordability**

Intense competition has lowered the prices of hardware and services in the telecom industry. Around the year 2008 a SIM card was worth an equivalent of 25 USD and currently a SIM card costs around 0.50 USD. At the same time, competition among multiple operators also reduced tariffs and promotions luring customers are now common in the telecoms sector.

The subscriber by technology graph shows that 92 % of the subscribers of one of the biggest telecoms operator are on 2G. This further supports the increase in affordability factor as a chief contributor to the increased number of subscribers. The attractive prices of 2G compatible phones and the emergence of cheap dual SIM phones can be attributed to the increase in number of subscribers.

On the other hand the likelihood that LTE launch will drive the number of subscribers to another level is very minimal. Based on the evidence from figure 4.5 3G launch did not stimulate the increase in number of subscribers. There has been a sharp increase of 2G subscribers instead. This graph further shows that technology advancements or new network upgrades in Zimbabwe are not related to the increase in number of subscribers.

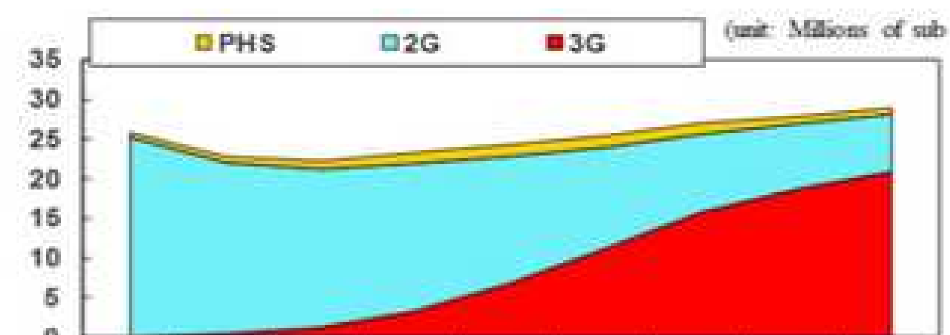
**II. Technology Innovation**

Technology innovation over the last decade has enabled the expansion of telecom infrastructure to rural areas where the majority of Zimbabwean population is located. Hence, telecommunication services become easily accessible and cover large portion of the country's population that eventually resulted in the increase of subscribers.

Owing to the increased coverage the country's teledensity stands at 103.5%

### 5.1.2 Implications of the number of subscribers factor

Regardless of the high growth of subscribers' volume, the challenge for Zimbabwe telecom operators is to boost the subscriber numbers of 3G users. As compared to other countries like India with the evolution of mobile market shown in figure 5.1 below the launch of 3G was followed by a rapid adoption by the subscribers.




| | 2003.12 | 2004.12 | 2005.12 | 2006.12 | 2007.12 | 2008.12 | 2009.12 | 2010.12 | 2011.12 |
|---|---|---|---|---|---|---|---|---|---|
| PHS | 0.6 | 0.8 | 1.0 | 1.4 | 1.5 | 1.5 | 1.4 | 0.9 | 0.8 |
| 2G | 25.1 | 21.5 | 19.9 | 18.5 | 15.9 | 12.7 | 9.8 | 8.2 | 7.2 |
| 3G | 0.1 | 0.5 | 1.3 | 3.4 | 6.9 | 11.3 | 15.8 | 18.7 | 20.9 |

**Figure 5.1 India mobile evolution**

Whilst there has been an increase in internet penetration in the country 3G network roll out is yet to make a positive impact in the mobile market. 3G was launched in Zimbabwe five years ago but the ratio of 2G is still far greater than that of 3G subscribers. In India after five years from the time of launch of 3G the ration of 3G subscribers had surpassed that of 2G subscribers by a wide margin as shown in figure 5.1.

## 5.2 Traffic volume, Revenue and Network costs Analysis

The ultimate goal for most operators in Zimbabwe until recently has been network roll-out or coverage everywhere. The network's real revenue pipe has been the antenna system. Massive installations of antennae system at any quality and cost have been the prime target.

The technology changed from 2G to 3G and now it is 3G to 4G, the user demands and profiles are changing as well from voice to data and it keeps changing to sophisticated data and applications. On the other end, the business environment is always in a changing mode with competition, tariffs and changing technology in tablets and smartphones.

We can safely conclude that the mobile industry in Zimbabwe has achieved the coverage everywhere goal and it is no longer the business objective.

Future projections suggest the number of bits/user needed to be increasing dramatically as shown in Table 4.4 for weekly data consumption for the week ending 03 Apr 2014

New technology is definitely expensive and is not easily deployed while the operations are also expensive and not easily controlled. On the other hand the revenue is dropping while the expenditure is increasing. This is illustrated in figure 5.2. The revenues and traffic gap seem to be widening.

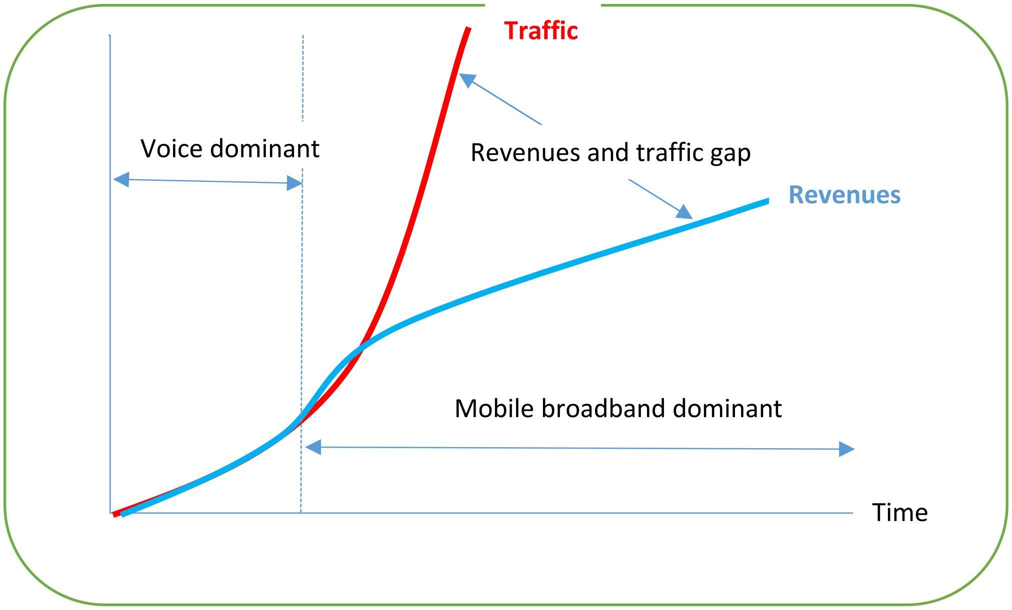



**Figure 5.2 Challenges in the mobile industry**

Base on the results collected in chapter four Zimbabwe mobile industry seem to be facing bigger challenges.3G deployment has been an expensive process and the graph of subscribers by technology indicate that the technology was poorly received .The reasons may be that smartphones which are generally 3G compatible are still expensive in Zimbabwe. The graphs in figure 5.3 summarizes the state of the telecom industry in Zimbabwe based on the collected results.

3G launch in December 2009 by one of the biggest operator raised the operations expenditure. This would have been consolidated if there has been a rapid adoption by the subscribers. However this is not the case, Voice services still dominate and constitute the bulk of the revenue.

The focus for Zimbabwe operators should be shifted to efficiently returning the investment made in to 2G and 3G networks

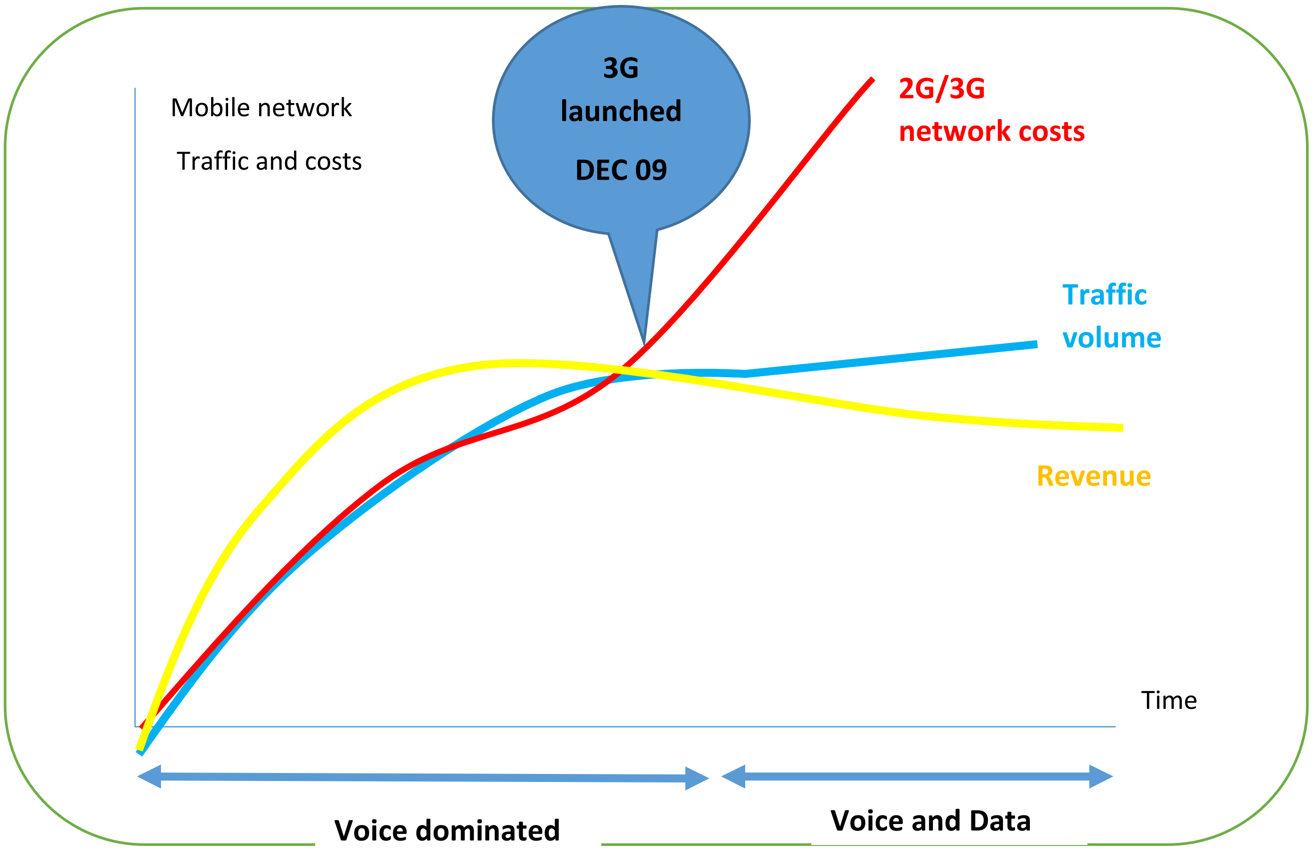



**Figure 5.3 Mobile industry state summary**

To a greater extent we can conclude that it is not yet the right time to launch LTE until such a time when the operators feel they have generated enough revenue from their investments.

The predictions will be that traffic demands would have grown to alarming levels raising the cost of maintenance of 2G and 3G network while generating little revenue. Figure 5.4 illustrates this prediction.

In that case LTE deployment will be highly recommended because of the low cost/bit and the user experience improvement. The expectation is that LTE will be easier and more flexible to maintain than 2G and 3G thereby reducing operational expenditure while raising revenue.

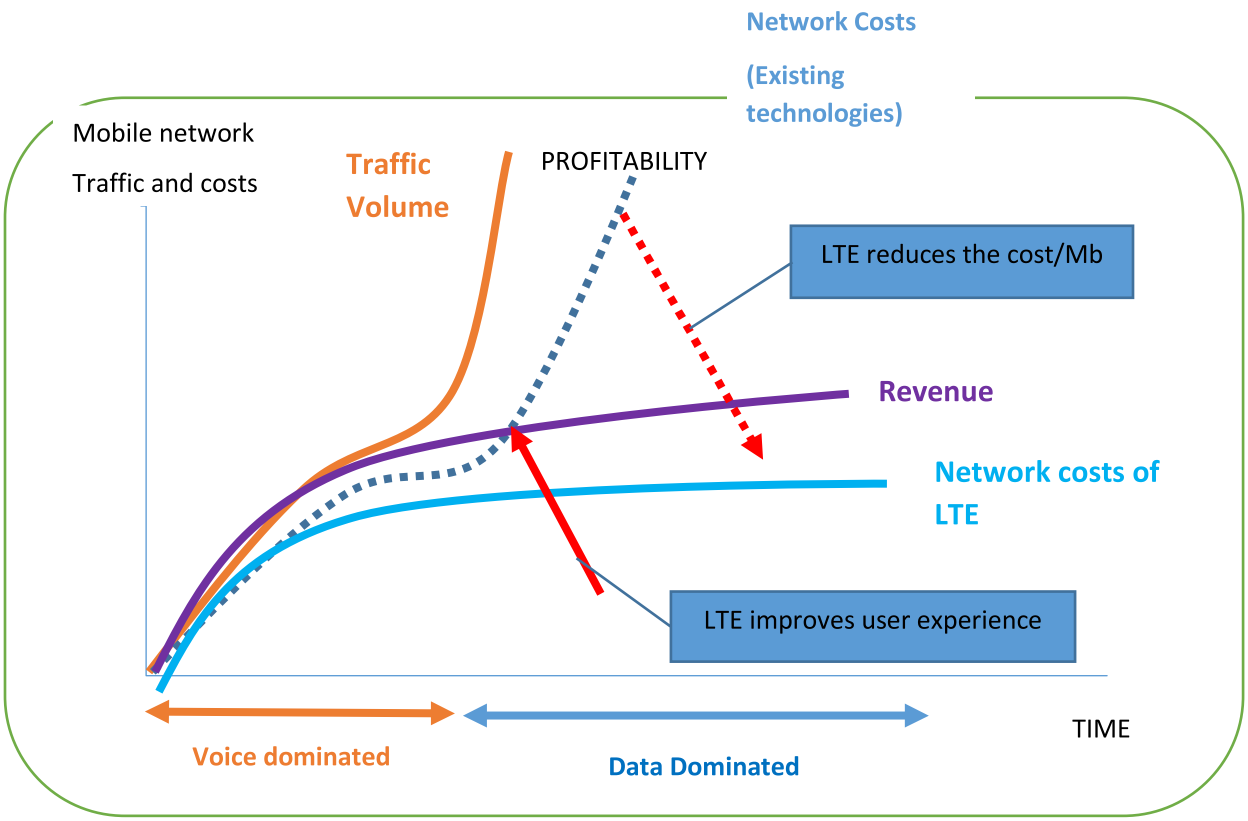



**Figure 5.4 Future predictions for the state of Zimbabwe telecom industry**

# Chapter Six

# Recommendations

## 6.1 .Recommendations

The following are the authors recommendations to Zimbabwe telecom operators based on the results collected:

- Launching 4G LTE services is a big challenge for operators as this will raise capital expenditure while raising minimal revenue levels. While the major focus of 4G LTE is to provide a superfast mobile internet service experience, there are also important features and attributes that need to be taken into consideration .As discussed in this research document voice quality will be an important aspect to be looked at since it contribute more revenue wise.
- It is also important to note that apart from network capability, pricing is an issue to be considered. Some mobile users may be willing to pay more for better services and therefore for an operator that is oriented towards satisfying its customers this issue cannot be ignored. Another limiting factor is that cutting edge 4G LTE mobile phones are expensive.
- To maintain and attract subscribers in the carriers, network quality and cheaper rates are influencing factors to be considered.
- All operators in the country have adopted a wait and copy attitude in as far as launching products e.g. mobile money, LTE deployment etc.

  The result is that there is always an operator that will invests a lot more in the initial investment of the product whilst the other operators will simply feed off a market ready environment. Initial investments include:

  -Customer Awareness campaigns

  -Market conscientisation

  -Market preparation e.g. Ecocash agents training etc.

## 6.2 Proposed Deployment Strategy

### 6.2.1 Marketing Strategies

Analysis of the numbers and the rate of increase of customers using any technology from the time the technology is introduced to the present show that the deployment strategies that have been followed by our mobile operators are more focused on the technical aspects and capability of the equipment.

The following are the strategies that the author proposes:

1. Retain the current 2G or 3G technology subscribers and migrate to LTE technology by offering incentives or customer packages such as LTE handsets with services such as data bundles and video gaming to customers already registered in the network
2. Grow the revenue base of the LTE technology before migrating by coming up with innovative marketing strategies like:
    a. Teaming up with Insurance Companies, Vehicle Tracking and Security Companies to offer better insurance cover for vehicles on mobile tracking. That way the whole vehicle population in the country is a potential data customers. Achieving this will guarantee a huge growth in data subscribers and revenue as well

    b. Look at potential revenue areas such as wildlife animal tracking for purposes of population and disease control

### 6.2.2 Technical Strategies

There are two primary LTE deployment strategies which are Single RAN and Network Overlay.

Single RAN involves the deployment of new multi-standard base stations with multi-mode radios as a common platform to add LTE while converging multiple generations of wireless networks. In this approach operators must carefully plan the removal of the legacy network equipment from each site replacing it with a new single RAN base stations with multi-mode radios to effectively support 2G, 3G and 4G services.

LTE Network overlay strategy would involve deploying LTE base stations without a simultaneous 2G/3G upgrade.

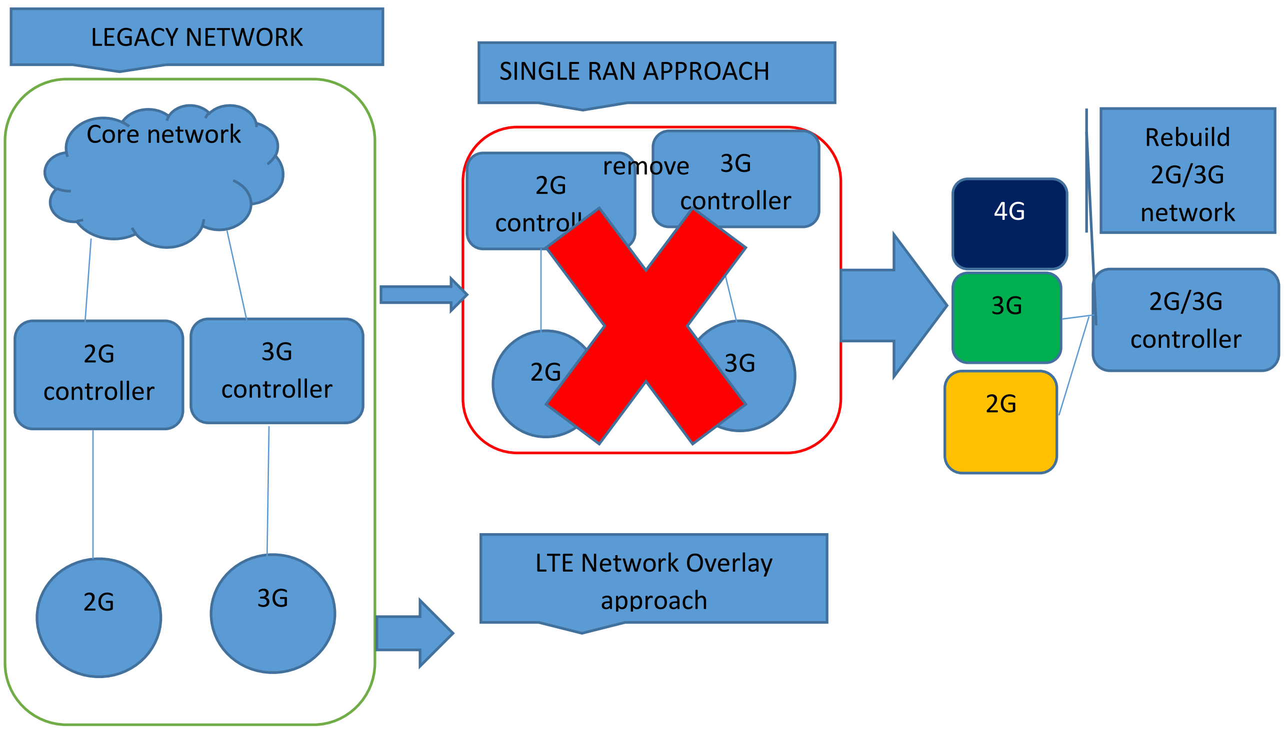



**Figure 6.1 Deployment strategies**

The advantages of the Network overlay method include:

- Faster, easier and less expensive LTE deployment.
- Minimize additional investment in legacy 2G/3G networks
- Avoid any disturbance to a stable 2G/3G network while capping its growth.
- Achieve efficiency in LTE deployment.

The advantages of single RAN method include:

- Converge multiple generations of wireless networks or newly merged operators.
- Longer time available to phase in a new LTE network
- Ability to upgrade 2G/3G network while deploying a 4G network
- Common 2G/3G/4G network platform with lower operational expenditures.

As shown in figure 6.2 the most leading operators in the world have been using the LTE network overlay deployment strategy.

These leading operators have been pressured by customer demand, competition and rapid data traffic growth to quickly upgrade their networks with LTE and the network overlay strategy has helped them achieve the speed to market with an efficient and economical LTE network deployment.

| COUNTRY | LTE SUBSCRIPTIONS YEAR END 2012 | OPERATOR | SPECTRUM BAND | LAUNCH DATE | DEPLOYMENT STRATEGY |
|---|---|---|---|---|---|
| South Korea | 7 million<br>5 million<br>4 million | SK Telecom<br>LG U+<br>KT | 800 MHz/1.8 GHz<br>800 MHz<br>1.8 GHz | 2011<br>2011<br>2012 | Overlay<br>Overlay/SR<br>Overlay |
| Japan | 7.5 million<br>1.5 million<br>1.0 million | NTT Docomo<br>KDDI<br>Softbank/WCP | 2.1 GHz<br>800 MHz<br>2.5GHz/2.1 GHz | 2010<br>2011<br>2012 | Overlay<br>Overlay<br>Overlay |
| Australia | 0.5 million | Telstra<br>Optus<br>Vodafone | 1.8 GHz<br>1.8 GHz<br>1.8 GHz | 2011<br>2012<br>2013 | Overlay<br>Overlay<br>Single RAN |

*Source: Heavy Reading*

**Figure 6.2 Leading operators in the world deployment strategies**

For these reasons the author recommend the Network overlay strategy if LTE is to be deployed in Zimbabwe.

# Chapter Seven

# Conclusion

From the results and analysis of this research, it is evident that the uptake of data services for the Zimbabwe mobile customers is still very low compared to voice services. As such the revenue generating capacity for data services is also low compared to voice services.

This presents the greatest potential for the migration from 3G to LTE in that new and untapped revenue streams in the mobile market are still very much abundant with services such as

- Video streaming
- Gaming

being typical examples of high revenue data centric services still to be deployed

The greatest challenge to the successful transition from 3G to LTE is that research data indicates that, the almost 40% of all subscribers who happen to data subscribers only generate 10% of monthly revenue, against 60% of all subscribers who happen to be  voice subscribers, who generate 90% of revenue.

This is presents a possible area of further research, that of investigating technical solutions to growing revenue streams in LTE networks in Zimbabwe.

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