

Declaration

I, Kunjuzwa Dumani Tau, hereby declare that *Exploring User-Driven Telephony Services in an Information and Communication Technology for Development Context* is my original work, and that all sources that have been used are fully acknowledged and correctly referenced. I further declare that this work has not previously been submitted to any other university for a qualification.

Signature: _____

Date: _____

Dedication

I thank God for the success of this work. I would like to dedicate this work to my late mother Nomangesi Nophumzo Shirley Kunjuzwa. You were my true inspiration and my source of energy.

Acknowledgements

Firstly, I would like to express my very special thanks to my supervisor Dr. M. Thinyane. I would like to further acknowledge Professor J. Chadwick for accepting me and allowing me to further my studies within the Department of Computer Science.

Secondly, I thank the financial funding I received from the National Research Foundation (NRF), without this financial support this research project would not have been a success.

To my family, the encouragement and support you provided to me throughout this research has made me withstand the difficult times and believed that there is a light at the end of the tunnel. I truly express my acknowledgements thereof and I hope that we will always be there for one another.

To my friends and colleagues, we had a wonderful journey together. I enjoyed every moment with you. All the love, help and life experience we shared together has contributed to the success of this dissertation. To me, you were my second family at the University of Fort Hare.

Publications

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Kunjuzwa, D.T., Hlungulu, B, Ndlovu, N., Samalenge, J., Ngwenya, S., Thinyane, M. and Terzoli, A. (2010). Technology Solutions to Strengthen the Integration of Marginalized Communities into the Global Knowledge Society, IST Africa, Durban, South Africa.

Abstract

There is a great difference that exists between people who have access to Information and Communication Technologies (ICTs) and those who do not. As a developing nation, South Africa is badly affected by the so-called *Digital Divide*. Information and Communication Technology for Development (ICTD) interventions are rapidly increasing in marginalized and rural communities in striving to bridge this digital divide.

This research project is undertaken within the context of the Siyakhula Living Lab (SLL) which is an ICTD intervention at Dwesa rural community. This research investigates how audio-based services can be applied locally for communication and information sharing. This research aims to develop a user-driven telephony framework which will enable users to construct customized audio-based services. This aims to empower the Dwesa community for skill development and supports the user-driven innovation.

The Internet and Telephones are the most popular technologies that are widely used in our daily life for purposes of communication and information access. Voice over Internet Protocol (VoIP) integrates these two separate technologies (Internet and Telephones) to produce real-time multimedia communication services such as Interactive Voice Response (IVR) systems. In addition, the ability of VoIP presenting information through voice plays a crucial role, more especially to those who do not have web visual access or those who are computer illiterate.

Index Terms – *Audio-Based Service, Free Open Source Software (FOSS), ICTs, Marginalized and Rural Communities, User-Driven and VoIP*

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Acronyms and Abbreviations

<i>AGI</i>	Asterisk Gateway Interface
<i>ASGISA</i>	Accelerated and Shared Growth Initiative of South Africa
<i>ASR</i>	Automatic Speech Recognition
<i>CSIR</i>	Council for Scientific and Industrial Research
<i>DTMF</i>	Dual-Tone Multi-Frequency
<i>FOSS</i>	Free Open Source Software
<i>GUI</i>	Graphic User Interface
<i>HTML</i>	Hyper Text Mark-up Language
<i>ICT</i>	Information and Communication Technology
<i>ICTD</i>	Information and Communication Technology for Development
<i>IP</i>	Internet Protocol
<i>ISDN</i>	Integrated Service Digital Network
<i>IVR</i>	Interactive Voice Response
<i>JDBC</i>	Java DataBase Connectivity
<i>LAMP</i>	Linux, Apache, MySQL, PHP

<i>NRF</i>	National Research Foundation
<i>PBX</i>	Private Branch Exchange
<i>PHP</i>	Hypertext Processor
<i>PSTN</i>	Public Switched Telephone Network
<i>RPT</i>	Real-Time Transport Protocol
<i>SIP</i>	Session Initiation Protocol
<i>SLL</i>	Siyakhula Living Lab
<i>SNO</i>	Second National Operator
<i>TCP</i>	Transfer Control Protocol
<i>TTS</i>	Text-To-Speech
<i>UDP</i>	User Datagram Protocol
<i>URL</i>	Uniform Resource Locator
<i>USAL</i>	Under-Served Area Licences
<i>VANS</i>	Value Added Networks
<i>VoIP</i>	Voice over Internet Protocol
<i>VSAT</i>	Very Small Aperture Terminal
<i>VUI</i>	Voice User Interface

<i>VXML</i>	Voice eXtensible Mark-up Language
<i>Wi-Fi</i>	Wireless Fidelity
<i>XHTML</i>	eXtensible HyperText Mark-up Language

1 Chapter One: Introduction

In this Chapter, Section 1.1 presents a general background and introduces the research location in which this project is based. Section 1.2 highlights the research questions that this dissertation seeks to answer. The aims and objectives of this research project are presented in Section 1.3. This Chapter also presents the research problem and research motivation in Sections 1.4 and 1.5 respectively. The structure of this dissertation is presented in Section 1.6. Lastly, Section 1.7 presents a summary of this Chapter.

1.1 Background

Information and Communication Technologies (ICTs) development infrastructures are believed to play a very important role in improving the socio-economic development of marginalized and rural communities. Chetty *et al* (2006) suggest that, when ICTs are introduced to marginalized and rural communities it is important to address the functionality of these ICT infrastructures so that the people's fear is taken away and they are able to enjoy the benefits of the ICTs.

Dwesa is the research location where this project was undertaken. The location of Dwesa rural community is well defined in the next Chapter. The University of Fort Hare (UFH) and Rhodes University (RU) initiated Information and Communication Technology for development (ICTD) intervention called Siyakhula Living Lab (SLL) which is in its fourth year of operation at the Dwesa rural community (Kunjuzwa *et al*, 2010). This ICTD intervention has deployed a wireless network in Dwesa. The deployed network runs on an Open Source platform. This platform is essentially a multi-functional, distributed communications system designed to integrate different e-Service functionalities (Tarwireyi, 2007).

1.2 Research Questions

This dissertation seeks to investigate the practical development and implementation of audio-based service for the Dwesa rural community. This study addresses the following research questions:

- *Can a user-driven audio-based telephony framework be developed to support information and knowledge sharing for the Dwesa community?*
- *If yes, how will it be implemented and how it will be used?*
- *Why it is important to develop such a system at Dwesa?*

The research questions above highlight the research agenda of this project. Jakachira (2010) indicate that the Dwesa rural area presents a relevant research site to extract the facts in order to find answers to these research questions.

1.3 Aim of the Research

The primary aim of this research is to develop an intuitive and localized framework. This framework aims to enable user-driven innovation by allowing the Dwesa community users to construct their customized simple or complex audio-based services rather than using readymade services. Information sharing over telephony is one objective that this research project intends to attain. Other important objectives that need to be attained in this research project include the following:

- *The system should be a simple intuitive and localized user-driven framework.*
- *The system should allow the end-users be the developers so to empower them with skill development.*
- *The system should give options of available telephony services.*

1.4 Research Problem

Information and Communication Technology for Development (ICTD) interventions are growing rapidly in the marginalized communities of South Africa. ICTs have gained wide adoption from those who live in these disadvantaged communities especially with support from various organizations such as government and non-governmental organizations (DoE, 2001).

ICTs strive to bridge the so-called *digital divide* between the urban and rural communities (Conradie *et al*, 2010 & Chapman *et. al*, 2002). The local computer lab in schools sets a good example of ICTs in rural development and the interaction between humans and ICTs (i.e., Computers and Internet) is rapidly increasing in marginalized communities.

ICT infrastructures are becoming increasingly available and accessible to the marginalized communities of South Africa such as Dwesa. However, there are serious challenges and constraints to the rural communities. These include the following:

- End-users are given closed systems which do not allow them to modify it.
- End-user's engagement in system development is sometimes ignored.
- Rural areas, such as Dwesa, have high level of illiteracy.
- The services currently running in these communities are web-based applications.

This research project seeks to minimize these challenges by providing the necessary framework. This framework will provide tools which will enable the end-users to develop their customized audio-based services. This is believed to be one method which will significantly engage the end-users in utilizing the ICT services.

Voice over IP (VoIP) is one ICT infrastructure which this research project takes full advantage of to overcome the challenges highlighted above. The VoIP concept is discussed in more into detail in the next Chapter of this study.

1.5 Research Motivation

This research project is motivated by the failure of many ICTs previously developed for rural and marginalized communities of developing countries. Thanasankit&Corbitt (1999) indicate that one of the reasons that these projects continue to fail is the Western approach which is inappropriately applied to the provision of ICTs in rural areas. Chau&Hu (2004) indicate that these systems are developed in laboratories and deployed in targeted areas without the proper training of the system users. Social characteristics of the targeted areas are sometimes completely ignored by the system developers (Cechini&Scott, 2003).

This research project seeks to contribute to ICT for rural development by developing an audio-based telephony framework which will enable user-driven telephony services in the Dwesa community. This framework will be intuitive and localized to the context of Dwesa as indicated under the research problem. The current developed and deployed services at Dwesa are web-based systems (e.g., E-Government, E-commerce and E-Judiciary) there is therefore a need to develop an audio-based system to facilitate information and communication access in the Dwesa rural community, particularly for people who are illiterate and visually challenged.

1.6 Structure Outline

Chapter Two –This Chapter reviews the literature on Information and Communication Technologies for rural developments in South Africa as well as in the African continent as a whole. A background of the targeted research location (Dwesa) is presented in this Chapter together with the ICTs development services brought by the Siyakhula Living Lab (SLL) project. Finally, this Chapter concludes by reviewing related work to the user-driven telephony services under the context of VoIP.

Chapter Three – This Chapter presents the methods which were applicable and used in the undertaking of this research project. This Chapter further reviews the core relevant tools and software technologies.

Chapter Four – This Chapter explores the design and implementation of the Dwesa audio-based system. This Chapter walks us through the demonstration on how the system was built.

Chapter Five – This Chapter presents the results attained during the system testing and evaluation. General observations on how the teachers, learners and the Dwesa community as a whole utilize the ICT facilities which are provided by the Siyakhula Living Lab are also presented in this Chapter.

Chapter Six – This Chapter concludes the study of this research project. Problems and challenges that were encountered during the development of this research project are also discussed in this Chapter. Finally, this Chapter puts forward possible suggestions for future work that can be conducted to extend the development and deployment of audio-based services in rural areas.

1.7 Summary

This Chapter provided an overview of this research project. This Chapter further presented the aim and objectives of this project and provided the research problem that this project seeks to bridge and overcome. Finally, the structure of the study is also presented in this Chapter.

2 Chapter Two: Literature Review

In this Chapter, we present the challenges faced by people who live in rural areas such as Dwesa. The Dwesa rural community as the research location for this research project is presented in Section 2.1. The importance and the impact of Information and Communication Technologies (ICTs) in South Africa, specifically and in the African continent, generally, are presented in section 2.2. In Section 2.3, the literature concerning Information and Communication for Development (ICTD) is reviewed. Section 2.4 presents service developments in the ICT context. Section 2.5 present the role played by Living Labs in rural development. South African telecommunication, which includes the concept of Voice over Internet Protocol (VoIP) as the bridge to the digital divide is presented in Section 2.6. In conclusion, this Chapter present work related to this research and presents the summary of this Chapter in Sections 2.7 and 2.8 respectively.

2.1 Research Location and Context

This section provides a detailed description of the research location which is Dwesa. The Dwesa community is situated in the Wild Coast of the former homeland of Transkei in Eastern Cape of South Africa (Palmer, 2002). Figure 1 shows the location of Dwesa. This community falls under the Mbashe municipality which belongs to the Amathole region based in East London. Palmer (2002) indicated that this community has approximately 15000 inhabitants who are distributed into 2000 households. Dwesa is a traditional and cultural farming community made up of Xhosa people, who depend on the land for their livelihood (Palma, 2002). Dwesa features a coastal nature reserve in its region and rich potential in terms of attracting tourists.

Dalvit *et al* (2007) noted that the nature reserve is a catalyst for tourism which, together with government subsidies should be the main source of income for the Dwesa community. Sadly the benefits and profits from the Dwesa nature reserve are still to filter

down to the community members, despite the fact that they have owned the reserve since 2006.

Tourism is seasonal in the area and visitors are most often South Africans. Finally, there are arts and crafts entrepreneurs in Dwesa who are primary organized as groups who serve the local markets with their artefacts.



Figure 1: Dwesa location (Dalvit *et al*, 2007)

The Dwesa location has extensive infrastructural constraints. According to Kunjuzwa *et al* (2010) the following constraints were noted.

- Road network is under-developed.
- Poor, and absence of, public transport – it is approximately 50 km on gravel road from Dwesa to the nearest town (Willowvale).
- Low level of literacy.
- Sometimes poor telecommunication coverage.

2.2 South African Technological Context

A new South Africa was born when the political negotiations took place prior to April 1994 which resulted to the first democratic elections (Horowitz, 1997). South Africa has a population estimated over 49.9 million of people (Jensen, 2010). Figure 2 shows the South African population by each province.

POPULATION BY PROVINCE 2010		
Province	Population	% of total
Eastern Cape	6 743 800	13.5%
Free State	2 824 500	5.7%
Gauteng	11 191 700	22.4%
KwaZulu-Natal	10 645 400	21.3%
Limpopo	5 439 600	10.9%
Mpumalanga	3 617 600	7.2%
Northern Cape	1 103 900	2.2%
North West	3 200 900	6.4%
Western Cape	5 223 900	10.4%
TOTAL	49 991 300	100%

Figure 2: South African population (STATSSA, 2010)

In 2006, the South African government launched the Accelerated and Shared Growth Initiative of South Africa (ASGISA) that will contribute to the country's socio-economic growth. This initiative aims to halve the unemployment and alleviate poverty by the year 2014.

Internet and other ICT infrastructures such as telecommunications are important components for any country's socio-economic development. The study carried out by Internet World Stats (2008) indicates that South Africa was rated in the fourth place in African top ten countries as shown in Figure 3 for Internet usage, access to information and business markets.

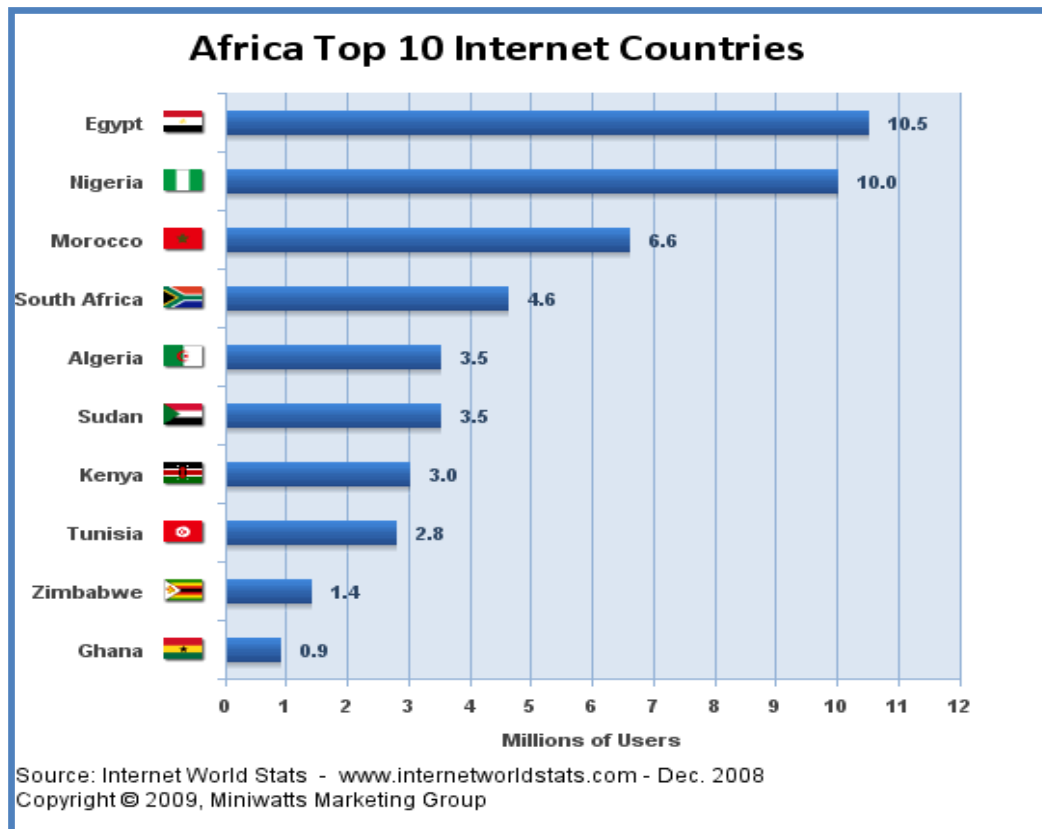


Figure 3 African top 10 Internet countries

According to Chapman and Slaymaker (2002), ICT activities and innovations are important components for developing any rural community. It is no secret that ICT developments have improved the lives of those who live in rural communities. The current state of ICT activities focuses on infrastructure development for the long-term and provides information and communication services to rural areas of South Africa (Chapman and Slaymaker, 2002).

In the economic development context, information and technologies provide access to markets and create job opportunities. ICT is not a solution to all problems. However it can enable wealth creation and cost reduction through applications such as price discovery, marketing assistance and so forth (Reddy *et al.*, 2004).

In the context of human development, Reddy *et al* (2004) further states that information and communication technologies can improve the quality of life of an individual by providing access to education, entertainment and healthcare. ICT alone cannot make one literate but can enable life-long learning and education independent of the limitations of language, distance, age and physical disabilities (Reddy *et al*, 2004).

2.2.1 South African rural areas

In South Africa there are many rural communities that exist below the standard of living (Herselman, 2003). This results in people migrating to urban areas for better living standards. These rural and underserved areas have no, or limited, access to basic ICT infrastructures. ICT developments have been introduced to revamp the lives of those living in rural areas but in Transkei some rural areas have no electricity, water, roads and communication technologies which are the building blocks of socio-economic development (Herselman, 2003). These marginalized and rural communities are normally classified as the areas of poor-information access (Chapman and Slaymaker, 2002).

2.2.2 Education in rural areas

Gush *et al*(2004) note that, at present we live in a world where the knowledge of ICTs and computer skills are pre-requisites for most, if not all, professions and semi-skilled jobs. In the introduction to South Africa's National R&D Strategy, the former African National Congress president Thabo Mbeki indicated the importance of the modern technologies and the necessity the integration of these technologies into social activities including education (CSIR, 2003).

Education in some rural areas of South Africa is badly affected by many various drawbacks which contribute to the information-knowledge divide. Herselman (2003) noted the following drawbacks.

- The geographical location of the rural community these drawbacks even though ICTs have made it easier to reach the rural areas remotely. However, in some cases other rural areas reside in inaccessible locations for ICT deliveries due to the lack of proper roads.
- Lack of proper school buildings and stationery makes it almost impossible for learners to receive education which is of a satisfactory standard. In some cases this is caused by the small subsidy provided the state government.
- The long distances that the learners have to walk to school add to the disadvantage that those rural schools face. When it rains rivers get full and flooded which prevents learners from going to school. The results of this are the high number of school dropouts and high levels of illiteracy in rural areas.

The 50% pass rate in 2009 of matriculation results in the Eastern Cape Province has caused the non-profit Cape Town organization called Axiom to intervene in order to improve the level of education in this province.

2.3 ICTD

The new information and communication technologies represent the greatest tool to date for self-education and add value to community development. (Pringle, 2002). Heeks (2008) and Pringle (2002) argue that billions of US dollars are invested by the public, NGO and private sectors in information and communication technologies for development (ICTD) projects such as telecentres, rural and marginalized phone schemes, e-health services and e-education projects as well e-government services, yet the poor

rural communities do not have the necessary awareness, skills or basic facilities to contribute to their own development.

Nungu (2002) and Heeks (2008) suggested that, the way forward is to add more ICT awareness training to advocate the needs and use of ICTs in rural areas and the involvement of the local and central government in ICT rural development projects.

2.3.1 Cultural and Social impact of ICTs

This section discusses the importance of ICTs and the impact they have in the rural development.

Max-Neef *et al* (1991) indicate human needs, self-reliance, and organic articulations as the fundamental pillars which support Human Scale Development (HSD). Max-Neef *et al* (1991) further state that the Human Scale Development approach is about people not about objects; secondly, the basic fundamental needs of human are finite, and lastly, human needs are similar or the same almost in all cultures.

COFISA (2008) reviewed the literature concerning the cultural and social impact of ICTs in rural development and observed the useful features which ICTs have to support the rural development.

- ICTs empower human skill and ability to perform tasks and activities quickly and efficiently.
- ICTs enable the facilitation of information sharing and indigenous knowledge.
- ICTs enable service delivery that is citizen-centred and focuses on the needs of the rural poor.
- ICTs enable social entrepreneurship and economic development.
- Lastly, ICTs have the ability to reduce poverty through integration into pro-poor policies and poverty reduction strategies.

Halewood & Kenny (2007) noted that young people in the rural areas of developing countries are often the first to adapt to new technologies as well as in the case of ICTs. ICTs in rural development are improving the quality of life daily and slowly bridging the urban-rural divide (Kunjuzwa *et al*, 2009).

2.3.2 ICTD activities in South Africa

In South African there are several governmental and non-governmental organizations that also play an important role in supporting information and communication for development (ICTD) projects in rural areas. These organizations include the Council for Scientific and Industrial Research (CSIR), Department of Science and Technology (DST), National Research Foundation (NRF) and other governmental organizations. According to CSIR, part of their mission and vision is striving to deliver appropriate ICT infrastructures which are relevant to the needs of the rural community. Under the theme of ICT for rural development, CSIR icomtek developed a wireless network system in the Eastern Cape province of South Africa that provides cost-effective service delivery the for local community telecentre that connects hospitals and police stations (CSIR, 2003).

ICTD projects are regarded as key priorities for poverty alleviation and rural development and should run for a life time. In practical terms projects create job opportunities. Pade (2006) state that information and knowledge are very important resources for socio-economic development as they play a crucial role in empowering rural communities with the ability of decision making and knowing what works best for them within the community.

Pade (2006) continues and discusses the issue of the failure and sustainability of these ICTD projects by reviewing the literature related to rural development. She notes the importance of being proactive in project management so as to ensure that the project operates for long term survival. Tarwireyi (2007), on the other hand defines sustainability as the property which arises out of the interaction between householders and

stakeholders. Heeks (2006) suggested that ICTD innovations in rural development should create a digital community where information is shared.

2.4 Services Development in the ICT Context

This section presents the e-society services that are developed in the ICT context.

Complete and functioning systems are developed and delivered to end-users. This becomes problematic because these systems do not provide the flexibility to be modified by the end-users.

To attract and attain a high level of system usage, the end-users should be given systems with tools that enable them to modify these systems. This will empower rural developing end-users to use ICTs in solving their development problems (Hanna, 2010). Hanna (2010) note the e-society is concerned with ICT distributional issues and helping poor communities to utilize these ICT tools to enhance their abilities, their local information and knowledge in order design new ICT applications.

Venkatesh *et al* (2003) stated that, technology is highly integrated with the daily lives of humans. Interactive systems and applications for end-users do not always provide the services, features and/or interface they would like to have. Therefore, some enthusiastic end-users modify these interactive systems in advanced and sometimes in unexpected ways (Dourish, 2004). This enables users to become innovators and develop their services from these interactive systems. In a rural development environment, Living Labs are the best examples of implementing grassroots initiatives using open source software technologies (Haddon *et al*, 2005).

2.5 Living Labs

Schaffers *et al* (2007) define a Living Labs as user-centric environment for open innovation which involves end-users at an early stage of establishment. Living Labs

allow end-users to be the driving force of the innovation process and to work closely together with the system developers (Schaffers *et al*, 2007). This human-centric approach considers humans as the primary source of the innovation rather than as an object for system testing and feedback. The Living Lab methodology is characterized by innovations which include services such as products and enhancements (Schaffers *et al*, 2007).

Niitamo *et al* (2006) indicate that there is a need to bring access to state-of-the-art technology, not only one kind but technologies that should provide delivery through different business models. The creation of the innovation application should be based on existing as well as future technologies (Niitamo *et al*, 2006). Niitamo *et al* (2006), in Figure 4, indicate three dimensional components upon which the Living Labs are built.

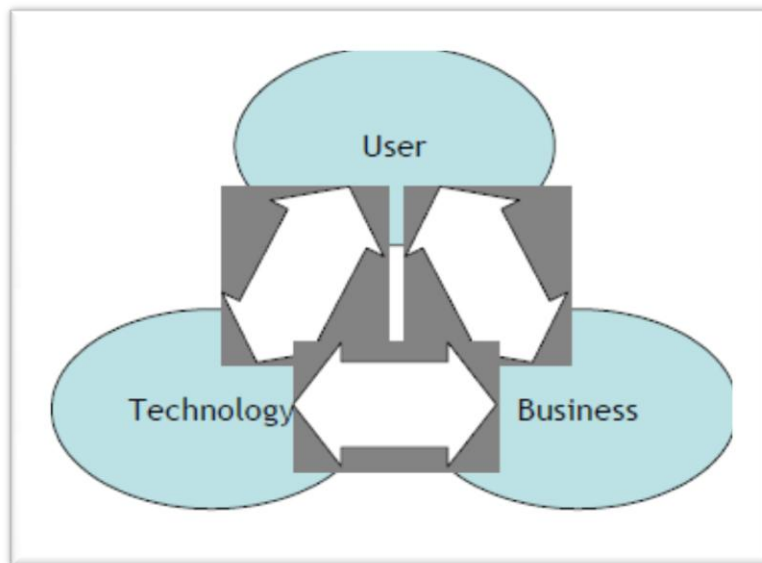


Figure 4: Components of Living Labs (Niitamo *et al*, 2006)

Niitamo *et al* (2006) further note that, the ability to bring public interests into the living labs innovations is important to cater for long-term operations.

2.5.1 Siyakhula Living Lab (SLL)

The Siyakhula Living Lab is an Information and Communication for Development (ICTD) intervention which was initiated by the University of Fort Hare and Rhodes University. This intervention is in its fourth year of operation with a field-site at the Dwesa community. The Siyakhula Living Lab provides a research platform that leverages the synergies of the multi-stakeholder, multi-disciplinary, user-driven innovation environment (Kunjuzwa *et al*, 2010).

Under the umbrella of the Siyakhula Living Lab, there are ICT eServices, besides the one this dissertation seeks to describe, which are already deployed and implemented for Dwesa community. These e-services include the following.

Cost Sharing and Revenue Management System: This project explores suitable internet billing models to make the Dwesa Internet infrastructure economical and sustainable for long term survival (Tarwireyi *et al*, 2007).

E-Government: The Dwesa community is located 47km away from the nearest town called Willowvale. This gap makes it very difficult for Dwesa community to access basic governmental services (e.g., application of ID, old age pension and so forth). The e-Government at Dwesa is a cost-effective web-based system that overcomes such challenges (Jakachira, 2009).

E-Commerce: This service was developed to modify the traditional telecentre model. Its main aims are to expand the financial revenue spectrum by exposing the products of local business men and women to the rest of the world (since they only depend on local revenues) and, in the process, exposing the same business people to the use of ICTs for business purposes (Jere, 2010).

E-Judiciary: The Dwesa's legal issues have been always discussed at the chief's house under a tree, and once the issues have been resolved, the people are dismissed. A few months down the line, a little is remembered concerning the matter. The e-Judiciary

offers a remedy to that by making available a way of safeguarding vital legal data, and guaranteed persistence and availability of data. It also makes legal information available to the public (Scott, 2010).

E-Health: This eliminates the unavailability of health knowledge in this rural community by implementing an intuitive system that will:

- Facilitate communication between local clinic nurses and system users.
- Collect indigenous knowledge from system users and store it in a database.
- Give system users access to indigenous knowledge.
- Provide the community with a coded medical ontology of isi-Xhosa traditional medicine (Hlungulu and Thinyane, 2009).

M-Payment: This is a system for Service Delivery in a Wireless Village Context. This project focuses on developing and implementing user-based rural mobile service applications for a rural community to make better their standard of living and enhance the business prospects of community entrepreneurs. This system offers two mobile applications namely, transferring money and buying electricity (Mpofu *et al*, 2009).

Help-Desk: This project aims to develop a help-desk system that will empower the Dwesa community by giving them access to ICT facilities, which liberates and nourishes human capacity (Makombe *et al*, 2009). This is accomplished by developing an end-user interface that will provide essential, effective and continuous end-user support to the Dwesa community. It serves as a knowledge management system that is used for retrieving and redistribution of Dwesa's ICT information (Makombe *et al*, 2008).

The e-Services discussed above run in the Dwesa network infrastructure (in [Figure 5](#)) to serve the community. The network was deployed and centred at four schools (*Mpume, Mtokwane, Ngwane, and Nondobo*) which serve as digital access points for the Dwesa community. It is a converged IP network which consists of both wired and wireless sections (Tarwireyi, 2007).

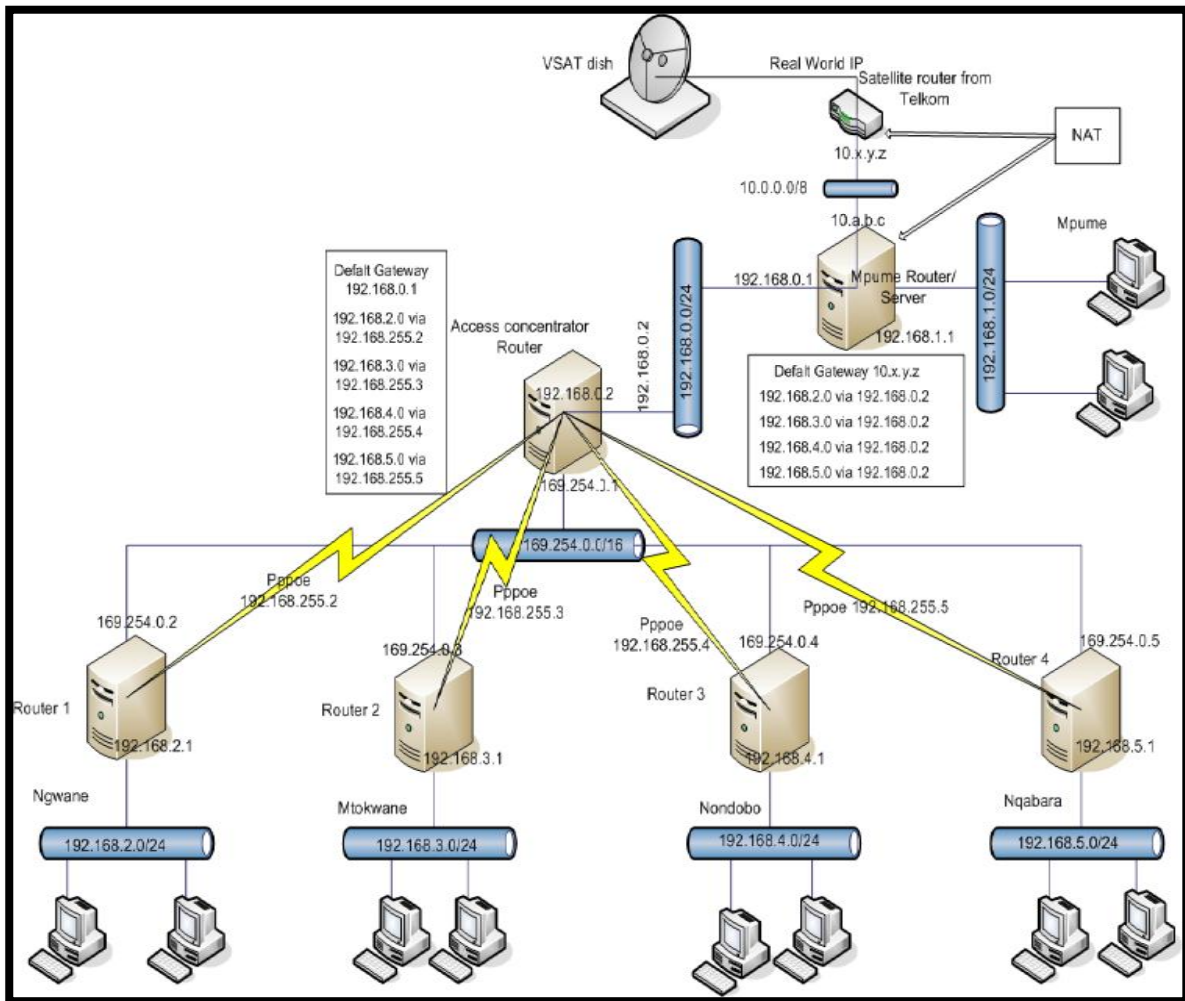


Figure 5: Dwesa network infrastructure (Siebörger and Irwin, 2008)

Mpume: This was the starting point of deploying the network (Tarwireyi, 2007). The location of and availability of electricity at this school suited the VSAT installation and other equipments, which include:

- VSAT
- One VoIP phone
- Six personal computers

- Eight port D-Link switch
- A sever (LTSP, HTTP, MySQL)
- WiMAX
- And a CPE

Ngwane: This school suited the installation of WIMAX micro-based installation and it is located in Line Of Sight (LOS) with Mpume.

- Twenty LCD personal computers
- A server and router
- One VoIP phone
- WiMAX and WiFi

Mtokwane and Nondobo: These schools are in line of sight with Ngwane, and this enabled the extension of the Internet to them (Tarwireyi, 2007).

2.5.2 User-Driven Platforms

Obrist (2007) indicated that in any innovation regarding an interactive system it is important to engage the targeted end-users as co-developers. This makes end-users active participants and it supports user innovativeness. Obrist (2007) suggests that developers should lead the users as they have a tendency of performing experiments with the existing applications and products. This enables the end-users to self-express their abilities and skills to modify the existing applications.

The theme *let the users develop* is used in this research project. The developers develop a user-driven telephony framework. This framework aims to innovate and promote the end-user's engagement and interaction with the tools which are provided by this framework and enables end-users to develop their customized audio-based services.

2.5.3 Web/GUI vs Audio-Based Applications

There are many illiterate people in the rural areas of South Africa. These people face great difficulty in accessing information that is often easily available to literate users. This becomes problematic in the developing world, where there are many non literate users, and where the importance of information is often presented via Web or GUI interfaces (Sherwani *et al*, 2009).

Audio-based interfaces serve as a bridge for information access for those who are illiterate. Audio-based services are gradually introduced to rural areas of developing countries where there is limited Internet connectivity and the existence of many illiterate and semi-literate people. In addition, audio-based services have an ability to present the same information that a web-based application presents (Kunjuzwa *et al*, 2009).

The rural environment suits the development and deployment of audio-based applications. Audio-based applications do not require special training as is the case of web-based or GUI applications. Interactive audio-based applications such as IVR systems have a potential to present the information to end-user in their spoken language (Kunjuzwa *et al*, 2009).

2.5.4 Interactive Voice Response (IVR)

Interactive Voice Response (IVR) is one VoIP application that this dissertation addresses by exploring user-driven telephony services. IVR is the telephony technology in which allows a caller to use a keypad to interact with the IVR system in order to acquire information from or enter information into the database (Shrestha and Regional, 2008). The telephone caller invokes the IVR system by calling a pre-defined extension number, the call is then routed into a computer system which plays a pre-recorded sound menu to the caller, the caller is expected to respond to the voice menu by selecting the dual-tone multi-frequency (DTMF) input that is associated with the voice prompt (Mundt *et al*., 1995).

As indicated in the previous Chapter, the services provided to the Dwesa community by Siyakhula Living Lab (SLL) thus far are web-based applications. This dissertation presents the introduction of an audio-based framework which will enable user-driven telephone services and allow the Dwesa community to share and access information via telephony. The approach and methodology used to explore this kind of VoIP application are further presented in more detail in the next Chapter.

2.6 IP Telephony

Internet and Telephones are widely used technologies that help us to easily get connected to and communicate with one another throughout the world. Voice over Internet Protocol (VoIP) integrates these two separate technologies (Internet and Telephones) and provides us with real-time multi-media services such as conference calling, messaging chat, Skype, and so forth.

VoIP is increasingly used by small and large organization to provide various telephony services. VoIP refers to the wide range of protocols that allow the transmission of voice traffic over the network using Internet Protocol (IP) (Cohen and Southwood, 2004). The term VoIP is used in this research project to define the combination of words such as *communication, network* and *voice*.

2.6.1 South Africa's Licensees Telecommunication

According to the Telecommunication Act no 103 of 1996, VoIP could be utilized by the telecommunication operators which include Telkom, Second National Operator (SNO) and Under Serviced Area Licensees (USALs). On the 1st of February 2005, The Minister of Communication announced that VoIP could also be provided by the Value Added Networks (VANS) (Chetty *et al*, 2006).

Table 1. South Africa's Licensees Telecommunication

1. Public Switched Telephone Network (PSTN) or Landline Operations (LO)	• Telkom (provides both VoIP and public switched communication) • Neotel (launched in August 31, 2006, ISP and VoIP)
2. Mobile Communication Network Operations (MCNO)	• Cell C • MTN • Vodacom • Virgin Mobile
3. Broadband provider	• Sentech
4. Under-Served Area Licenses (USAL)	• Amathole Telecommunication Services (Eastern Cape Province) • Bokamoso Consortium (Free State) • Bokone Telecoms (Capricorn District) • Ilizwe Telecommunication (OR Tambo District) • Karabo Telecoms (North West) • Kingdom Communication (Kwazulu Natal) • Thinta Telecoms (Ugu District, Kwazulu Natal)

Source: (Thorton, 2006)

2.6.2 South Africa's Mobile Operators

South Africa is rated fourth in the list of countries amongst the world's fastest developing cellular communications market (Esselaar *et al*, 2006). Figure 6 shows the country's cellular network operators namely Vodacom which has the 58% of market share, MTN which has 35% of market share, followed by Cell C and Virgin mobile which have 14.5% and 10% respectively (Esselaar *et al*, 2006).

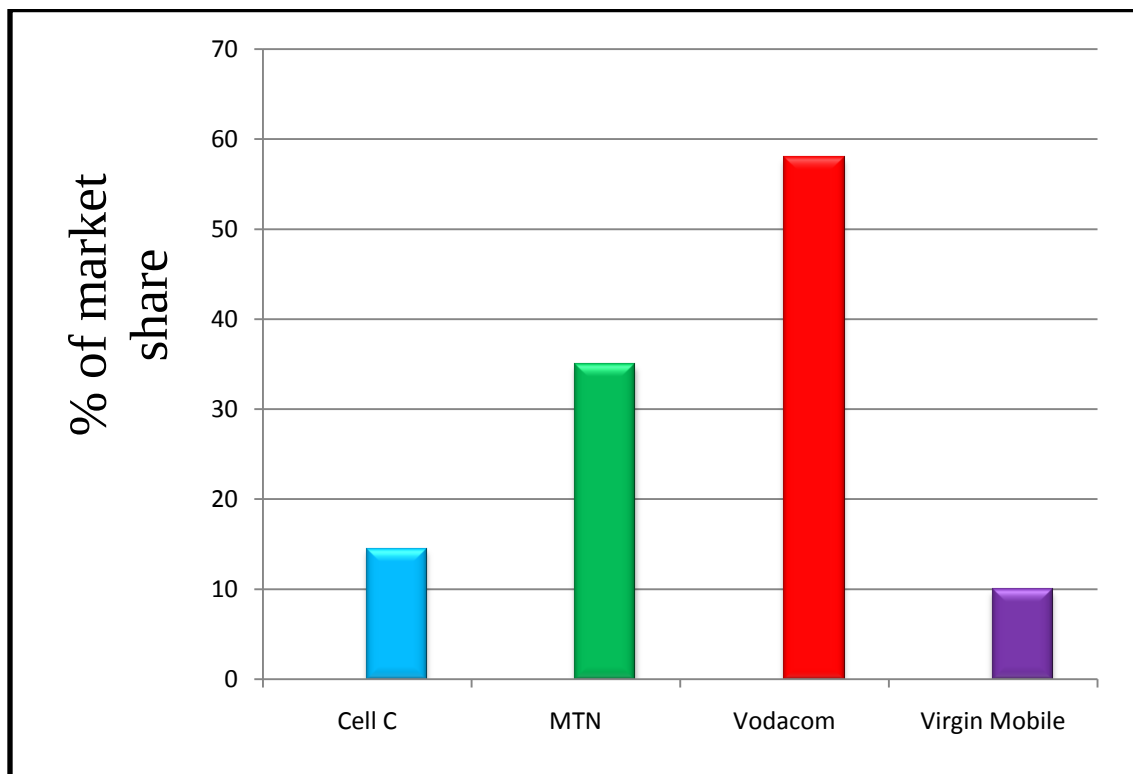


Figure 6: SA's mobile operators

Source: MTN (2010), Vodacom (2010), Cell C, (2010) & Virgin Mobile, (2010)

Mobile phones also play a crucial role and are used extensively in the developing world (Sherwani *et.al*, 2007) Mobile phones are easy to use, affordable and suitable for those who are illiterate (Sherwani *et.al*, 2007).

2.6.3 VoIP vs PSTN

According to the study carried out by Chetty *et al* (2006), VoIP offers several advantages compared to the public switched telephone network (PSTN). In the VoIP environment, bandwidth is used efficiently since packets are transmitted when it useful to do so. Chetty *et al*, (2006) further observe that in VoIP there is no requirement of an end-to-end open channel whereas in the PSTN environment a call requires an end-to-end channel for voice traffic. Goode (2002) noted that the encoding and decoding algorithm used to convert voice, generally works at 11.8kps in VoIP and 64kps in PSTN. The installation of VoIP is cheaper to set up than the traditional telephone network (Chetty *et al*, 2006). In conclusion, Chetty *et al* (2006) indicate that in the VoIP environment users can browse the internet and also make telephone calls using the same line.

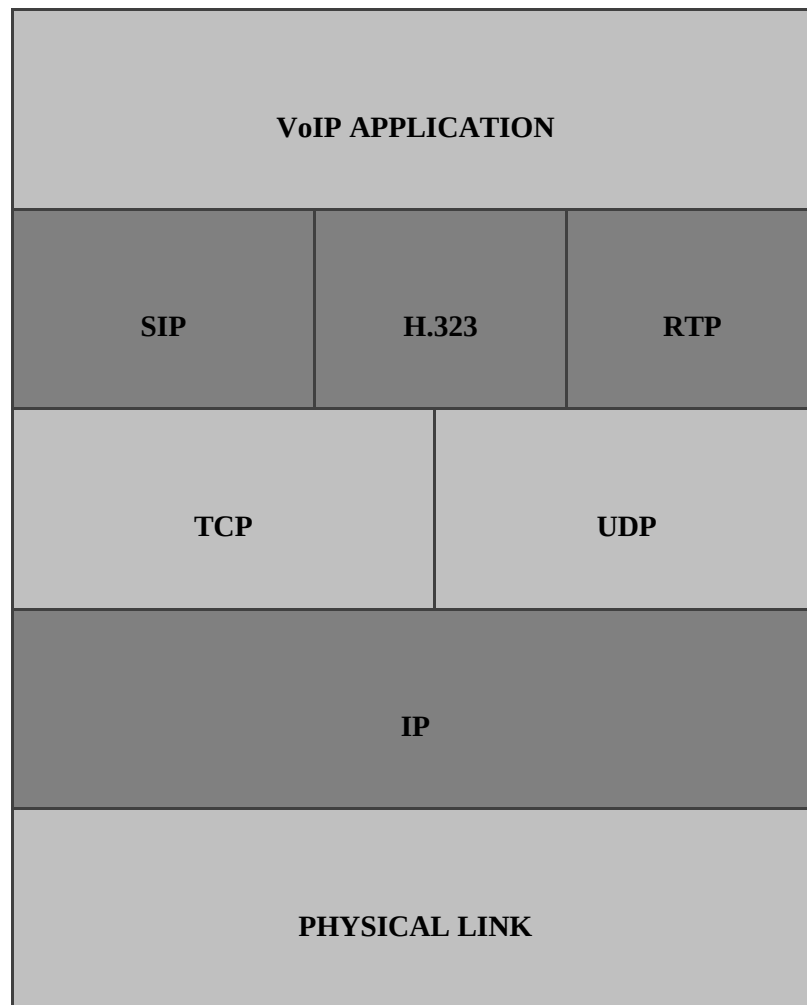
Based on the several advantages offered by VoIP, one can choose VoIP as the better alternative for telephony services. However, VoIP also suffers from other disadvantages. PSTN has a high Quality of Service (QoS) to VoIP (Chetty *et al*, 2006). The QoS in VoIP is badly affected by the packet loss in data transmission, latency, and jitter (Tucker, 2004).

2.6.4 VoIP Communication

The integration of the Internet and telephones enables VoIP to produce real-time multimedia communication services (Cohen and Southwood, 2004). These services include IVR, web-based call centres, web-messaging, chat rooms and so forth. As pointed out by Chetty *et al* (2006), VoIP could be combined with Wi-Fi data technologies to enhance access to the basic telecommunication services so as to serve marginalized communities. In addition, the ability of VoIP to present information via voice plays a crucial role more especially to those who do not have web visual access or to those who are computer illiterate.

Tucker,(2005)note that VoIP uses User Datagram Protocol (UDP) to establish sessions at transport layer, unlike the TCP. UDP operates in a connectionless and unreliable fashion and is much faster than TCP. UDP carries Voice over IP in a Real-time Transport Protocol (RTP). Table 2, below, shows the VoIP stack in a layered fashion (Tucker, 2005).

Table 2. VoIP Protocols structure



(Adopted from Tucker, 2005)

2.6.5 VoIP Protocols

In the VoIP environment there are two important protocols namely session initiation protocol (SIP) and H.323. These two protocols are responsible for establishing a call connection between end points. Table 2 above shows these two reliable protocols (SIP and H.323) sitting on top of an unreliable protocol like IP (Tucker, 2005).

1. SIP protocol

SIP is an Internet Engineer Task Force's (IETF) application layer control protocol for the establishment, modify, and terminate multimedia sessions such as Internet telephony calls (Chetty *et al.*, 2004 & Papageorgiou, 2001). SIP is used in this research project as a signalling protocol. Table 3 below shows the SIP methods.

Table 3. SIP protocol

1. Invite	This request is used to invite a user to participate in a multimedia session, with specific media characteristics. It is also used to modify an already established call session.
2. Ack	Acknowledges that a user agent client has received the final response to an INVITE request.
3. Bye	Terminates a call.
4. Cancel	This request is sent to abort a previous request.
5. Options	Queries the capabilities of the other side.

Source: (Cisco Systems, 1999)

2. H.323

H.323 is an International Telecommunication Union (ITU) signalling protocol which defines the multimedia communications system over the packet-switched networks and also internet protocol networks (Dalgic and Fang, 1999). Jones (2007) pointed out the five elements of H.323 which are:.

- Terminal: provides audio, video, data communications which work well in point-to-point and multipoint conferences.
- Gateways: provide interworking with terminals using other signalling protocol, such as SIP, PSTN, ISDN terminals.
- Multipoint Control Units (MCUs): provide support for multipoint conferences together with multipoint processors (MP) and multipoint controllers (MC).
- Gatekeeper: provides admission control and address translation services.
- Border Elements: are special types of peer elements that exist between two administrative domains and may assist in call authorization/authentication.

2.7 Related Work

In this research project, several case studies were reviewed under the context of VoIP and user-driven innovations. These case studies briefly describe the importance of VoIP and telecommunication in developing countries.

2.7.1 VoIP in Ilanga

The availability of a local network in the Siyakhula Living Lab (SLL) enabled the deployment of a VoIP (Voice over Internet Protocol) telephone system. An experimental

version has already been developed and deployed at Rhodes University (Dalvit *et al*, 2004). The VoIP system is named i-Langa (which means “sun” in isi-Xhosa) and it is basically an internal phone system, like the ones used by firms and academic institutions. Four VoIP phones have been deployed at the four schools (*Mpume*, *Nodobo*, *Gwane* and *Mtokwane*), and an experimental Asterisk server (on top of which i-Langa is run) has been deployed at Ngwane (Dalvit *et al*, 2007). The purpose is to improve communication within the Dwesa community and with the outside world (Wittington and Terzoli, 2006).

2.7.2 VoIP in Telemedicine

Tsilitwa rural area was identified as the target community in the Eastern Cape province of South Africa in which Telemedicine was deployed and implemented. Within the Tsilitwa village there is an existing network project undertaken by the Council for Scientific and Industry Research (CSIR). Tsilitwa village is linked to several sites and other neighbouring villages using 802.11b wireless Ethernet (Wi-Fi). Chetty *et al*, (2004).

The Telemedicine service was made possible through a combination of VoIP with a Store and Forward approach. Through VoIP, which allows calls to take place at the end of the other sites (clinics and hospitals) and data video transmission via a low cost webcam the system was useful but problematic. The problems which include the following:

- Power failure for long hours.
- Insufficient nurses and doctors at hospitals.

A store and forward approach was observed by Chetty *et al* (2004) as a solution to the above mentioned problems. This approach allows patients’ data to be stored at any given time and then to be sent to the recipient at the other end when the power or connection becomes available. Laptops were also used to capture the patients’ data, even during power failures.

Chetty *et al* (2004) conclude by indicating that VoIP and store and forward technologies are appropriate in the provision of telephony services to rural areas of South Africa.

2.8 Summary

This Chapter has presented the importance of ICT development in improving the lives of people living in the rural areas of South Africa. Information and knowledge are important resources that used to enhance socio-economic development in order to empower the rural community with the ability of decision making (Pade, 2006). The interaction of the rural community with ICT services and pro-activeness in project management are important as they ensure that the information and communication for development projects run for life time. In order to archive their long-life survival, services brought by ICTs should be relevant to the needs of the rural communities.

The integration of the telephone and Internet by VoIP facilitate communication by producing real-time multimedia services. VoIP has the ability to present the same information that web-based applications can present. Chetty *et al* (2006) noted that VoIP could be utilized over the wireless network (Wi-Fi) to connect and provide voice services to the rural communities at reduced costs. In conclusion, VoIP in ICT developments can bridge the digital divide in rural communities by introducing appropriate audio-based services via telephony.

3 Chapter Three: Methodologies and Technology Review

The previous Chapter reviewed the literature on how Information and Communication Technology for Development (ICTD) has the ability to overcome some of the challenges faced by the rural communities. This Chapter, present the approach adopted in developing the user-driven telephony framework for the Dwesa rural community. In Section 3.1 system development is presented. In Section 3.2, the system methodology applied for the data collection is also presented. The system tools and core technologies used in developing our framework are presented in Section 3.3. Finally, a summary of this chapter in Section 3.4is presented.

3.1 System Development

The Waterfall model is presented in this Section as a relevant approach for developing the user-driven telephony framework.

To recap our research objectives:

- *This research project aims to develop an intuitive and localized User-Driven telephony framework.*
- *The system aims to improve the level of literacy within Dwesa community by empowering users with skill development to construct their customized audio-based services.*
- *The system should give options of available telephony services*

3.1.1 Waterfall Model

The Waterfall model, also known as the linear sequential model, is defined as the software development process that has several stages which are represented as directly dependent upon one another as shown in [Figure 7](#) (Pfleeger *et al*, 2001 & Bell, 2000). This means that, the process cannot start without the completion of the previous stage.

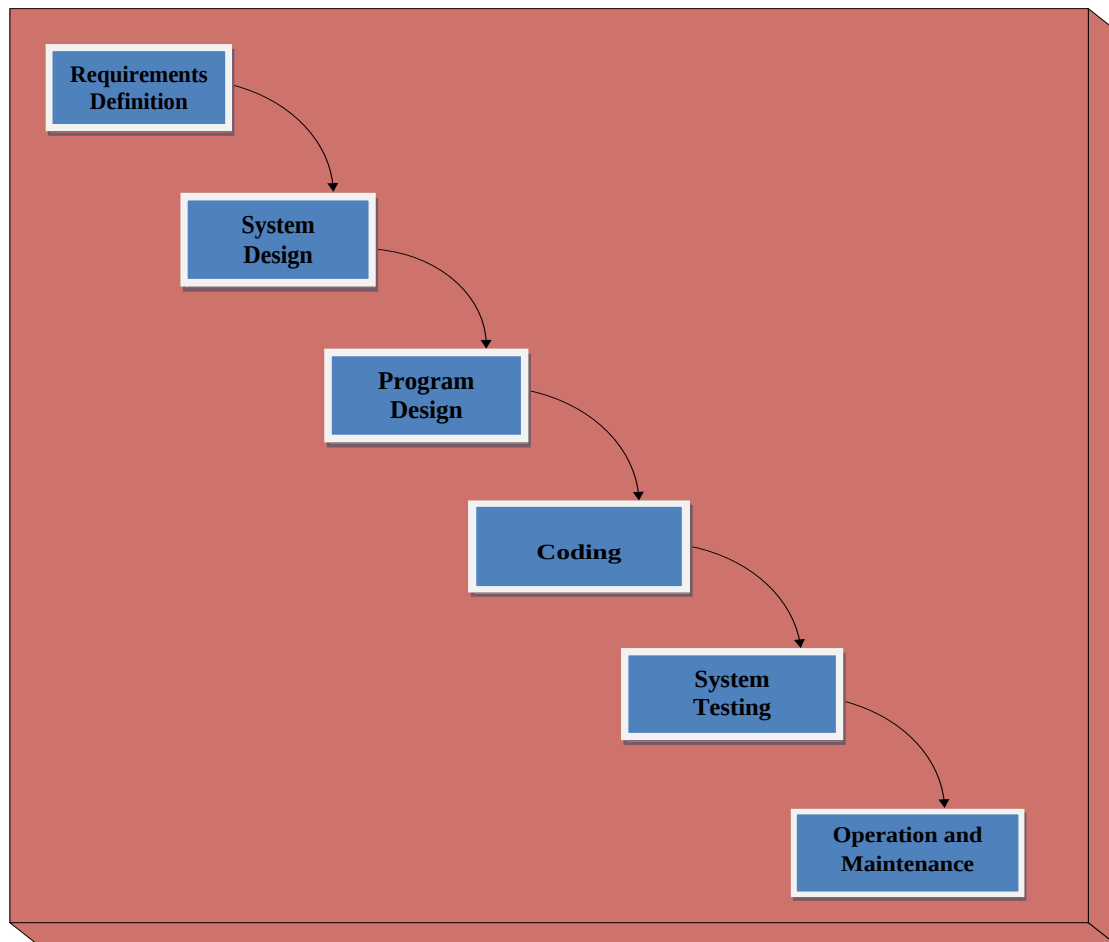


Figure 7: Waterfall model (Bell, 2000)

Several disadvantages were noted by Pfleeger *et al* (2001), who stated that software is a creation process and not a manufacturing process. Bell (2000) note a serious problem

with Waterfall model, in that the client gets to see the product at the end of the system development which becomes problematic if it is not what the client wants.

During the development of the user-driven telephony framework, the approach of the Waterfall model was adopted to break-down complex tasks into smaller and more manageable tasks.

Bell (2000) noted the following strengths of the Waterfall model.

- During the coding, errors in the design were discovered.
- The Waterfall model reveals design faults during the unit testing.

Evolutionary Prototype was also taken to account in this framework development as an alternative however the System developers did not closely work with the targeted end users. The framework was designed and developed based on the specifications and system requirements which were defined prior to system coding and development. The user's feedback which is presented in Chapter five was collected or recorded during the evaluation stage. This stage was a delivery or last stage of the system development where the users had to accept or reject the system hence the Waterfall model was adopted by the developers.

3.2 Research Approach

This section presents the methodology which was applied before, during and after the completion of the system development. The aim of the data collection prior to developing the system was to develop the Dwesa user-driven telephony framework based on the user's needs so as to attain a high level of system usage and minimize the risk of system failure.

3.2.1 Interview Data Collection

This type of data collection allows software developers to ask questions of the targeted system users about the features that should be offered by the system and establishes a better understanding from both the users and developers. The following questions were asked during the semi-structured interview:

- ***How do you share information or pass messages amongst each other within the Dwesa community?***

The word of mouth method, from one person to another, is the way they pass information amongst themselves. This becomes problematic because one risks receiving a distorted message.

- ***What kind of information do you share amongst each other?***

They share community announcements which include cultural activities, community meetings and funeral announcements.

- ***How well is the community informed about the audio-based services?***

The Dwesa community seemed unaware of any such service. Since 2007, there have been a minimal number of Dwesa community members with cell phones. There are no telephones in the Dwesa households.

3.2.2 Literature Review

As indicated in Chapter Two, the literature was reviewed on how audio-based services can be applied locally in the rural areas of developing countries. This helped the developers determine which important steps they should take in developing the user-driven telephony framework. This review surfaced from the existing ICT infrastructures in Dwesa, the profile of the targeted users and the living environment in Dwesa community.

3.2.3 Observations_Data Collection

The initial findings during the regular field trips to Dwesa in order to conduct computer literacy training were observed. These observations include:

- The utilization of ICTs (computers and Internet) by teachers, learners and the community.
- The way the Dwesa community share information and communicate amongst each other.

This data assisted the developers in easily developing the user-driven telephony framework based on what the Dwesa community regularly do with ICTs.

A detailed presentation of how the Dwesa community utilize ICTs is presented in Chapter Five of this study.

3.3 Ethical Issues

This Section addresses potential ethical issues such as user's confidentiality and consent. During the system testing and evaluation, the participants did not want the system developers to disclose their names in this document. The communication barriers between the participants and the system developers were addressed. Isi-Xhosa language was used during the experiment which is the participant's home language to prevent misunderstandings.

At the end of the system evaluation, system developers asked questions to the participants based on the experiment performed. The participants preferred an informal type of interview rather to a written feedback.

3.4 Core Technologies

This section presents system tools and software technologies which were applicable in developing the Dwesa user-driven telephony framework.

3.4.1 Asterisk

Madsen *et al* (2007) defines Asterisk as a complete open source Private Branch eXchange (PBX) that provides several telephony features which include the following.

A. Asterisk as an IVR system

Asterisk provides a service to business customers reducing the workload of business employees (receptionists). This is made possible by the power and flexibility of a programmable phone system which responds business customers in a meaningful way (Gomillion *et al*, 2005).

B. Asterisk as a Voicemail System

Asterisk has a complete functional voicemail system embedded within it. This component of Asterisk supports the hosting multiple organizations on the same server. The voicemail system is so powerful that it provides the options of notifying the recipient of new messages via email and via audio messages (Gomillion *et al*, 2005).

C. Asterisk as a VoIP system

In Chapter Two of this document the literature on Voice over Internet Protocol (VoIP) was reviewed. Asterisk gives us the ability to make use of the Internet Protocol (IP) although there are some other business organizations that run two separate networks, one for telephony and one for computers. Asterisk is the most popular technology in

telephony which enables the integration of these two separate networks allowing telephony to run on-top of the IP network (Gomillion *et al*, 2005).

3.4.2 VoiceXML

VoiceXML (VXML) is a W3C's standard XML based mark-up language for scripting audio-based interaction applications between a caller and computer system via voice or dual tone multiple frequency (DTMF) (Adgaonkar, 2005). Matzon (2005) defines VoiceXML as an offspring of HTML. However these two differ in the sense that in VoiceXML applications the caller speaks to the computer system whereas in HTML web-based applications the user communicates to a computer through the mouse and keyboard.

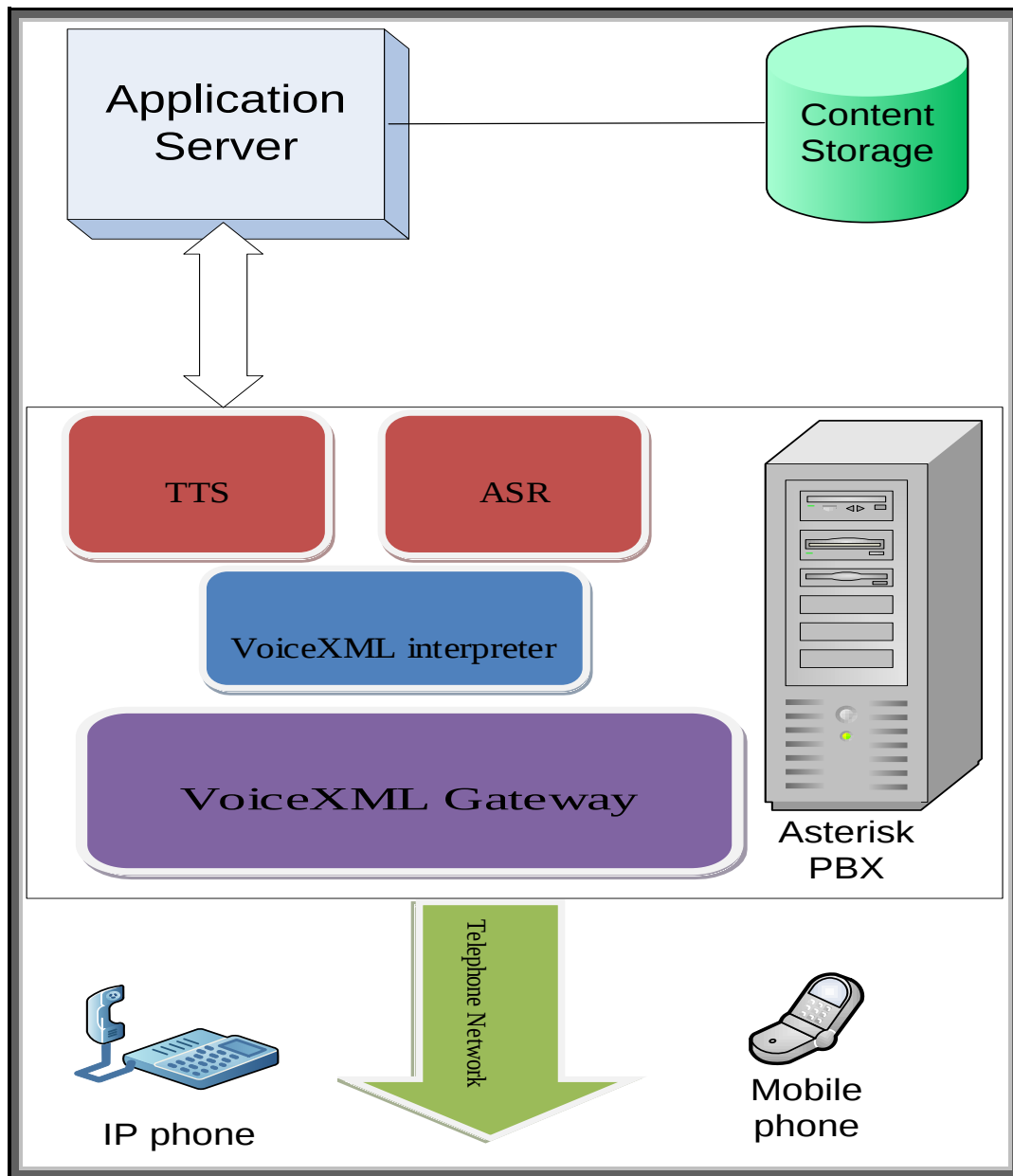


Figure 8: VoiceXML Architecture (adopted from Adgaonkar, 2005)

VoiceXML is observed as the most popular IP-telephony choice for developing audio-based services by various organizations. Figure 8 shows how a phone call is handled in the VoiceXML environment.

The user invokes the VoiceXML system by placing a call using any IP phone or any mobile phone. The VoiceXML gateway serves as a platform for VoiceXML applications

to run on (Adgaonkar, 2005). Adgaonkar (2005) also indicates that the VoiceXML gateway is an important component within the architecture, as it plays various roles which include:

- Processing calls.
- Interaction: Auto Speech Recognition, Text-To-Speech, Dual-Tone Multi-Frequency.
- Retrieving and interpreting VoiceXML pages.

The application server plays its role within the VoiceXML architecture as well. It hosts the applications and accepts the HTTP requests from the voice browser, and sends responses (Matzon, 2005). It also accesses the database and provides the data to the voice browser.

Flite and Festival Text-To-Speech (TTS) were used in this research project to respond to the user's requests in audio format. The developers took full advantage of these TTS engines (Flite and Festival) because they run on the Linux operating system and are compatible with Asterisk.

3.4.3 Asterisk Gateway Interface (AGI)

In this research, AGI applications were only explored. AGI provides a standard interface in which the external applications may interact with the Asterisk server and easily retrieve data from the storage content (Madsen *et al*, 2007).

AGI applications can be written in any modern programming language such as PHP, Perl, Python or Java. Traditionally, communication between Asterisk PBX and AGI scripts was via the standard input and standard output while AGI scripts had to run on the same machine that run Asterisk (Madsen *et al*, 2007). FastAGI protocol allows the AGI scripts to communicate with Asterisk over Transfer Control Protocol or Internet protocol (TCP/IP) socket instead of using standard input and standard out. Using FastAGI

protocol, Java applications can run on the same machine as Asterisk or on separate machines (Madsen *et al*, 2007).

3.4.4 Asterisk Dialplan

Asterisk dialplan is said to be the most important component in Asterisk architecture, as it defines how Asterisk should handle incoming and outgoing calls (Gomillion *et al*, 2005). The Asterisk dialplan is defined in the configuration file called *extension.conf*. This file is detailed in [Figure 10](#) of this dissertation. There are four main components that make up the Asterisk dialplan which include the following (Madsen *et al*, 2007 & Gomillion *et al*, 2005).

- **Contexts** - these are groups of extensions and serve various functionalities. Contexts are denoted by name in square brackets ([]).
- **Extensions** - in computer science and telecommunication, the term extensions normally refers to a numeric identifier that, if called it will ring a particular phone. Extension is denoted by `exten =>`. For example: `exten => 321, 1, Answer ()`.
- **Priorities** - each and every extension has its own sequential steps called priorities these priorities are numbers starting from 1, which execute a specific application in dialplan.
- **Applications** - applications in dialplan are responsible for executing specific actions on the current channel. These actions include answering the call (`Answer ()`), playing the sound file (`Playback ()`), accepting the DTMF input or ending the call (`Hangup ()`).

In this research, Dialplan IVR applications were also explored using dialplan in combination with Festival TTS engine. This is shown in the extension configuration file in Appendix C of this document.

3.4.5 SIP Servlets

SIP Servlets are sometimes referred to as Siplets which are widely used to develop Java-based IP telephony applications. This type of technology uses Session Initiation Protocol (SIP) which is a client/server protocol for multimedia call control and services (Eslami, 2007). In the previous Chapter of this study, SIP components (i.e., *Invite*, *Bye*, *Cancel*, *Acknowledge* and *Register*) were defined. In the SIP Servlets environment, these components are used as methods to handle the messages received (Eslami, 2007).

Figure 9 shows how communication is established in the SIP environment between two ends phones.

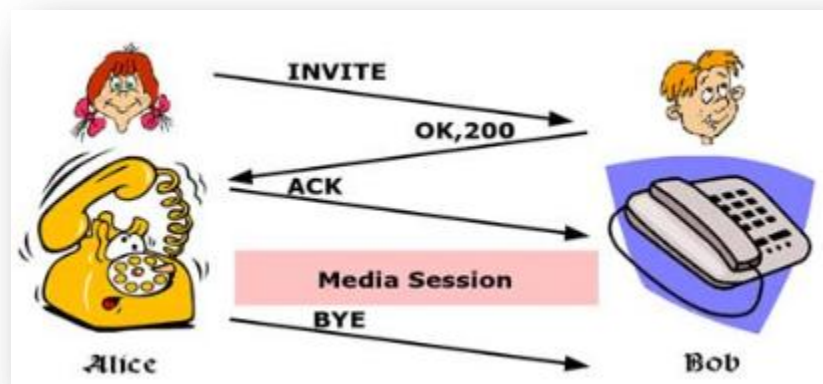


Figure 9: SIP message architecture (Eslami, 2007)

SIP Servlets were only explored as an alternative in developing the user-driven telephony framework.

3.5 Summary

This Chapter presents a detailed methodology, system tools and software technologies applicable in developing the user-driven telephony framework. Among the software development model, the Waterfall model was used as an approach in the development of

the telephony framework. In the next Chapter, the design and implementation of the system will be presented.

4 Chapter Four: Design and Implementation

The previous Chapter presented the methodology and reviewed the tools and software technologies that are relevant to the development of the user-driven telephony framework. This Chapter presents the design and implementation of the user-driven telephony framework. In Section 4.1, an overview of our system architecture is presented. In Section 4.2, the system design and system functionality in regard with user's and administrator's interaction with the system is presented. Following this is the presentation of the database design is in Section 4.3. The presentation of a Graphical User Interface (GUI) telephony framework is available in Section 4.4. In conclusion, this Chapter presents the Voice User Interface (VUI) telephony framework in Section 4.5 and a summary of this Chapter in Section 4.6.

4.1 Dwesa Telephony Architecture

The Dwesa user-driven telephony framework was developed using free and open source software (FOSS) technologies which includes the LAMP package (Linux, Apache, MySQL and PHP). The diagram in [Figure 10](#) shows the Dwesa telephony architecture.

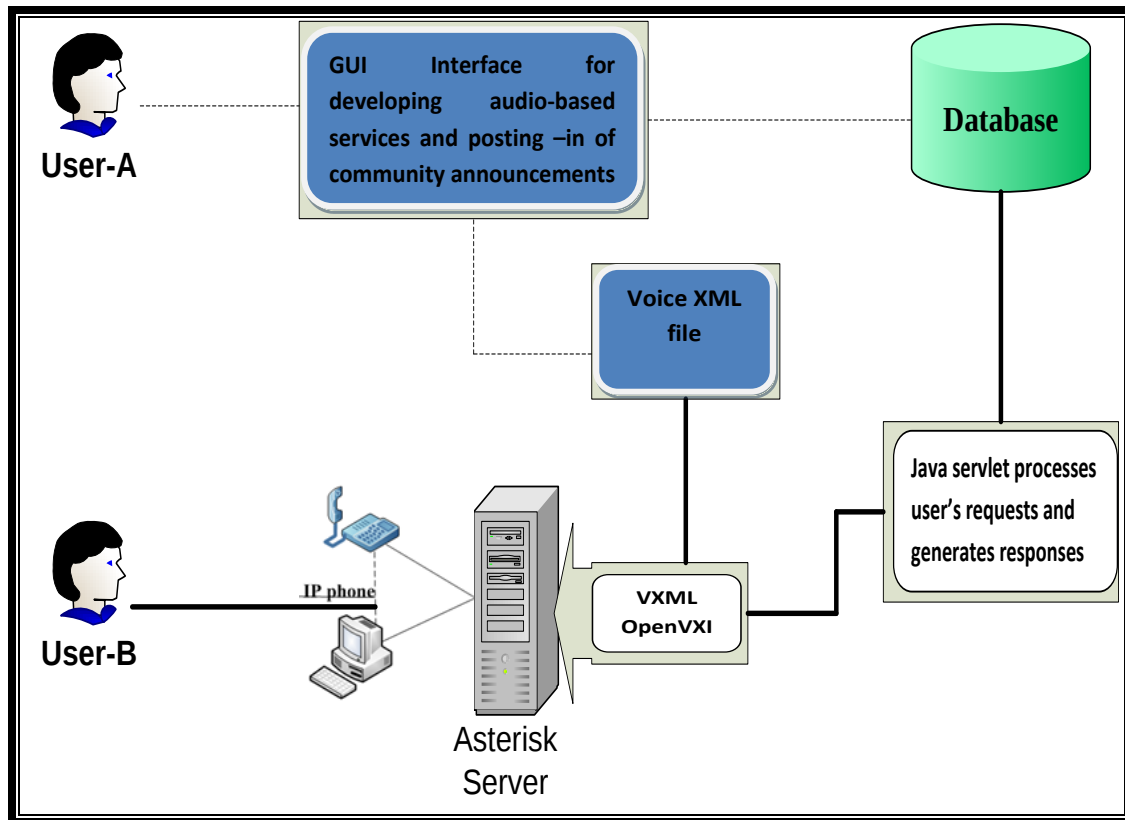


Figure 10: Telephony architecture

The diagram in [Figure 10](#) shows *User-A* developing audio-based services while *User-B* accesses the audio-based services via the IP (hard or soft) phones.

4.2 System Design and Functionality

4.2.1 System Functional Requirements

The Use Case diagram shown in [Figure 11](#) depicts the system functional requirements from the administrator's and user's perspectives. The end-users can construct their audio-based services, post-in community announcements, manage their accounts and access the audio-based services and posted announcements via telephony. The administrator on the hand manages (i.e., *view*, *update* or *delete*) the posted announcements and administers the user's accounts.

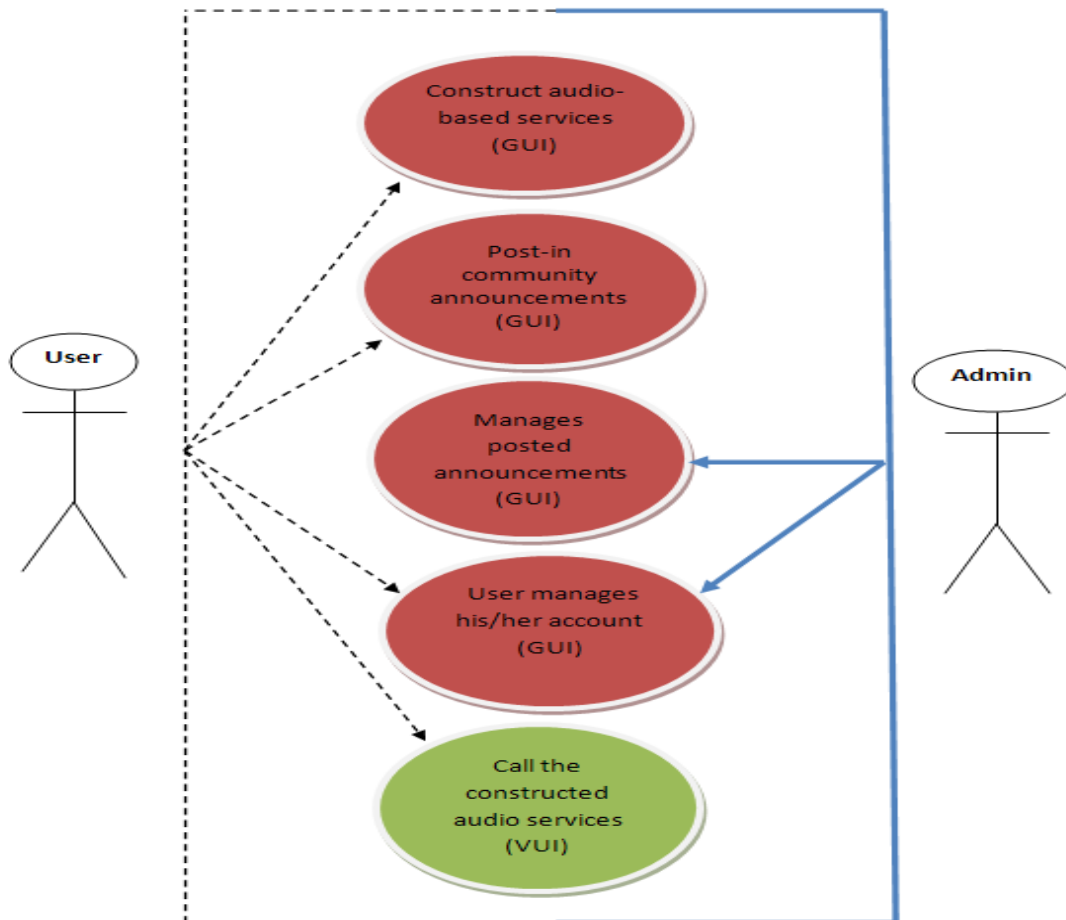


Figure 11: Use Case scenario

4.2.2 System Non-Functional Requirements

The following system development factors were considered throughout the design and implementation of the user-driven telephony framework.

- **Friendly GUI** – The system will be localized into isi-Xhosa which is the language of our targeted users. This aims to engage the illiterate user with the utilizing of system. Some of the English words can not be directly translated into isi-Xhosa hence some screenshots of our GUI framework have English words in them.
- **Secure system** – This is an important consideration in any system. This component includes confidentiality, integrity and availability.
- **Open Source** – The design and implementation of the user-driven telephony framework using free and open source software technologies will later enable further developments on our system. Given our targeted users, the system should be low cost or free so as to ensure affordability and to attain high system utilization.

4.3 Database Design

The MySQL database is utilized as the back-end storage of the Dwesa user-driven telephony framework. Sheldon *et al* (2001) indicate that, the front-end system enables the accessibility of the back-end services and allows users to interact with applications from the front-end sending requests to be processed at the back-end. Our database is called *telephony_db* which has three tables indicated in [Figure 12](#)

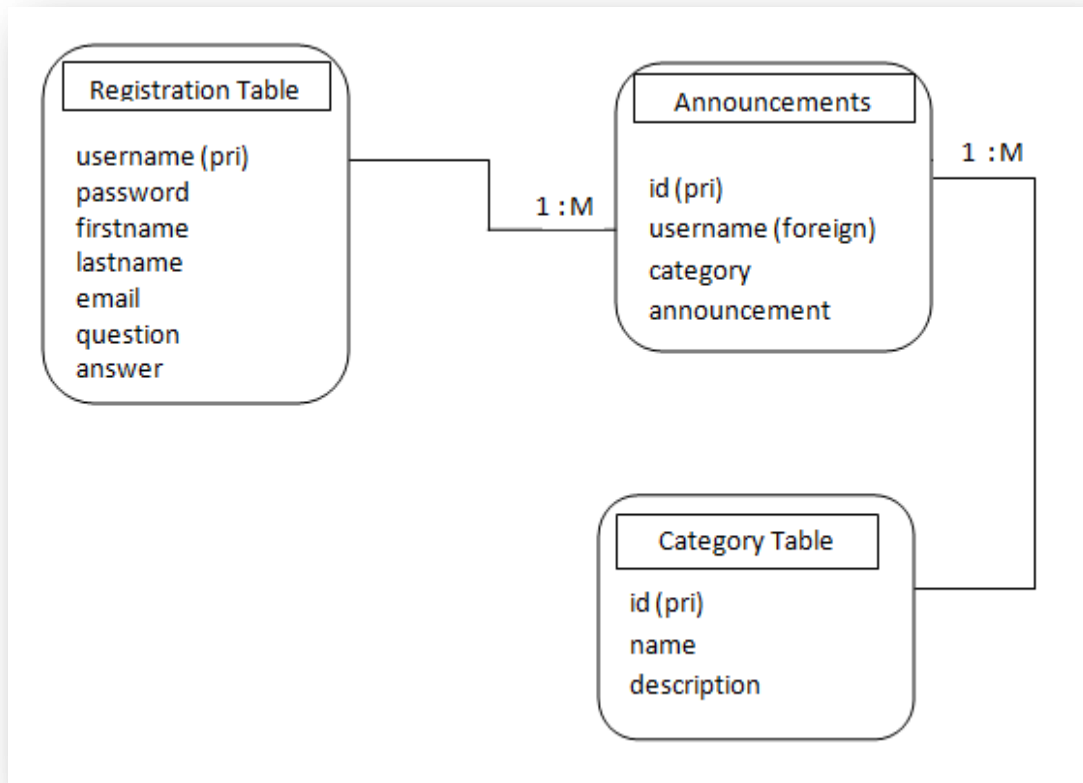


Figure 12: Database tables

The diagram in [Figure 12](#) shows the relationship that exists amongst the *telephony_db* database tables. This diagram shows that one registered user can post many community announcements hence the relationship is one-to-many between the *Registration* table and the *Announcement* table. Username is the primary key in the *Registration* table and a foreign key in the *Announcement* table. The *Category* table stores announcements based on their categories, this means that, one category can have many announcements hence the relationship is one-to-many between the *Category* table and the *Announcements* table.

4.3.1 Registration Table

This table was designed to capture the personal details of the users who were registered to use the system. [Figure 13](#) shows the structure of the *Registration* table. The registration process is invoked by clicking the *Bhalisa* (register) button in **Error! Reference source not found.**[Figure 19](#) and allows the users to fill-in their required personal details. The user's details are stored into the *Registration* table and the registration is successful if all the required fields are filled. The form for registration is shown in [Figure 17](#).

Field	Type	Null	Key	Default	Extra
username	text	NO	PRI	NULL	
password	text	NO		NULL	
firstname	text	NO		NULL	
lastname	text	NO		NULL	
email	text	NO		NULL	
question	longtext	NO		NULL	
answer	longtext	NO		NULL	

Figure 13: Registration Table

4.3.2 Announcement Table

The system also allows users to share important information such as community announcements with each other. Users post the announcements into the database and capture them into the *Announcement* table. The design of this table is shown in [Figure 14](#).

Field	Type	Null	Key	Default	Extra
id	int(11)	NO	PRI	NULL	auto_increment
username	text	NO		NULL	
category	int(11)	NO		NULL	
announcement	longtext	NO		NULL	

Figure 14: Announcement Table

4.3.3 Category Table

This table captures different types of community announcements based on their categories. [Figure 15](#) shows the design of this table.

Field	Type	Null	Key	Default	Extra
id	int(11)	NO	PRI	NULL	auto_increment
name	varchar(30)	NO		NULL	
description	varchar(100)	YES		NULL	

Figure 15: Category Table

4.3.4 Database Connection

Java DataBase Connectivity (JDBC) is used to enable java applications to manipulate data that is stored into the *telephony_db* database. [Figure 16](#) shows how the connection is established with the *telephony_db*. The JDBC DriverManager class defines objects that can connect to the Java applications to JDBC driver (Foster, 2002). Prior to connecting

to the database, the DriverManager defines three parameters which are url, username and the database password.

```
String us = "root";  
String pa = "pass";  
String url = "jdbc:mysql://localhost:3306/telephony";  
Class.forName ("com.mysql.jdbc.Driver");  
conn = (Connection) DriverManager.getConnection (url, us, pa);
```

Figure 16: Database connection

4.4 GUI Telephony Framework

One of the objectives in developing the user-driven framework was to design it in such a way that it is intuitive and localized into isi-Xhosa which is the home language of the Dwesa community. This was done to overcome the challenge of illiteracy as a number of Dwesa community members are illiterate or semi-literate. This effort was essentially to attain a high level of system usability and a good understanding of the system functionality.

- **Registration** – Unregistered users should provide their personal information to be registered before logging onto system. [Figure 17](#) shows the registration form.

Nceda ufake inkcukacha zakho ngokupheleleyo kuzo zonke iibhokisi ezingezantsi wandule ngokucofa. iqhosha elingu-Gqibile. Ukuvala le form chofa u-Vala

<i>username*:</i>	dkunjuzwa
<i>password*:</i>	••••••••
<i>firstname:</i>	Dumisani
<i>lastname:</i>	Sehole
<i>e-mail:</i>	sehole@gmail.com
<i>Question*:</i>	your favorite colour ▼
<i>Answer*:</i>	red

Umva Ngenisa Vala

Figure 17: Registration Form

The registration is complete and successful when the user has completed all the required details. New users are required to register with a different username and password which means that new users are not allowed to register with username and password that already exists in the database. Once the new user has completed the registration process, he/she will have full access to the services that are provided by the system.

The piece of code shown in [Figure 18](#) **Error! Reference source not found.** outlines how the user's data is retrieved from the GUI registration form and inserted into the *telephony_db* database.

```

String igama = fname.getText();
String ifani = lname.getText();
String usern = user.getText();
char[] passn = pass.getPassword();
String mail = email.getText();
String ques = (String)box.getSelectedItem();
System.out.println(ques);
String answ = answer.getText();

String str = "INSERT INTO registration VALUES ('+usern+', '"+passn+', ' +
    " '"+igama+', '"+ifani+', '"+mail+', '"+ques+', '"+answ+')";

```

Figure 18: Register

- **Login** – The user has to type his/her authentication credentials into the *username* and *password* textfields and click the *Ngenisa* (submit) button as shown in [Figure 19](#)**Error! Reference source not found.** The user's credentials are verified and validated by the Java *login* application for the existence of the user in the database and for security purposes. Only registered users can login into the system.



Figure 19: Login form

This GUI also has the *Bhalisa* (register) button for registration and *Password* button for password retrieval.

Figure 20 shows a *JOptionPane.showMessageDialog* pop-up message which is triggered by the incorrect *username* or *password* combination when the user tries to login. This message asks the user, in isi-Xhosa provide the correct login credentials.

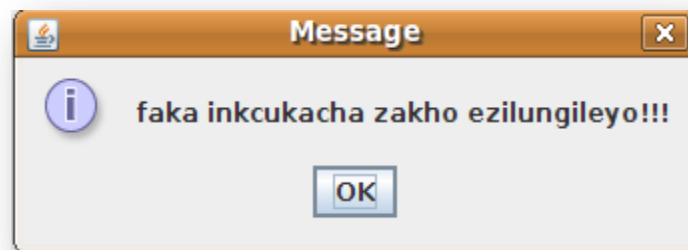


Figure 20: Error message

The system gives the user three attempts to provide the correct credentials to login. When these three attempts are exhausted, the system assumes that the user has forgotten his/her password and ask the user to click the *password* button for password retrieval.

- **After login** - The top part of our GUI telephony framework, shown in [Figure 21](#) indicates the various options available once user has successfully logged-in.

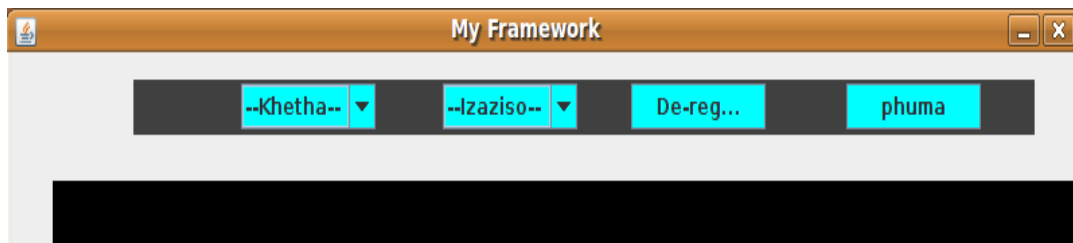


Figure 21: User's GUI options

- The *Khetha* (select) *dropdown* option allows users to construct audio-based services that can be shared and accessed by other users via the telephony. [Figure 22](#) shows a GUI of an audio service that has three Dual-Tone Multi-Frequency (DTMF) options together with the welcoming message option.

When the user is done providing the welcome message and audio options, the user should click the *Ngenisa* (submit) button, a VoiceXML file will be generated and mapped into the Asterisk extension configuration file.

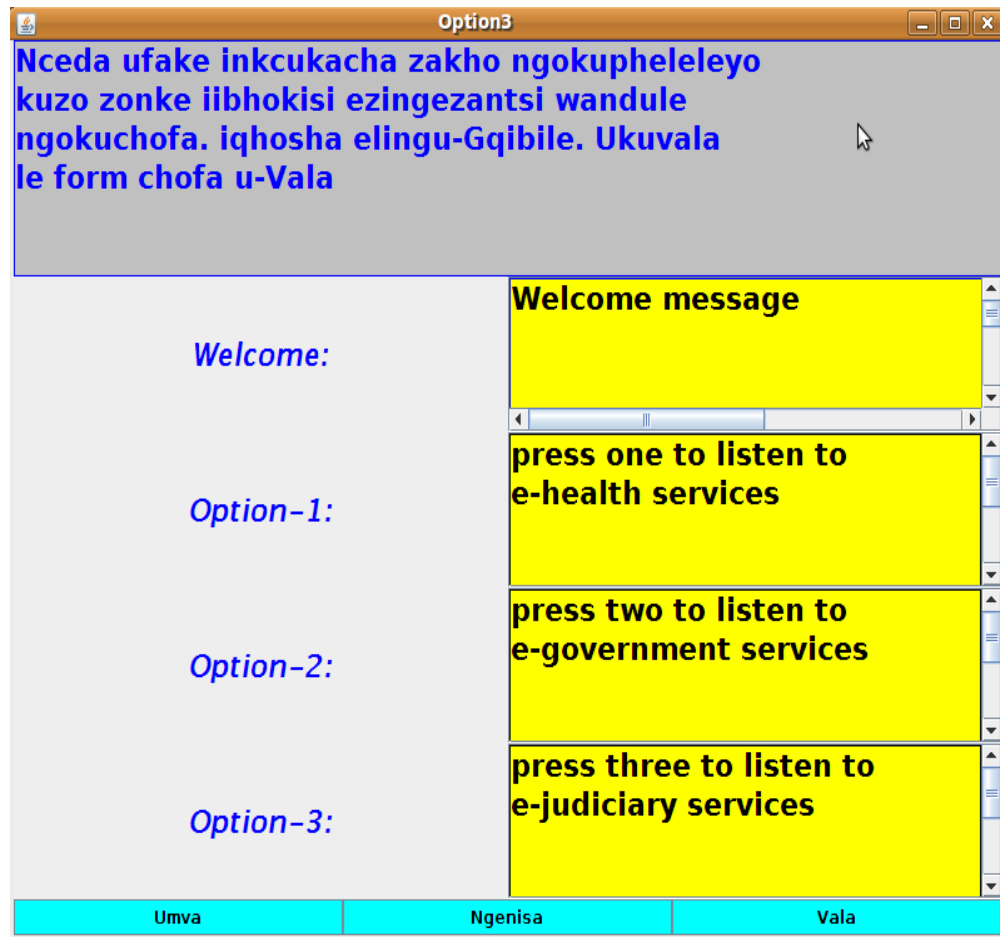


Figure 22: IVR construction

The construction of the VoiceXML file is achieved by a Java application which retrieves the user's input from GUI. The result of the user's input is shown clear in [Figure 23](#). The rest of this file (*output.vxml*) is defined in Appendix F of this document.

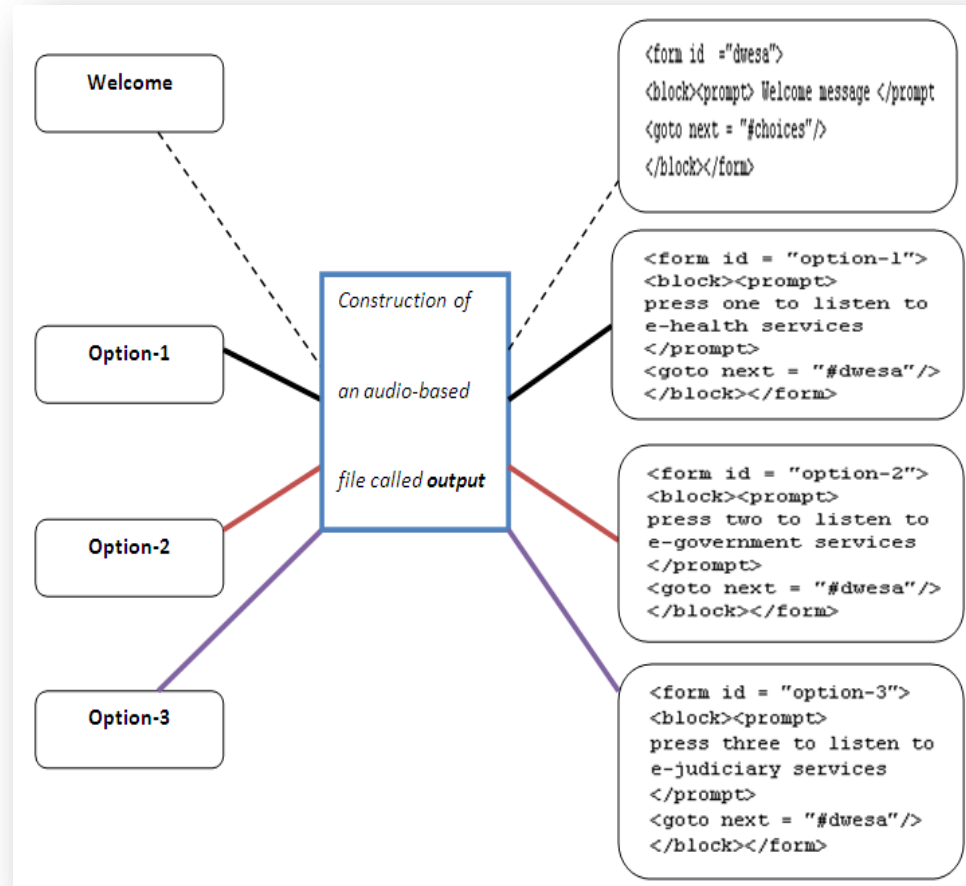


Figure 23: Constructing VXML file

- ISAZISO (announcement)** – Unlike the IVR dropdown menu, this option allows users to post important community announcements for information sharing within the Dwesa community. These announcements are stored and captured in the *Announcement* table of the database (*telephony_db*) as indicated earlier. [Figure 24](#): Posting announcements shows a GUI that allows registered users to post-in their announcements. The GUI has three buttons *Ngenisa* (submit), *Umva* (back) and *Vala* (close).

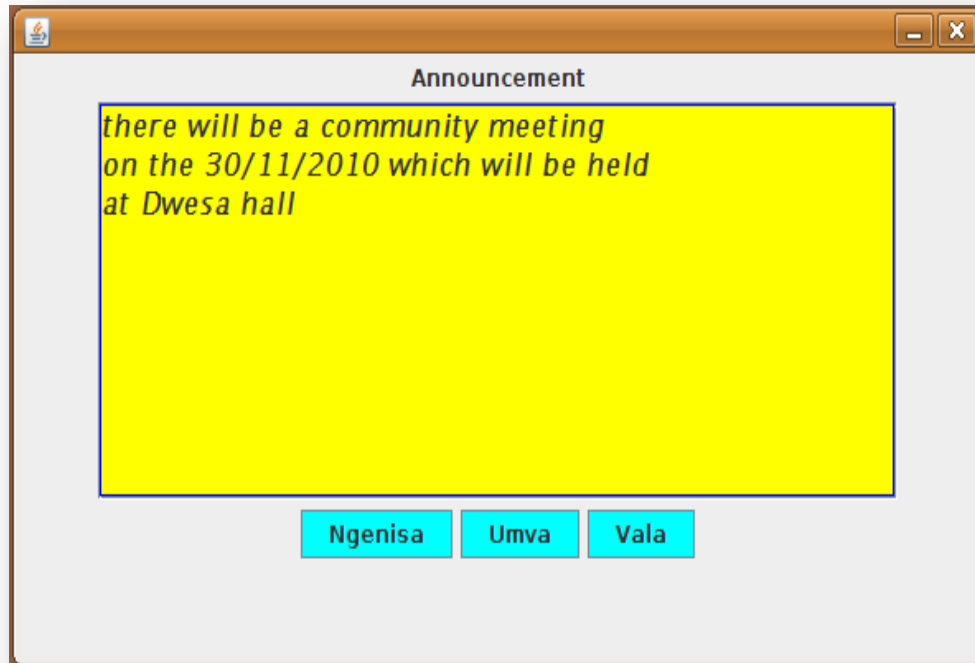


Figure 24: Posting announcements

- **De-register** –This button allows registered users to deregister themselves from the system. When this button is clicked, the GUI [Figure 25](#) pops-up and requires the user to provide his/her security answer to his/her security question to continue with the deregistration process. In this case, the user *dkunjuzwa* has to enter his security answer or click the *Umva* (back) button to go back to the main menu. As indicated in [Figure 11](#), the administrator also administers the user's accounts.

Wamkelekile eKhaya	
Wamkelekile kwi-User-Driven telephony Service yase Dwesa. Nceda ufake i-security answer yakho ukuba ufuna ukucima i-account yakho uze ucofe iqhosha elingu-Delete wakugqiba	
<i>username:</i>	<i>dkunjuzwa</i>
<i>s_question:</i>	<i>name of your pet</i>
<i>s_answer:</i>	
Delete	Umva

Figure 25: Deregistration

- **Phuma** – This button allows the logged-in user to simply logout and goes back to the home GUI (home page) as shown in [Figure 21](#).
- **Administrator** – [Figure 26](#) **Error! Reference source not found.** shows that the administrator manages the posted community announcements. The administrator can view, delete, or update the posted community announcements.

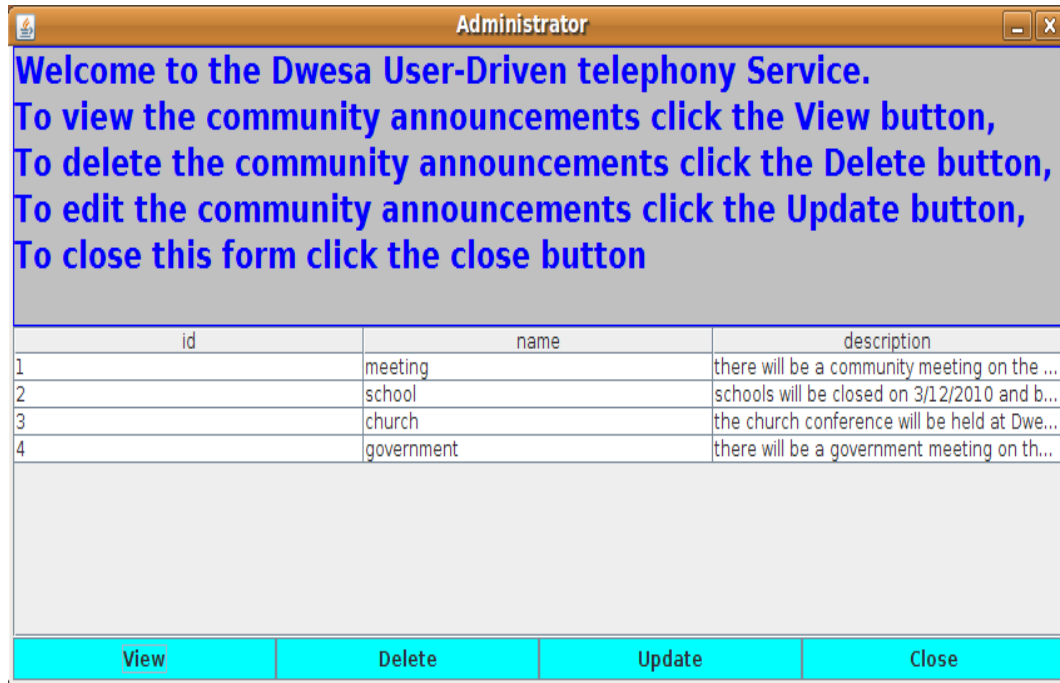


Figure 26: Announcement management

The diagram in [Figure 26](#) shows that the administrator has clicked the *View* button to see all the posted community announcements from the announcement table.

4.5 Voice-based User Interface

This Section presents how *User-B* from the *Telephony architecture* diagram in [Figure 10](#) accesses the posted community announcements and the constructed audio-based services.

- a) **Design - Error! Reference source not found.** clearly depicts the navigation design of a phone call when it is initiated by the caller to the audio-based system. The main menu welcomes the call and defines the menu options for the caller by using voice prompts. The caller is expected to respond to the voice prompts using key-pad inputs associated to the respective voice prompt.

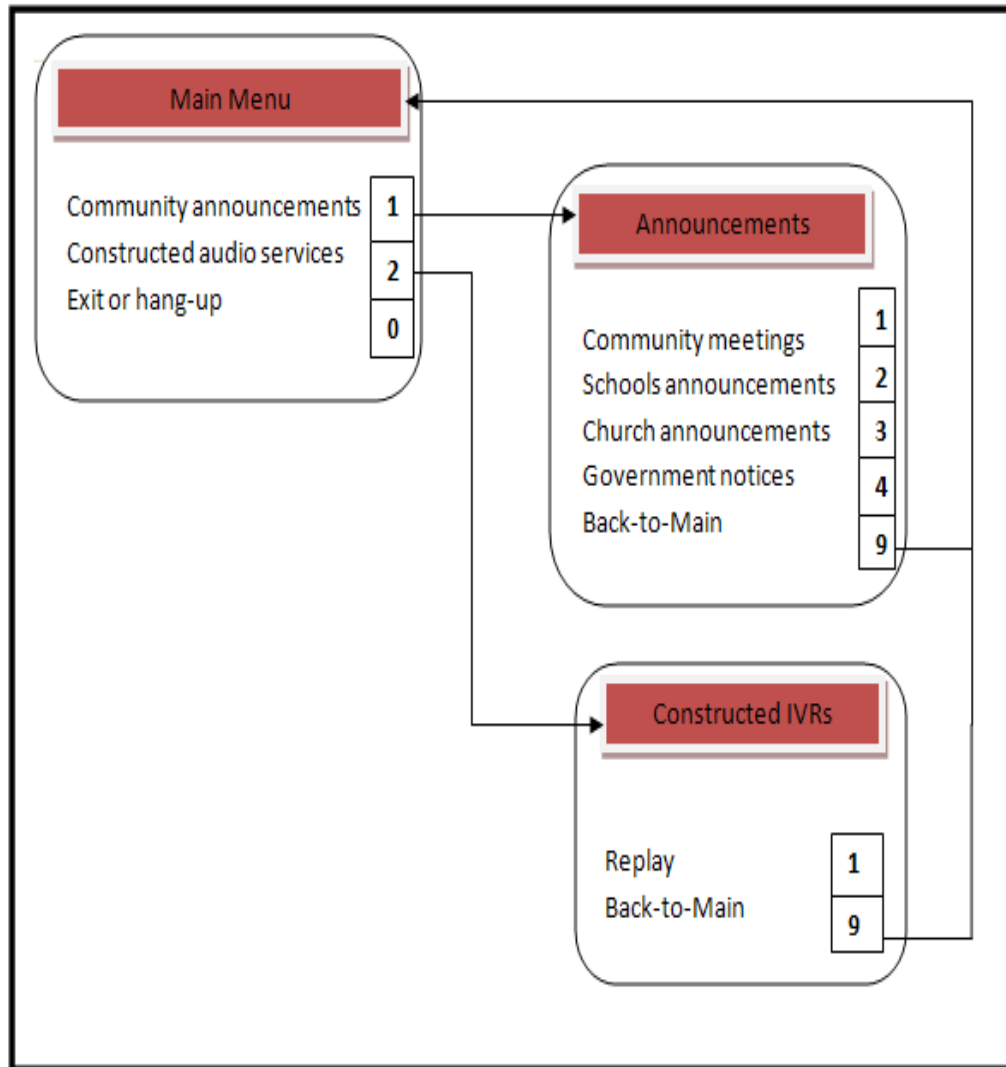


Figure 27: Voice menu

- b) **Implementation** - The piece of code in [Figure 28](#) shows how developers have implemented the VUI. The code defines the DTMF input options for the caller.

```

private String doDefault() {
    String result = "<?xml version='1.0'?">"+
        "<vxml version = '2.0' xmlns='http://www.w3.org/2001/vxml'">"+
        "<menu dtmf='true'">"+
        "<prompt> welcome to the Dwesa telephony framework. Please      "+
        "<enumerate>press <value expr='_dtmf' />, to <value expr='_prompt' /></enumerate>"+
        "</prompt><choice dtmf='1' next='http://localhost:8080/?func=category'"> +
        "listen to community announcement categories </choice>"+
        "<choice dtmf='2' next='http://localhost:8080/'" > +
        "listen to a constructed audio-based services </choice>"+
        "<choice dtmf='0' next='#doexit'">exit the platform </choice></menu>"+
        "<form id = 'doexit'"><block>Good bye</block></form></vxml>";

    return result;
}

```

Figure 28: Welcome menu

In contrast to the graphic user interface, the voice user interface is a system that enables one to interact with it by using touch-tone or spoken language applications (Cohen *et al*, 2003). According to Cohen *et al* (2003), there are many small and large organizations which have deployed the VUI. He observed the benefits of the VUI which include:

- Saving money
- Increasing customer satisfaction
- Ease of use

4.6 Summary

The design of the audio-based telephony framework from both side of GUI and VUI applications were presented in this Chapter. The Chapter also presented some of the Java

applications to show how the design and implementation of an intuitive and localized user-driven framework was developed.

5 Chapter Five: Evaluation and Results

In Section 5.1, delivers the results of the system evaluations based on the questionnaires and testing that was performed. Section 5.2 presents the general observations on how the teachers and learners utilize the ICTs facilities which are provided by Siyakhula Living Lab. A summary of this Chapter is presented in Section 5.3.

5.1 System Evaluation

At the end of the developed prototype system, a system evaluation was performed. This has helped the developers to identify the challenges and difficulties that users experienced when using the system. The developers were able to identify the features that find easy to use and enjoy within the system. Before conducting the usability evaluation, a demonstration was conducted to clarify what the system does. After the demonstration, participants were asked to interact with the system to construct their audio-based services. During the evaluation, questions were asked by the users and the developers took note of their questions which included the following:

- *How do I login into the system?*
- *How many announcements can I post-in?*
- *How do I modify my audio-based file?*
- *How do I call and hear my audio services?*

The system evaluation was conducted amongst a total of seven participants. There were five learners (three males and two females) from A.M. Tapa secondary school and two community members (both males) from Middledrift village. This evaluation was carried out on two PC machines and one IP phone (hard phone).

5.1.1 Usability

System usability testing was undertaken to evaluate the effectiveness and the efficiency of our user-driven telephony framework. The Developers tested the system based on a few of the key attributes (i.e., *learnability*, *errors* and *user satisfaction*) of usability testing (Scholtz, 2004).

1. *Learnability*

This attribute has helped the developers observe which features of the system users find easy to learn, memorize, and gain knowledge of teaching others.

The developers evaluated five participants in terms of learnability. [Figure 29](#) shows the results of this evaluation.

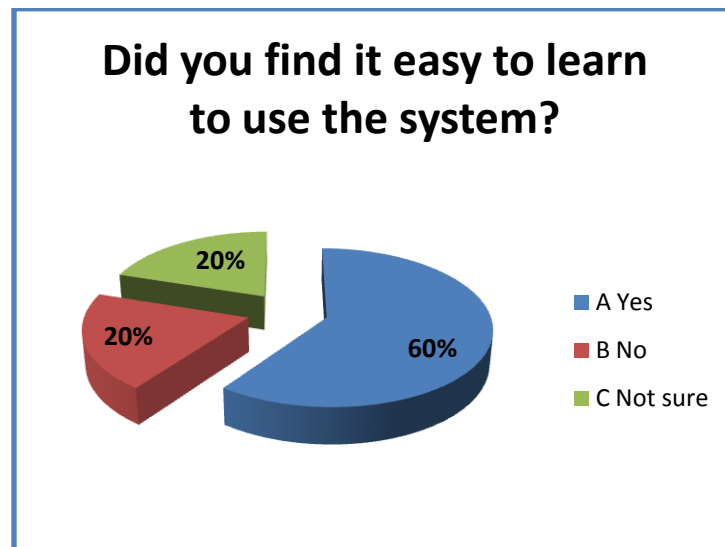


Figure 29: Learnability results

- A. Yes
- B. No
- C. Not sure

The chart in [Figure 30](#) shows that 60% (three) of the participants, which includes the community member, found the user-driven telephony framework system easily to learn to use. Although, on the other hand 20% (one) of those who battled with learning the system found it difficult to use. Finally, 20% (one participant) was not sure.

2. Error

The developers wanted to observe whether the error messages (e.g., incorrect username and password) that were given by the system were clear and understood by the users in order to be corrected.

The evaluation shown in [Figure 30: Error results](#) carried out on six participants.

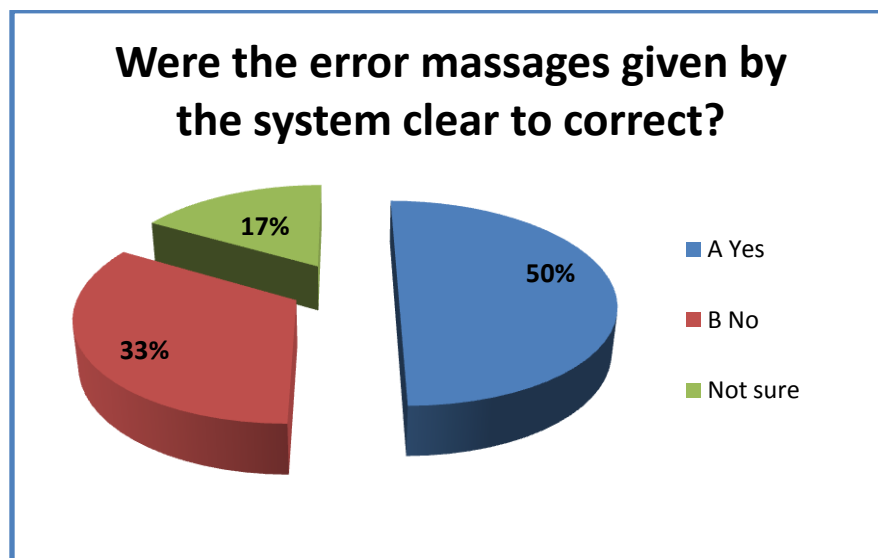


Figure 30: Error results

- A. Yes
- B. No
- C. Not sure

The system was evaluated based on the error messages that were given by the system if they were clear understood by the end-users. The chart in [Figure 31](#) showed that 50% of the group (three participants) had no difficulties in correcting their mistakes as the system gave clear instructions on how to fix them. 33% (two participants) battled with fixing the errors which were given by the system, while 17% (one participant) was not sure.

3. User satisfaction

The developers evaluated the user's feelings and wanted the user to share his opinion based on his experience.

There were five participants for this evaluation.

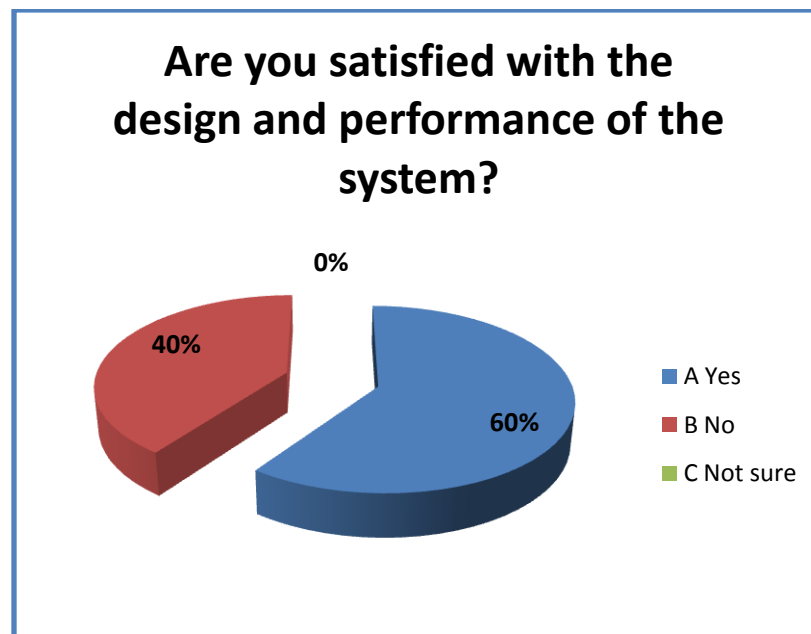


Figure 31: User satisfaction results

- A. Yes
- B. No
- C. Not sure

At the end of almost every system development, the developers need to evaluate and know whether the targeted system users can accept the system. The chart in [Figure 32](#) indicates that 60% (three participants) of the system users showed satisfaction and 40% (two participants) was not satisfied, while none felt that they were not sure.

The results of seven participants are shown in [Figure 32](#)

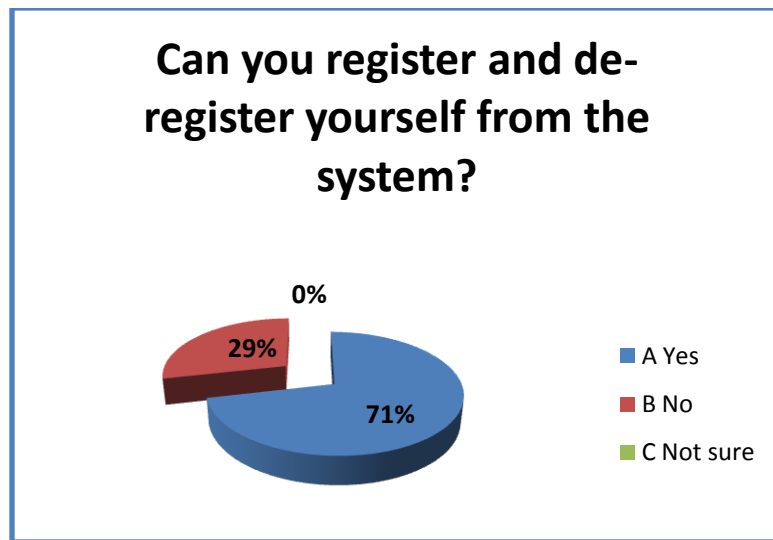


Figure 32: Registration and De-registration results

- A. Yes
- B. No
- C. Not sure

[Figure 32](#) shows that 71% (five participants) of those who participated were confident that the system is fit to be deployed and works just fine. On the

other hand 29% (two participants) of the group battled to use some of the features provided by the system and felt that the system still needs further improvement and none were not sure.

This evaluation was conducted on seven participants.

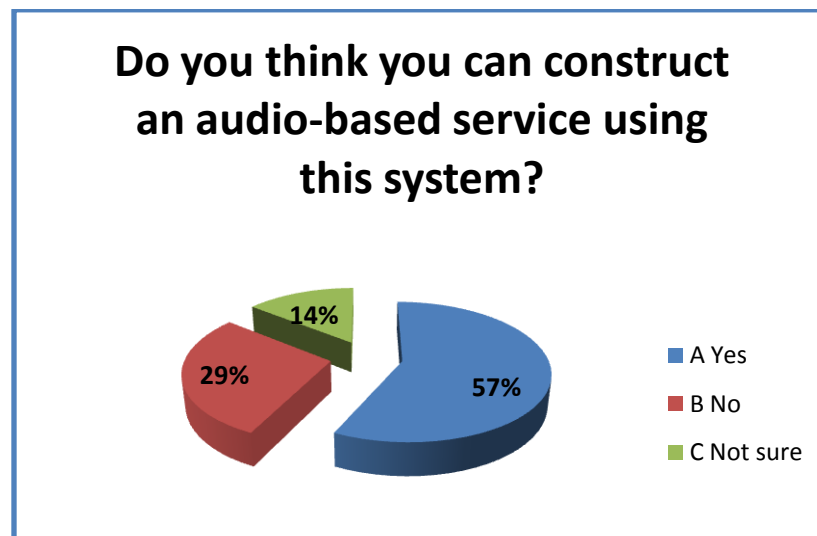


Figure 33: Audio-based construction results

- A. Yes
- B. No
- C. Not sure

This was a very important question we needed an answer for. The chart in Figure 33 indicated that 57% (four participants) of those who participated were able to construct their customized audio-based services. 29% (two participants) on the other hand could not and found it difficult to construct audio-based services. 14% (one participant) were not sure.

This evaluation was conducted amongst five participants.

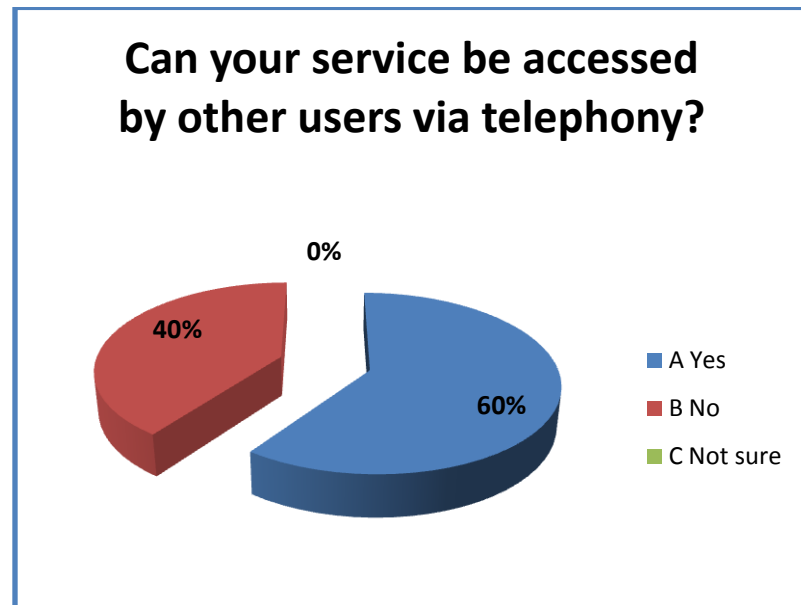


Figure 34: Accessibility results

- A. Yes
- B. No
- C. Not sure

The chart in [Figure 34](#) indicates that 60% (three participants) of the system users had no problem with accessing their services whilst 40% (two participants) argued that their services were not accessible and no-one was not sure.

5.2 General Observations

The engagement of the Dwesa community in terms of their utilization of the ICTs brought by the Siyakhula Living Lab project was observed.

5.2.1 Teachers

Teachers make significant use of the ICT services offered by the SLL project. They do not continuously depend solely on the knowledge that they acquire through their educational training, but they also use the Internet to extend their knowledge (Kavhai, 2010). Kavhai (2010) further noted that, most teachers believe that they are now competent in the use of technology and can do anything with computers and the Internet.

Kavhai (2010) stated that in 2009 some teachers had enrolled for a professional course that Rhodes University administers through its Department of Education. Instead of just acquiring computer literacy skills for personal use, they have also acquired professional skills which were officially accredited by Rhodes University upon completion.

5.2.2 Learners

The Internet provided by the SLL in local schools has managed to bridge the absence of libraries at Dwesa. The end of the year results at Ngwane School have been improved and are bound to increase pass rates as learners have a lot of information to use for their studies and in answering examination questions (Kavhai, 2009). Kavhai (2009) noted that many learners spend a number of hours on the internet reading and searching with the use of search engines such as Google and Yahoo. Throughout the computer literacy training program, learners have gained extensive computer skills.

Kavhai (2009) noted that, from the community point of view, education for the learners is an important component as they hope to develop and improve the standard of living in their community. Kavhai (2010) stated that contemporary learners have a better chance of progressing into tertiary education better equipped and to eventually attain employment.

In Chapter One, it was indicated that it is important to address the functionality of ICT developments so that the people's fear is removed. In other words, it still remains a mystery to many what they can do with ICTs and how relevant ICTs are to their

livelihood (Kavhai, 2010). It is therefore important that the services brought by ICTs for rural development are relevant to the community's culture, language and belief.

5.3 Summary

The research objectives of the study were presented and address in this Chapter. The results attained, based on the system evaluation were also presented. General observations on how the ICTD impacts within the Dwesa community were also presented in this Chapter. The ICTs made available and accessible by the Siyakhula Living Lab indicate a positive trend with regard to the use of ICTs at Dwesa, whilst slowly improving the lives of the Dwesa community.

6 Chapter Six: Conclusion

This Chapter concludes the research project. A summary of the research is presented in Section 6.1. Challenges and constraints encountered during the system development are presented in Section 6.2. In Section 6.3, the Chapter presents what has been learnt and discovered throughout the research project. Successes and limitations are also presented in Sections 6.4 and 6.5 respectively. The Chapter concludes by presenting future extensions of this system and summarizing the research project.

6.1 Research Summary

This Section re-caps the main aim and objectives of the research project. This Section continues to show clear how each objective was attained. The research questions highlighted in Chapter One are also answered based on the research findings of this study.

- **Objective One:** *The project aimed to design and develop a simple, intuitive and localized user-driven GUI framework.*

As shown in some of the screenshots in Chapter Four, the GUI is localized in isi-Xhosa which is the language Dwesa community.

- **Objective Two:** *The system targeted the improvement the level of literacy within the Dwesa community by empowering users with skills development to construct their customized audio-based services.*

A significant role played by the Siyakhula Living Lab project in Dwesa is the provision of the computer literacy training program. During the lab testing, users were initially trained on how to use the system prior to developing their own audio-based services.

- **Objective Three:** *The system should provide options of available telephony services.*

This was achieved, and depicted in Chapter Four under, the Voice User Interface (VUI) section. The VUI handles the incoming calls and defines the system menu options which the caller/user can choose from.

The findings show that marginalized and rural communities can be reached remotely via the audio-based systems and that there exists a need for further research and investigation in this field.

6.2 Challenges and Constraints

There were a number of different constraints and challenges encountered by the developers during the development of this research project.

- The targeted users were illiterate and had no idea of the audio-based services. This was challenging as some of them believed that this system would not make any difference in their lives.
- The developers did not deploy the system, due to time constraints, but they performed a system walk-through in lab testing to simulate the real world environment. The results of system evaluation are presented in the previous Chapter.
- One of the objectives of the study was to localize the interface. This means that the developers had to translate English words into isi-Xhosa in order to achieve the intuitive and localized interface. Some of the words in the English language can not be directly translated into the isi-Xhosa language.

- During the system evaluation, other users poorly illiterate as in some cases they were unable to perform simple tasks such as registration. This required extensive explanation and demonstration of the process.

6.3 Lesson Learnt and Discoveries

This section presents the research discoveries from the social and the technical perspectives of the system development.

Based on the results presented in Chapter Five, the user's feedback clearly indicates to the system developers that in order to attain a high level of system usage in terms users interacting with the system, They should improve some the functionalities or features that users find difficult to use and also make use colours or shapes to represent features of the system as the targeted users are low-literate. This means a new or different approach of the system design is required to improve the user's feedback.

From the technical perspective, system developers have discovered that the engagement of system users and the social environment are important for the understanding of system development. The system developers discovered that the prototyping approach to system development is helpful for the collection of system requirements. This advanced the system being developed so that it is able to adapt to the new requirements.

From the social perspective, the developers designed and developed the system with the understanding of how the targeted users could make use of such a system in their social environment. The developers discovered that, in order to attain a high level of system usage in the social environment, the targeted users need continuous and constant computer literacy training.

6.4 Successes

From the design and implementation perspectives, the system meets and satisfies the research objectives highlighted in Chapter One. Chapter Four of this document presents the implementation of the system which indicates that the system is flexible enough for the Dwesa community to be able to develop customized audio-based services. The framework provides features which include the following:

- Constructions of audio-based services by end-users
- Posting-in of community announcements
- Accessing audio-based services via telephony

6.5 Limitations

OpenVXI did not have an Auto Speech Recognition (ASR) module loaded. This means that the system users were limited to use only Dual-Tone Multi-Frequency (DTMF) input when we interacted with the system.

The system overrides the constructed audio-based services. This means that, the user was required to construct his/her service and save it with the different name to that of the system as it gave one name to all constructed services. Therefore, the future version of this system should auto generate and store the already constructed audio-based services with different names.

Lastly, Flite and Festival text-to-speech engines are limited to only presenting English text to English voice. This means that the system could not provide the voice services in isi-Xhosa, which is the language of the targeted users.

6.6 Future Recommendations

There are several possible future extensions which can advance this research project. The starting point is to overcome the limitations already highlighted which point to the direction of future extensions.

This research project aimed to develop a user-driven telephony framework to enable the Dwesa community to develop their own audio-based services. This telephony audio-based framework provides the basic Interactive Voice Response (IVR) functionalities hence the future version of this framework should provide complete services.

As part of the bigger on-going research project conducted in Dwesa, the e-services provided by the Siyakhula Living Lab should be accessible via telephony.

6.7 Discussion and Summary

This dissertation has presented the design and development of the user-driven telephony framework and the implementation of the system prototype. The system was developed in an open source environment using technologies which included the Asterisk and LAMP packages. The open source environment allows for future extensions and easy developments.

This research project aimed to empower the Dwesa community by enabling the construction their customized audio-based services in support of information sharing.

Audio-based information services hold tremendous potential for information access in rural development. Basic Interactive Voice Response (IVR) systems or intelligent systems using speech recognition and speech synthesis are ideal platforms for delivering information to low literate and semi-literate end-users (Naidoo *et al*, 2005). Naidoo *et al* (2005) suggested that, it is important to challenge the design of the telephony interfaces for low literate and illiterate end-users.

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Appendix A

System installation and setup

The user-driven telephony framework required the installation of software technologies which included the following:

- Asterisk with OpenVXI interpreter for Voice XML

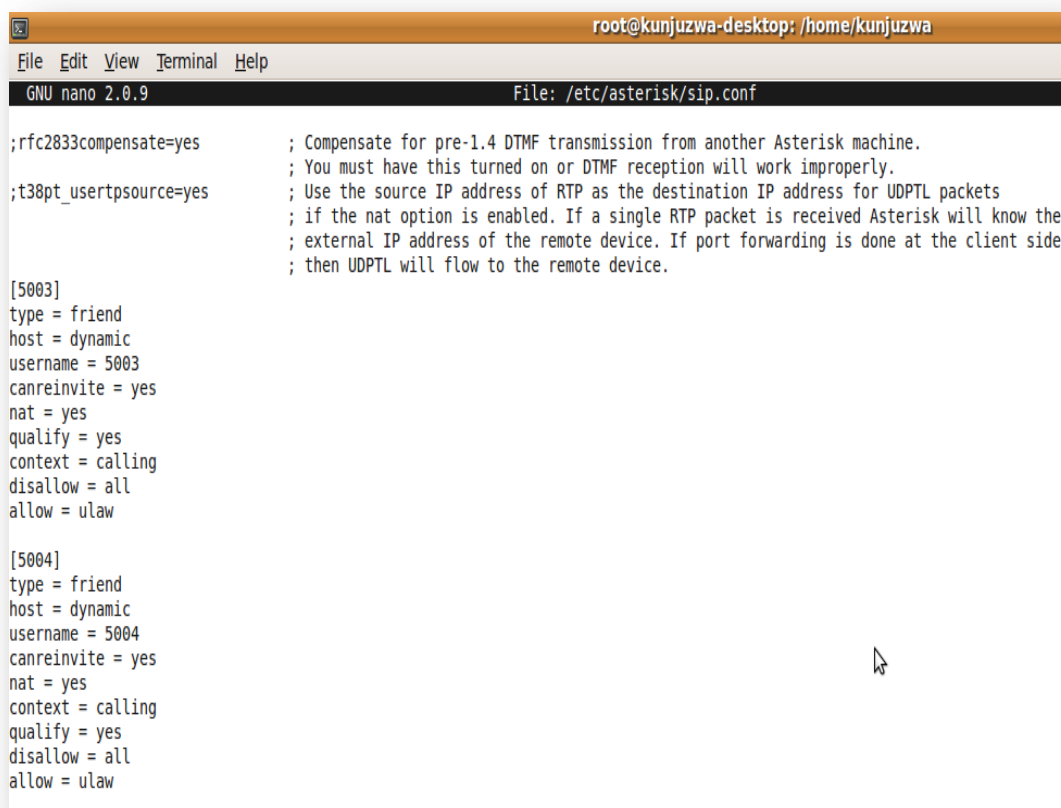
```
*CLI> help vxml
      vxml debug  Enable VoiceXML application debugging
      vxml no debug  Disable VoiceXML application debugging
      vxml reload  Reload VoiceXML interpreter configuration
      vxml show accounts  Show the accounts configured
      vxml show account  Show an account configured
      vxml show applications  Show and check the dependencies applications
      vxml show configuration  Show the configuration of VoiceXML interpreter
      vxml show dates  Show dates of VoiceXML interpreter
      vxml show license  Show license of VoiceXML interpreter
      vxml show sessions  Show the sessions of VoiceXML interpreter
      vxml show session  Show the session of VoiceXML interpreter
      vxml show statistics  Show statistics of VoiceXML interpreter
      vxml show top  Show top of VoiceXML interpreter
```

- Java 6 and Netbeans 6.8 IDE
- MySQL database
- Festival and Flite text-to-speech
- LAMP package

Appendix B

Asterisk sip configuration file.

This file allows the developers to define the IP phone (s) into the Asterisk system. After defining the IP phone, the developer needs to save this file and restart Asterisk then the phone becomes registered in the Asterisk PBX system.

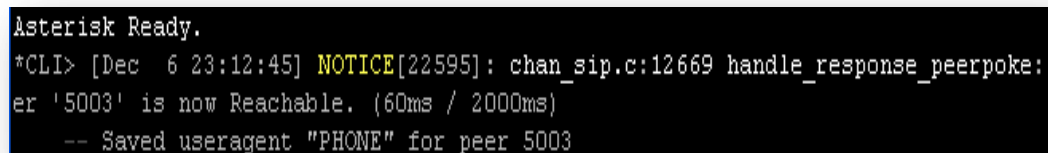


```
root@kunjuzwa-desktop: /home/kunjuzwa
File Edit View Terminal Help
GNU nano 2.0.9 File: /etc/asterisk/sip.conf

;rfc2833compensate=yes      ; Compensate for pre-1.4 DTMF transmission from another Asterisk machine.
                             ; You must have this turned on or DTMF reception will work improperly.
;t38pt_usertpsource=yes     ; Use the source IP address of RTP as the destination IP address for UDPTL packets
                             ; if the nat option is enabled. If a single RTP packet is received Asterisk will know the
                             ; external IP address of the remote device. If port forwarding is done at the client side
                             ; then UDPTL will flow to the remote device.

[5003]
type = friend
host = dynamic
username = 5003
canreinvite = yes
nat = yes
qualify = yes
context = calling
disallow = all
allow = ulaw

[5004]
type = friend
host = dynamic
username = 5004
canreinvite = yes
nat = yes
context = calling
qualify = yes
disallow = all
allow = ulaw
```

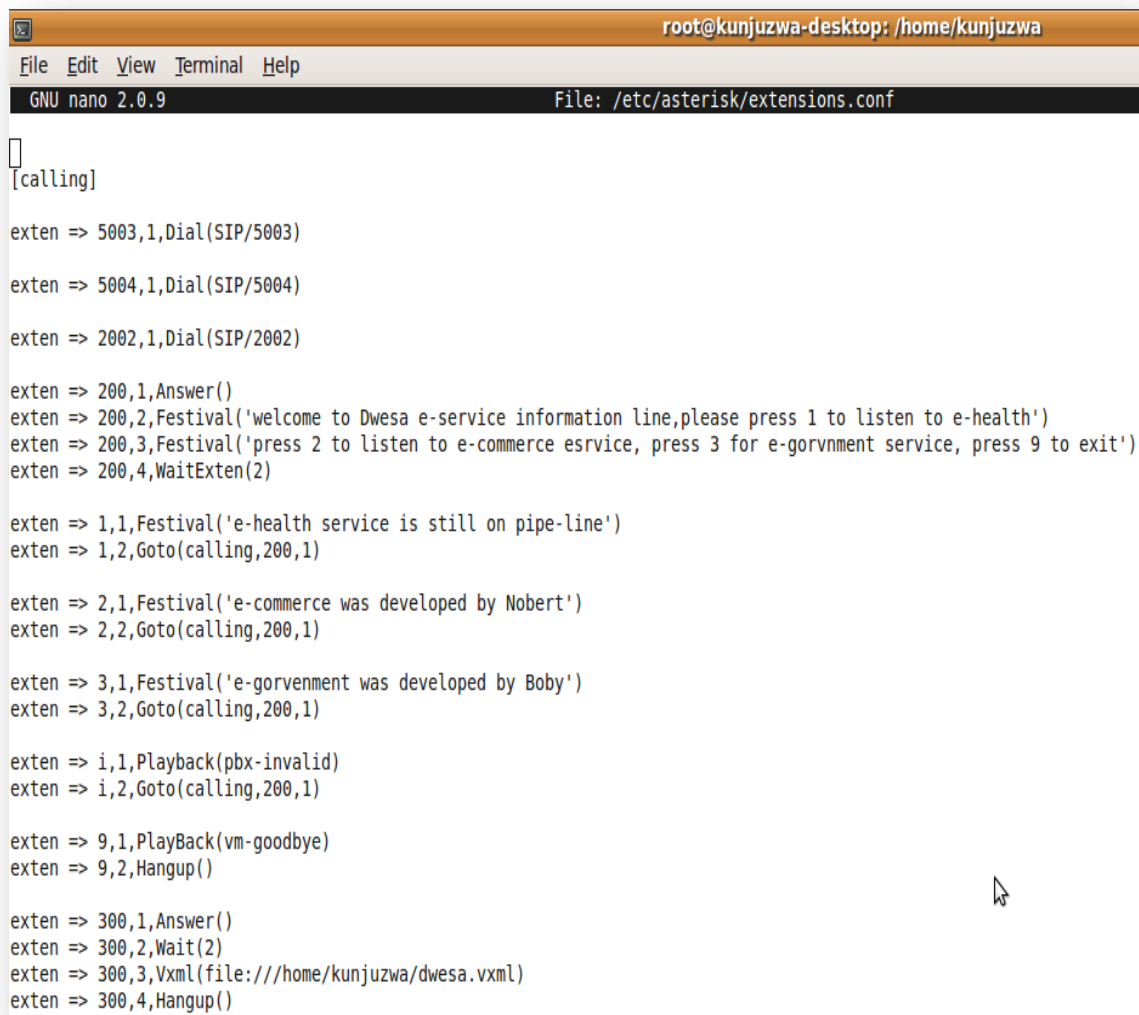


```
Asterisk Ready.
*CLI> [Dec 6 23:12:45] NOTICE[22595]: chan_sip.c:12669 handle_response_peerpoke:
er '5003' is now Reachable. (60ms / 2000ms)
-- Saved useragent "PHONE" for peer 5003
```

Appendix C

Asterisk extension configuration file

This file allows the developer to define the Asterisk dialplan. It controls and executes the flow of incoming and outgoing calls in the Asterisk PBX system



```
root@kunjuzwa-desktop: /home/kunjuzwa
File Edit View Terminal Help
GNU nano 2.0.9 File: /etc/asterisk/extensions.conf

[calling]

exten => 5003,1,Dial(SIP/5003)
exten => 5004,1,Dial(SIP/5004)
exten => 2002,1,Dial(SIP/2002)

exten => 200,1,Answer()
exten => 200,2,Festival('welcome to Dwesa e-service information line,please press 1 to listen to e-health')
exten => 200,3,Festival('press 2 to listen to e-commerce esrvice, press 3 for e-gorvnment service, press 9 to exit')
exten => 200,4,WaitExten(2)

exten => 1,1,Festival('e-health service is still on pipe-line')
exten => 1,2,Goto(calling,200,1)

exten => 2,1,Festival('e-commerce was developed by Nobert')
exten => 2,2,Goto(calling,200,1)

exten => 3,1,Festival('e-gorvenment was developed by Bobby')
exten => 3,2,Goto(calling,200,1)

exten => i,1,Playback(pbx-invalid)
exten => i,2,Goto(calling,200,1)

exten => 9,1,PlayBack(vm-goodbye)
exten => 9,2,Hangup()

exten => 300,1,Answer()
exten => 300,2,Wait(2)
exten => 300,3,Vxml(file:///home/kunjuzwa/dwesa.vxml)
exten => 300,4,Hangup()
```

Appendix D

The graphic user interface below shows the configuration of the IP hard phone. Due to the instability of the network, the developer configured a static IP address: (172.20.56.45) for the phone. The phone was defined and connected to the Asterisk host running on the static IP address :(172.20.56.44).

network settings					
iptype	static ▾	ppp id		ppp pin	
local ip	172.20.56.45	subnet mask	255.255.255.0	router ip	172.20.56.254
dns	172.20.0.1	dns2	172.20.0.2	mac	00-09-45-00-00-00
protocol settings					
protocol	sip ▾	use service	☒		
service type	common ▾	service addr	172.20.56.44	service id	172.20.56.44
nat traversal	disable ▾	nat addr		nat ttl	30
phone number	5003	account	5003	pin	
register port	1720	signal port	1720	control port	1722
register ttl	60	rtp tos	0	rtp port	1722
local type	phonenumber ▾	call type	advanced ▾	dtmf	control string ▾
phone settings					
use dialplan	disable ▾	dial number		ddcode	10
iddcode	86	iddprefix	00	dddprefix	0
innerline	disable ▾	local prefix	0	nonlocal prefix	0
answer	30	ring type	dtmf0 ▾	use digitmap	☐
forward number	82378009	fwd poweroff	☐	fwd noanswer	☐
fwd always	☐	fwd busy	☐	call waiting	☐
audio settings					
audio type	auto ▾	audio frames	2	g.723.1 high rate	☒
vad	☐	agc	☐	aec	☒
handset in	7	handset out	31	speaker out	31
other settings					
password	1234	super password	12345678	debug	disable ▾

Appendix E

```
<?xml version = "1.0"?>
<vxml version = "2.0" xmlns = "http://www.w3.org/2001/vxml">
<property name = "control" value = "yes"/>

<form id = "dwesa">
<block><prompt>
  Welcome message
</prompt>
<goto next = "#choices"/>
</block></form>

<menu id = "choices" dtmf = "true">
<choice dtmf = "1" next = "#option-1"/>
<choice dtmf = "2" next = "#option-2"/>
<choice dtmf = "3" next = "#option-3"/>
</menu>

<form id = "option-1">
<block><prompt>
press one to listen to |
e-health services
</prompt>
<goto next = "#dwesa"/>
</block></form>

<form id = "option-2">
<block><prompt>
press two to listen to
e-government services
</prompt>
<goto next = "#dwesa"/>
</block></form>

<form id = "option-3">
<block><prompt>
press three to listen to
e-judiciary services
</prompt>
<goto next = "#dwesa"/>
</block></form>
</vxml>
```

Appendix F

The code in this appendix shows how the Java application easily interacts with Asterisk via the FastAGI protocol.

```
1 import org.asteriskjava.fastagi.*;
2
3 public class Announcement extends BaseAgiScript{
4
5     public void service(AgiRequest request, AgiChannel channel) throws AgiException{
6
7         // .. answers the call ...
8         channel.answer();
9
10        // ..play the text...
11        channel.exec("Festival",hello whorld);
12
13        // ...and hangup.
14        hangup(channel);
15    }
16 }
17
```