



ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER SCIENCE

**MULTI-LINGUAL MARKET INFORMATION
INTERACTIVE VOICE RESPONSE SYSTEM**

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DEDICATED TO:

My father **Endale Mulugeta Negewo**

&

My mother **Amarech Lambebo Bejigo**

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List of Abbreviations

ECX	Ethiopian Commodity Exchange
IVR	Interactive Voice Response System
TTS	Text to Speech
MM_IVR	Multilingual Market Information Interactive Voice Response System
ODBC	Open Database Connection
DTMF	Dual Tone Multi-Frequency
PHP	Hypertext Preprocessor
XML	Extensible Markup Language
WWW	World Wide Web
W3C	World Wide Web Consortium
IS4A	Information Systems for Agriculture
ICTD	Information and Communication Technologies and Development
FBK	Fondazione Bruno Kessler research center
EMCIT	Ethiopia Ministry of Communication and Information Technology
P2P	Peer to Peer
MIPs	Market Information Points
SMS	Short Messaging Service
PC	Personal Computer
DSP	Digital Signal Processing
PBX	Private Branch Exchange
LAN	Local Area Network
WAN	Wide Area Network
ACD	Automatic Call Distributor
MMP	Multi-channel Message
KACE	Kenya Agricultural Commodity Exchange
MCX	Multi Commodity Exchange of India Limited
ASCE	Abuja Securities and Commodity Exchange
NGO	Non Governmental Organization

Abstract

In this paper, we address the issue of how to design and implement multilingual market information interactive voice response system (MMI-IVR) for the low literacy target groups. Thus, we propose a three tier multilingual market information interactive voice response (IVR) system utilizing text to speech (TTS) technology. It is especially designed to help farmers to obtain the market information they seek in a timely manner and is reliable, scalable and user-friendly operating on a 24 hour by 7 week bases. With MMI-IVR system, farmers can obtain real time market information using just their telephone set or mobile phone via a DTMF (Dual Tone Multi-Frequency). To reduce the complexity of the system, it is decomposed into two sub systems (speech synthesis and voice interface subsystem). From the developer point of view, MMI-IVR system has three major components, user, asterisk server and MMI-IVR application. In this system user interacts by using telephone keypad with the asterisk server and then the asterisk server has dial plan which is used to define how calls flow into and out of the system. When messages are received on this channel to asterisk server, the message is sent to the MMI-IVR application for processing using Asterisk's Application Gateway Interface (AGI). Finally, the MMI-IVR will interact with the user on the channel based on predefined IVR process tree on MMI-IVR application. In this thesis, speech synthesis and multilingual interactive voice response system are designed and implemented. Firstly, unit selection voice has been built on Festival speech synthesis framework using phrase as basic unit. Secondly multilingual IVR system is designed and implemented based on multilingual IVR tree structure. MMI-IVR is developed using PHP programming language and PHPAGI script is used to interface with PBX as software (i.e. Asterisk server). To emulate telephone X-lite soft phone is used as phone interface to communicate with MMI-IVR system. Finally, evaluation of MMI-IVR and speech synthesis is conducted by involving 37 people who are speakers of each language (15 from Amharic, 13 from Afaan-Oromo and 9 from Tigrigna). MMI-IVR systems evaluation results have shown that the system provide good quality speech in terms of naturalness, is easy to navigate and functional in terms of designed menu structure, and it gives customer satisfaction.

Keywords: Speech synthesis, interactive voice response system, Asterisk server, Market information, Dial plan, Asterisk Gateway Interface.

CHAPTER ONE

INTRODUCTION

1.1. Background

In Ethiopia, agriculture is the largest livelihood provider (more than 80% being farmers)[41]. Like other developing countries, farmers and intermediaries have continued to rely on market information supplied and verified through traditional word-of-mouth approach. Many producers and smaller intermediaries also lack experience to effectively utilize such market information to improve their well being. Very often, information systems tend to be supplier led, rather than user oriented, and many have neither been sustainable nor cost effective. Due to the lack of robust Information Systems for Agriculture (IS4A), it is customary to witness the dominance of one actor in the business interactions of the smallholders. For example, in the case of perishable commodities, widely broadcasted data on prices result in aggressive reaction by supplier, and a form of fallacy of composition would result, with suppliers swiftly flooding the market, and the broadcasted prices drop drastically as a consequence.

The existing solutions mainly target upper class stakeholders. In contrast, the majority of smallholder farmers produce just consumable commodities and selling these commodities are the only ways to get money for purchasing input for the next farming, besides using it to cover their living expenses. In addition, some of the commodities exchange systems Ethiopian Commodity Exchange (ECX), force farmers to have at least a certain predefined amount of a commodity before entering the market competition. Most of the farmers in marginalized society own too small land size. As a result of this, they are often forced to stay in the usual marketing system. Moreover, existing solutions are limited in scope, type and amount of the actual information and service delivery, typically they lack delivering integrated information. With respect to this, the existing commodity exchange services are observed to disseminate only little commodity market information. Clearly, the abundance of the mentioned challenges in the existing solutions and their increasing popularity make a strong case for the need to look for interventions at the level of processes, logistics and services, delivery and presentation with IT support for the benefit of all stakeholders. In other words, an appropriate

ICT-based information system for agriculture can be an enabler to improve the current trading process, provide fine-grain logistic support, and bring a transparent and fair trading process. For instance, it can increase the number of times the traders can go back into the market to purchase grain, increase competition as well as reducing the sharp drop of prices at harvest. If the smallholder farmer meets the minimum conditions for a deposit to a warehouse, s/he can delay selling the commodity, waiting for prices to increase [18], and still provide for immediate cash needs through financing the warehouse receipt.

Because of the above challenges result of a study that identifies the limitations of existing IS4A with respect to service coverage, rural accessibility, delivery channels, open standards, and long-term sustainability among others and a roadmap for the development of IS4A that includes the identification of relevant stakeholders in agricultural sector, their roles and requirements for IS4A is presented in [41].

1.2. Statement of the Problem

The provision of basic market information is a service that aims to increase the efficiency of Ethiopian Commodity Exchange and contribute towards overcoming basic issues of market failure based on asymmetrical access to information [15]. Access to spot prices assists farmers to make decisions on where to sell their goods and to negotiate for better prices from a position of strength. Traders also use this information to assist in facilitating arbitrage and the distribution of goods.

The majority of Ethiopian population lives in the countryside and makes a living by producing agricultural products. Farmers in the rural areas sell their agricultural products to merchants from the cities at very low prices. This is because farmers do not have the option of getting market information of agricultural products in the major market places other than their localities. Due to this fact, the livelihood of farmers is deteriorating day by day. This has a direct impact on the Ethiopian economy since the economy strongly depends on agriculture. To improve the livelihood of farmers, it is important that they get market information to enable them sell what they have at reasonable and fair prices. Hence, efficient and practical way of providing up-to-date market information to farmers is highly needed. The Ethiopian Commodity Exchange is established to create a better market environment for farmers as well as consumers. ICT is one of the three

pillars of Ethiopian Commodity Exchange. *Using tools of ICT, one can provide accurate market information to farmers and traders in rural areas.*

To date, there have been a few pockets of research activities to explore the feasibility of IVR interfaces for low literacy users [5, 6, 7, 3, 4, 8]. There have been a number of preliminary findings and practical lessons learnt but much still needs to be done in terms of fully exploiting the possibilities of IVR interfaces in a context very different from the developed world [9, 10]. In light of the foregoing, the question addressed in this paper is how we should design IVR system for low literacy users in the developing world. In Ethiopia, the majority of the population in the rural areas is not educated enough to use computers. In addition, implementation of computer based Market Information System may require installing computer and computer network in the villages of rural Ethiopia. This kind of venture can be very expensive. Furthermore, the necessary infrastructure, such as electricity, for setting up computer networks is not available in most rural parts of Ethiopia. Hence, a solution which is not too costly to implement and at the same time easy to use is needed. One of the greatest strength of this solution is the fact that it is accessible for anyone who has a connection to a normal telephone network. There is no need of having a computer or Internet connection. Up to date and live market information can be received using IVR based systems. Implementation and operational costs are also reasonable. Market information is provided for end users in their own local languages as well.

1.3. Objective

1.3.1. General Objective

The general objective of this thesis work is to develop a multilingual market information interactive voice response system.

1.3.2. Specific Objective

The specific objectives are to:

- Prepare a limited domain speech corpus for Amharic
- Design multilingual market information IVR architecture.
- Develop TTS engine for Amharic for market information domain.
- Develop multilingual market information IVR system
- Map the corresponding Amharic limited domain TTS with other language
- Test quality of the proposed model and usability of the system

1.4. Scope of the Project

The scope of this thesis is limited to delivering market information via fast expanding mobile and telephone line using DTMF based IVR tree navigation for the three mostly spoken Ethiopian local languages, Amharic, Afaan-Oromo and Tigrigna.

1.5. Methodology

1.5.1. Literature Review

A thorough reviewing of literatures will be done so as to make known underlying theories/principles, methodologies, algorithms and tools which could be used in IVR system. Review on IVR researches will be explored to a greater depth to comprehend what have already being done and what is missing. Therefore, a comprehensive investigation and analysis on text to speech synthesis will be conducted. In addition we will consult Amharic language, Afaan-Oromo and Tigrigna language experts to translate from English language.

1.5.2. Data Collection

For successful analysis and building an IVR system developing TTS engine is necessary. To design a good TTS engine we need to have a corpus. The possible source to make up our corpus is Ethiopian Commodity Exchange office. In addition to corpus preparation knowledge base preparation of TTS will be performed for the IVR system to be well organized system.

1.5.3. Modeling Techniques

The proposed methodology offers IVR technology so that those with literacy difficulties, learning pronunciation of words and characters easily get market information. Generally IVR system can use input either from prerecorded voice or speech synthesis (i.e. text to speech) to deliver the final out put to the users but this thesis is based on the input from TTS, which will be integrated with IVR system.

Any Text to Speech system comprises of two phases. One is text analysis and second is speech synthesis. The task of text analysis is to find the words and the task of speech synthesis is to generate the speech. To attain this, different models are available such as text as language

models, grapheme to phoneme models, full linguistic analysis model and complete prosody generation model. In complete prosody generation model, the quantities like phrasing, stress and the like are determined to generate naturalness bearing synthetic voice. Towards generating such a speech, an explicit prosodic model is required. This makes the speech more understandable. This makes our choice to be prosody model for speech synthesis. We will use concatenative based approach to synthesis desired speech through pre-recorded speech waveforms because the quality of synthesized speech via concatenative approach is very close to natural speech. The quality of synthesized speech waveform depends up on the number of realization of various units present in the speech corpus. In concatenative TTS, the quality of speech corpus is very important because the characteristic of synthesized speech are directly related to nature of speech corpus [2].

1.5.4. Testing

In this part we discuss usability test of the system and how we can conduct a test for quality of the proposed model. During usability test to evaluate a multilingual market information IVR system user-centered interaction testing on the product and system performance testing is performed. To test MMI-IVR system likert scale questions in English is prepared and translated to Amharic, Afaan-Oromo and Tigrigna languages. Then training to respondents on the system in their farm place is given and respondents participate in phone examinations, listen to recorded questions, and respond by pressing a touch phone digit(s). This type of examination is highly efficient and cost effective. No monitor is required and the exams can be taken by the respondents from their farm place or home.

1.6. Tools

The following tools will be used to accomplish the overall tasks:

- Asterisk server used as a server for MMI-IVR system
- PHP programming language for the actual program of the IVR application
- Asterisk Gateway Interface used as an interface between asterisk server and IVR application
- X-lite soft phone to simulate analog or mobile phone
- Festival (Festvox) for TTS prototype development

- Wave Surfer for displaying and labeling the speech waveform.
- Audacity for recording IVR voice
- Edinburgh Speech tools to be used by Festival for speech data processing
- SPSS for usability testing

1.7. Application of the Study

Currently some preliminary project work is being done by the Ethiopian Commodity Exchange to deliver Market Information. This work will help provide market information for the lower stakeholders. This project work is not intended to replace or duplicate the work that is being done by the Ethiopian Commodity Exchange but rather its outcome can help to provide additional market information to what is already being done by the Ethiopian Commodity Exchange. Multilingual market information interactive voice response system will be used to serve hundreds of thousands of farmers to access market information simply and independently using their mobile and fixed line telephones network. The system is applicable for three mostly spoken Ethiopian local languages Amharic, Afaan-Oromo and Tigrigna.

Additionally, the result of this project work can be used by farm households, farmers' organizations, cooperatives and cooperative unions, traders, brokers, provider, advisors (e.g., agricultural extension), authorities, suppliers, and service providers.

1.8. Document Organization

This report contains eight chapters including this Chapter. Chapter Two presents review of research works on IVR system. In Chapters Three and Four, we presented the analysis and design of the developed system respectively. In Chapter Five, implementation of MMI-IVR system is covered. Chapter Six is about evaluation of MMI-IVR system. The conclusion and recommendations drawn from the research are briefly explained in the last Chapter, Chapter Seven.

CHAPTER TWO

LITERATURE REVIEW AND RELATED WORK

2.1. Background

More or less every form of exchange of goods and services used throughout history still co-exists in today's world. Type of exchange activity include roadside salesmen, fixed market places, travelling salesmen, retail stores, auctions, commodity exchanges, stock exchanges, online market places, etc. Usually, the form of the market is determined by the type of product being traded.

All the types of market described above not only need to offer market users the assurance that they will not be cheated, but also need to give potential clients market information which might include the volume of trade conducted and the price paid for the commodities [19].

There are some markets that have no means of informing potential clients about the details of their transaction. Buyers and sellers are often hesitant to make the effort to bring their goods to market if they have no idea what price they will get for them. This reduced the overall volume of trade, decreases production and increases waste, which has a negative effect on a country's economy. Once the market is established, market information of this type is, at first, disseminated by word of mouth, as market participants travel to and from the market to other locations. As the market evolves, market information is also often carried by newspapers that are distributed from market areas. Today such information can also be disseminated by radio, telephone links and via the web.

2.2. Market Information System

Agriculture is the backbone of Ethiopia's economy. To bring millions of Ethiopians out of poverty requires a fundamental change in the way agriculture is done. Agriculture should be replaced with technology-driven and market-oriented production. As Ethiopia is poised to transform its agrarian economy, so too must Ethiopia's marketing system take the country into the new millennium. It is time to enter the modern age of globally connected trading systems,

relying on technology and knowhow, while tailored to Ethiopia's realities and conditions. It is time to forge a new partnership between the private and the public in the new arena created by market liberalization.

To make a living, the rural community of Ethiopia is mainly dependent upon agricultural products. Their lives are directly attached with farming. Farmers produce agricultural products to satisfy their basic needs. Usually, farmers sell their product to merchants from the city. Farmers in the rural areas do not have access to market information. The main source of information they have is the merchants who come to buy their agricultural products. However, there is a conflict of interest with this scenario. For their own benefit, merchants do not give the farmers the correct market information. Due to lack of market information, farmers are forced to sell what they produce at very low prices. This has a direct impact on the economic development of the rural areas hence that of the country. Ethiopian Commodity Exchange is established to alleviate the above stated problem. However, the problem can only be solved if Ethiopian Commodity Exchange implements the right type of Market Information System. Ethiopian Commodity Exchange's Market Information System can play an important role in promoting increased trade within Ethiopia and East Africa. Establishing sustainable Market Information System that serves all stakeholders is important. This means that Market Information System interventions must go beyond the important technical details of collection methodology and database management to consider the responsiveness of the system to users' needs.

2.2.1. Observed Problems of Market Information Delivery

The following are some of observed problems of market information delivery [20].

➤ *Accurate and Specific Market Information Delivery*

One mechanism of getting market information is by asking people who come from the cities. Information is transferred from one farmer to the other through word of the mouth. Usually, market information provided in this manner is not accurate and highly susceptible to error. The other problem is that up to date information cannot be obtained through this technique. Generally, people who come from the cities do not have fresh market information. Hence, what farmers get is usually out dated and inaccurate market information. Often, farmers want to know the price of a specific agricultural product having specific quality. Radio and Television broadcasts cannot

provide specific market information. Usually, the information broadcasted is too general and cannot provide specific information needed by farmers. In fact, it is not technically and financially viable to broadcast the price list of agricultural products at every market in the country every hour. Using radio and television technology one can only give price indication of major agricultural product at major market places of Ethiopia. Hence, specific and accurate mechanism of information delivery is required to effectively serve the agricultural product producers of Ethiopia.

➤ ***Information On Demand***

The other issue that can be raised is the timing of information delivery. When do we give farmers market information? The answer is straight forward and simple – *When they want it!* Farmers must get market information only when they want it. The Ethiopian Radio and Television broadcast market information, however, the broadcast time and date is usually not convenient for farmers and it is not when they want the information. Furthermore, the farmers may miss the broadcast time. Radio and TV broadcast is simply too inconvenient and inefficient way of providing market information, in spite of their wider reach capacities.

➤ ***Technical Skill and Language***

Farmers and cooperative societies are the main users of this market information delivery system. Most of Ethiopian farmers are not educated enough to use computers. Hence, for a proposed market information delivery solution to be feasible, it should not require too much technical skill. Radio and television broadcasts do not require technical skill from the farmers' side. In fact, anyone who knows how to turn on and tune a radio and television can get market information. On the other hand, using computers to get market information may require technical skill which farmers of Ethiopia do not have. The other problem is the language issue. Most farmers in the rural parts of Ethiopia only speak and understand one language – their local language. Market information should be delivered to farmers in their own local language.

➤ ***Lack of Skilled ICT Manpower***

Implementation of ICT based Market Information Systems and research on ICT based solution requires trained manpower and computer literate end users. Ethiopian Commodity Exchange may need to train and dispatch its staff members all over Ethiopia to support its Market Information System.

➤ ***Lack of Proper Infrastructure***

The rural parts of Ethiopia are mainly characterized by poor availability of telecom and electricity infrastructure. Due to this fact, implementing computer based systems in the villages of rural

Ethiopia is very difficult. Therefore Ethiopian Commodity Exchange must think over of implementing mobile based market delivery means.

2.3. Market Information System Types

After doing a thorough survey of Market Information System implementations of other commodity exchanges, in the system investigation process the following traditional and modern Market Information System alternatives have been identified [20]:

- Mass Media (Radio and Newspaper) Based System
- Mobile Phone Short Messaging Service (SMS)
- Interactive Voice Response (IVR) Based System
- Email Based System
- Plasma Display Based System
- Market Information Points (MIPs)
- Telephone Based Query System
- Website Base Market Information System
- Word of Mouth Based System

2.3.1. Interactive Voice Response System

The need for a human operator to handle a high volume of simple repetitive phone calls is a thing of the past. Today, Computer Telephony Integration (CTI) leverages the power and versatility of computers to enhance phone systems with automated applications that answer and direct calls and even provide callers with the information they require – many times without having to speak to a call center agent. Most customers have experienced automated call systems at one time or another. Have you ever called a business and been greeted by a voice prompting you to press (or say) a number to choose from a menu of options? You were interacting with either an Auto Attendant or an Interactive Voice Response (IVR) system. An auto attendant is a system that is integrated into an existing phone system or an external server to answer incoming phone calls. The auto attendant provides callers with a menu of options for navigating the phone system to reach the department or phone number they desire. An auto attendant can be quite simple or it can provide advanced features such as voice recognition and text-to-speech translation. However, an auto attendant is unable to retrieve information from other systems, limiting its ability to be truly interactive. On the other hand,

IVR provides all the features of an auto attendant plus the ability to use input from callers to interact with separate external systems.

The Interactive Voice Response (IVR) System serves as a bridge between people and computer databases by connecting the telephone network with the database [1]. The telephone user can access the information from anywhere at any time simply by dialing a specified number and following an on-line instruction when a connection has been established. The IVR system uses pre-recorded or computer generated voice responses to provide information in response to an input from a telephone caller. The input may be given by means of touch-tone or Dual Tone Multi-Frequency (DTMF) signal, which is generated when a caller presses a key of his/her telephone set, and the sequence of messages to be played is determined dynamically according to an internal menu structure (maintained within the IVR application program) and the user input [11, 12, 13, 14].

Other IVR systems include speech-recognition software that allows a caller to communicate with a computer using simple voice commands. Speech recognition software has become sophisticated enough to understand names and long strings of numbers. On the other end of the phone call, a business can employ text-to-speech (TTS) software to fully automate its outgoing messages. Instead of recording all of the possible responses to a customer query, the computer can generate customized text-like responses and read it back to the customer using an automated voice.

IVR systems can improve call center efficiency with recorded, frequently requested information or by routing callers to the most relevant agent based on their input. IVR systems retrieve information requested by callers and present it in a variety of ways, such as a recorded or synthesized voice, fax, web page or even an email, the advantage of an IVR system is that applications can be customized for almost any situation imaginable to accommodate callers' requests. For instance, IVR allows customers to call their credit card company, and by inputting their account number and password, get real-time information about their current account balance, amount of credit available, payoff information, etc. Or, someone might use the airline's IVR to check if his flight is on time before leaving for the airport. IVR systems are used to remove the burden from human representatives and get customers the information

they need quickly. The examples listed are only a few of the numerous implementations that are possible.

➤ *Interactive Voice Response System Benefits*

IVR systems provide customers with many services such as fax on demand, secure access to confidential account information, general information such as phone numbers and working hours, and an easy way to navigate through a complex phone system. From a business perspective, IVR adds to customer satisfaction by giving customers what they want, and several options to get it. If the customer is satisfied, the IVR system will pay for itself through increased sales. IVR systems also reduce call center costs by fielding the bulk of routine calls, allowing live agents to handle only the calls that require specialized skills. Fewer agents perform the same amount of work and maintain the quality of the call center. IVR systems also extend business hours, allowing customers to retrieve information or even place orders 24 hours a day, 7 days a week, whether agents are working or not. Businesses also benefit when the IVR system is used to inform callers about products and services during hold time. Additionally, an IVR system provides detailed information about call center activity and services that customer access making it easy to tailor a call center to the specific needs of the customer and streamline operations to reduce waste.

2.4. Speech Synthesis

A Text-To-Speech (TTS) synthesizer is a computer-based system that reads a given text aloud, or we can define Text-To-Speech as the automatic production of speech. There are several kinds of speech synthesizers that use various methods to convert textual input into sound output. Synthesizers are most commonly distinguished as being either rule based or data-driven [40].

Rule-based synthesizers base their output on an acoustic model of speech production. This method can create a vowel by modeling how the signal is led through a filter, which mimics the human vocal tract, creating a set of particular resonance (formant) frequencies depending on the relative position of the different articulator organs. Generalized rules are extracted from the filtered information. The phonetic input of the synthesis is tested on the rules; when a

match is found, the synthesizer produces digital speech. Rule-based synthesizers are also referred to as formant synthesizers, because the speech information behind the generalized rules is related to formant and anti-formant frequencies and bandwidths. As opposed to data-driven synthesizers, this method does not use human speech samples in order to create the output speech. These types of synthesizers are considered to have a greater degree of intelligibility, as well as to be resource-economic, since they do not depend on stored segments of human speech [40].

Data-driven or concatenative speech synthesis is a method for creating artificial speech by merging slices of pre-recorded human speech. Two subcategories can be distinguished within this method, diphone and unit-selection, differing mainly in the size of the units being concatenated. Both methods store the pre-recorded speech units in a database, from which the concatenation originates. Parts of utterances that have not been previously processed and stored in the database are “built up from smaller units.” The diphone data driven synthesis refers to storage of all possible diphones in a particular language, which are then merged in accordance with the phonetization of the input text. A diphone is a speech unit consisting of two half-phonemes, or of the phonetic transition in between. The other method, unit selection, collects its speech data from a repository containing units of various lengths, including diphones as well as words and phrases. Each pre-recording is stored in multiple occurrences, pronounced in different prosodic contexts. Hence, this type of synthesis requires an extensive storage facility, and has only recently become a popular method, since memories and performance of computers have increased. The primary motivation for a large database is that with a large number of units available with varied prosodic and spectral characteristics it should be possible to synthesize more natural sounding speech than that can be produced with a small set of controlled units. Since the diphone unit requires digital post-processing in order to incorporate prosodic information, the naturalness of the pre-recordings may be reduced. The unit selection synthesis, however, requires no digital post-processing; it simply concatenates the stored units as they are. Therefore, this type of synthesis usually gives the greatest naturalness [40].

2.4.1. General Architecture of TTS System

The process of converting written text into speech can be considered into a two step process with two independent but interacting modules:

- Natural Language Processing (NLP) Module and
- Digital Signal Processing (DSP) Module.

This two step process is depicted graphically in Figure 2.1.

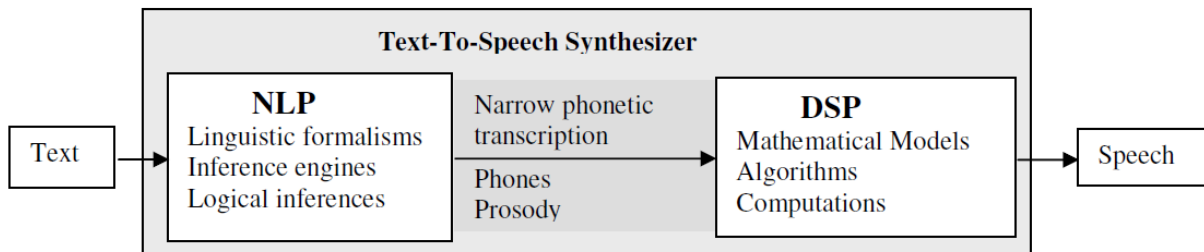


Figure 2.1: The two step process of speech synthesis [39]

The NLP module consists of text analysis, automatic phonetization and prosody generation main processing stages or components. In the DSP module a transformation of the received symbolic information into actual speech waves is performed. There are three different categories of waveform generation (called types of speech synthesis):

- **Articulatory Synthesis:** a method of synthesizing speech by controlling the speech articulators and determines the characteristics of the vocal tract filter by means of a description of the vocal tract geometry,
- **Formant Synthesis:** specifies directly the formant frequencies and bandwidths as well as the source parameters. Formant Synthesizers are also referred to as Rule-Based Synthesizers, where generalized rules are extracted from the filtered information. The input is then tested on the rules.
- **Concatenative Synthesis:** This is the most commonly used technique, where segments of speech are tied together to form a complete speech chain. The speech output is produced by coupling segments from a database to create the sequence of segments.

2.5. Related Work

Among the important tasks that are currently undertaken by the Ethiopian Commodity Exchange are selection, design and implementation of a Market Information System. The Ethiopian Commodity Exchange has plans to distribute market information, at Woreda level, through its 200 rural sites across Ethiopia. The exchange plans to transmit real time price information to these 200 sites directly from the trading floor in Addis Ababa. Prices of other markets (off exchange) will also be distributed to the public. Price information of agricultural products will be displayed on Plasma Display Screens which will be installed near rural market places.

[41] Research shows Figure 2.2 shows the architecture for a distributed information system with the interconnected components grounded into four categories (presentation, data transfer, and application logic and data storage). The presentation layer is the one responsible for various platforms, interfaces and standards for the actual delivery of services. All the data within the proposed system is stored to the three databases authentication database, general IS4A database and expert system database. Authentication database contains the access permissions to data that are used when dealing with (e.g., authorities and regulatory bodies) besides containing the standard identification and authentication information for all users of the system. The authentication database additionally contains the authentication information for other services. General IS4A database contains heterogeneous collection of information about the market price information (which will be updated either online or offline), that is stored by any existing (commercial) commodity exchange initiatives along with ontology backed commodities information. This database must also contain information on services' registry which we require for efficient service discovery as a web service. Expert System database contains data related to expert system in agriculture which is best stored in a non-relational format.

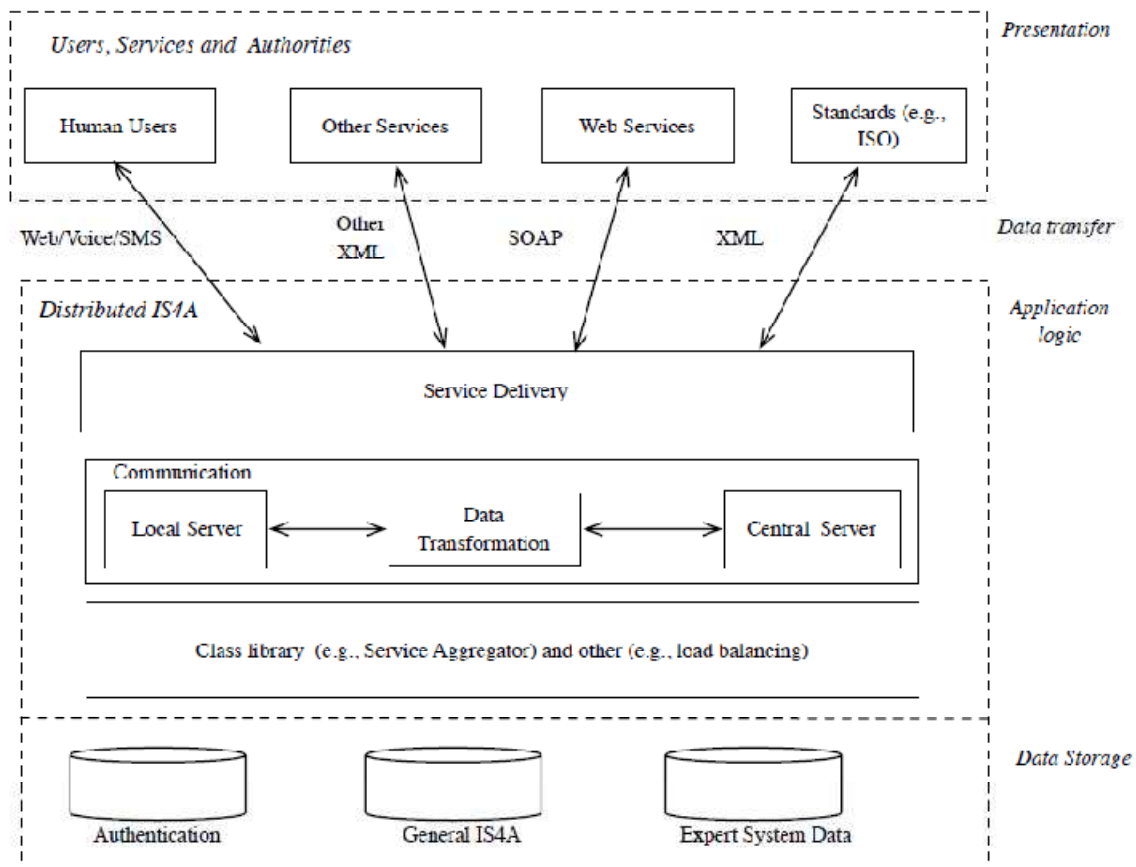


Figure 2.2: The proposed architecture from the viewpoint of the developer [41].

Interfacing these databases with the application logic may have different level of complexities. A dedicated module inside the class library will carefully handle these issues, by providing an object-oriented abstraction for the data stored in these databases. The data transformation inside the communication layer of the application logic transforms data from the internal representation of the system to formats more suitable for the service deliver module or for external services connected to the application logic. The top layer of the application logic is service delivery which is the most complicated layer as it creates contents suitable for every delivery channel appropriate for all users of the system.

The architecture shown on Figure 2.3 for a distributed service delivery with the aim of achieving a platform with qualifying characteristics such as aggregated services and multi-channel service delivery based on Information and Communication Technologies and Development (ICTD) best practices and open standards are proposed by FBK research center. Figure 2.3 shows the modules

of the type of delivery channels of the presentation layer and the application logic. Specifically, the application logic is based on one central server dedicated to service aggregation and with multiple local servers handling (local) social networks and localized knowledge bases. The central server will be dedicated to the aggregation of these services and to the aggregation of information coming from all the other nodes. Ideally, the central server has national scope. The communication among the nodes of the system will be Peer-2-Peer, thus achieving a completely distributed social networking service complemented by a set of aggregated services. In the local server, we particularly seek to build a distributed social network platform by mapping the traditional social engagement process within the society, in addition to structuring, integrating and standardizing data and information from various trusted sources. Thus, each local server provides services that are relevant to the community in which they are deployed (e.g., a province or a group of villages), namely a social networking service to allow all the system stakeholders in the area to communicate freely and a localized knowledge base providing information relevant to the area in the local language. The local servers are connected with all the other servers and the central server; thus, allowing to function as gateways to the aggregated services (i.e., integration and aggregation of different information and data from various existing sources) and the other social networks. The important aspect of localization is divided between the application logic and the user interfaces, where the application logic is mainly responsible for the localization of data management and the user interfaces are responsible for the actual content delivery management per users of the system. Moreover, security should be handled throughout the entire system, though certain aspects of security are best implemented at specific layers of the architecture.

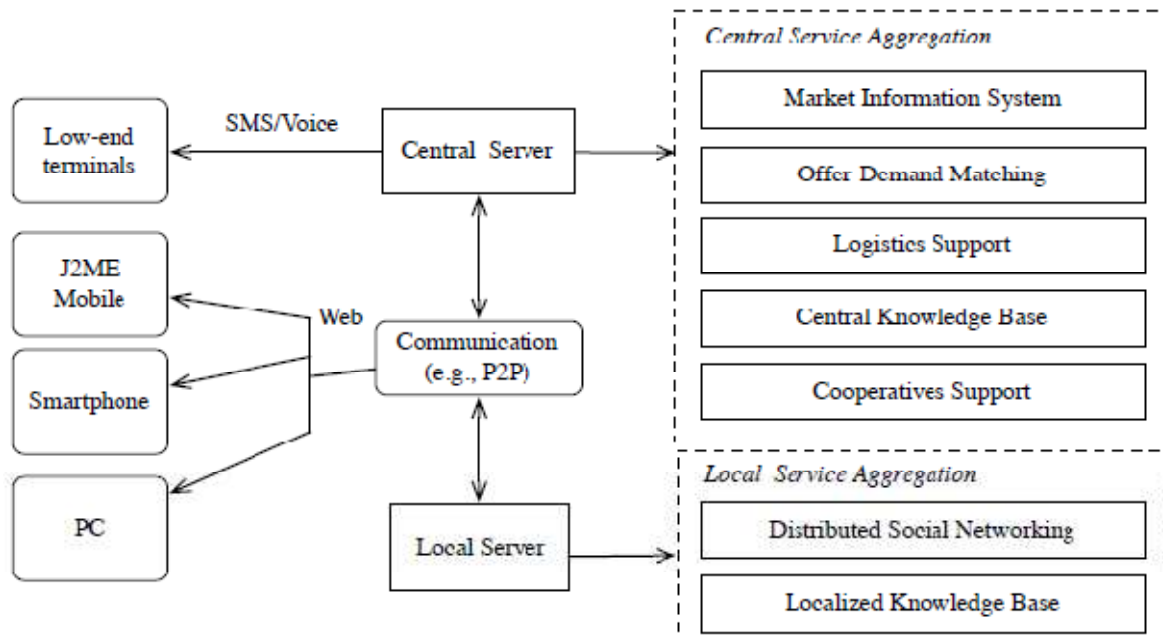


Figure 2.3: High level architecture of Distributed Agricultural Information Services for developing Countries [41].

In multi-channel delivery of services the generic architecture for the proposed system shall allow all stakeholders easily update (online or offline), communicate, and manage information and data. This would allow the delivery and end-user interaction with the system to be based on multichannel modes, delivered mainly on mobile devices. Though the current mobile phones penetration in developing world [16, 17] answers our choice of mobile-based service delivery, in fact with different levels of sophistication, the following devices are targeted for the delivery of agricultural services.

- Low-end terminal: these devices can access limited services via SMS or IVR (Interactive Voice Response). Individual farmers and transporters are expected to access the system mostly through this category of devices.
- J2ME/Android: dedicated applications for these categories of devices provide access to the functionalities of the system. Large scale farmers (e.g., SMEs) are expected to be users of this category of devices.
- PC: a web interface accessible via PC will be provided to be used on laptops, (one-stop-shop) kiosks and in tele-centers as well as in public bulletin-board. The web

interface should be based on technologies that allow for asynchronous communication with the server as connectivity is expected to be non-continuous.

In addition ECX has implemented SMS and IVR market data dissemination project, the project is contracted by apposite to develop the first ever market data dissemination system using multiple communication channels such as short message service (SMS), interactive voice response system (IVR), fax and email.

The current IVR system has been evaluated by the researcher. The following are the drawbacks of the existing ECX IVR system from the developer point of view:

- It does not target lower level stockholders
- The market information delivery service is limited in its content coverage and service delivery
- Language coverage does not target the majority of illiterate farmers
- The system is not easily scalable
- The name of commodity items are difficult to understand
- It is not cost effective

Like Ethiopia some developing countries Kenya, India, Nigeria, South Africa and Asia have market information dissemination project. Some projects have been able to successfully target rural developing world farmers by allowing them to use either information kiosks or mobile phones to receive information [27, 28].

The Kenya Agricultural Commodity Exchange (KACE) was set up in 1994 to provide the basic services of a commodity exchange. The products meant to be traded were agricultural commodities like cereals, dairy products and cotton. However, the exchange was not able to materialize its primary goal which is commodity trading. Instead, focus has shifted towards information dissemination. KACE initiated the idea of agricultural Market Information System. Initially, KACE was funding the project from its own capital. However, later on, the initiative has attracted funding support through various projects from a number of development partners and aid donors [3]. Different types of Market Information Systems are implemented by KACE like market information points, market information centers, mobile phone SMS, email based Market Information System , web site , multimedia and interactive

voice response system (IVR). In responding to the different client needs KACE has, in collaboration with an IVR service provider, also developed where users call a telephone number to access market information in voice mail. Any mobile phone or digital landline can be used to call the IVR system. This service is available in both English and Kiswahili and a caller follows an easy step-by-step pre-recorded voice prompt menu to choose the language and access the information. Like the SMS service the IVR Hotline service is low-cost, timely and convenient to use [21].

Multi Commodity Exchange of India Limited (MCX) is an exchange with permanent recognition from the Government of India for setting up a nationwide, online (electronic) multi commodity marketplace. Promoted by Financial Technologies Limited, MCX has introduced a state-of-the-art, online digital exchange for commodities trading in the country. Market information system implemented by MCX is fully web based [22].

Nigeria is an agrarian society having over 70% of its estimated population engaged in agricultural sector. However, Nigerian agricultural sector is characterized by low output, low access to financing, poor quality of agricultural products and lack of efficient market. In order to address these problems the government intervened through the establishment of Abuja Securities and Commodity Exchange (ASCE). ASCE was originally incorporated in 1998 as a stock exchange. Later it was converted to a commodity exchange by the federal government of Nigeria. ASCE mainly uses email based and website based Market Information System to disseminate price information to the public [23].

The agricultural commodity derivatives market in South Africa was established in 1995 as a separate division of the South African Future Exchange. The primary reason for the establishment of the market was the emergence or recognition of agricultural price risk within the sector. Around 20% of commercial farmers are actively involved in the market. Indeed, the price discovery role of the exchange is such that the price is used throughout South Africa as reference price. The main market information dissemination tool used is the Internet utilizing email services and website [24].

The Warana Wired Village project was one of the first rural ICT interventions in Asia that succeeded at large scale [7]. Originally intended to provide 70,000 farmers in rural Maharashtra access to market prices, the project transitioned to a remote bookkeeping system

for the Warana cooperative, allowing the NGO to keep track of farmer outputs and issue pay stubs, land records, and other documents. Recently, the Warana Unwired initiative successfully migrated all of the functionality of the kiosk-based system to a mobile phone / SMS solution, resulting in significant cost savings and increased system flexibility [26].

Market information is essential for informed decision making for producers, intermediaries and even for third parties and consumers [29].

In Ethiopia, it has been demonstrated that access to market information (in this case, via mobile phones) can improve the economic performance of small producers. Web-based initiatives are currently being developed in India, Bangladesh, Central and South America, the Caribbean, Africa, and the United States for information about market prices and access to the latest agricultural practices [30, 31, 32, 33, 34, 35, 36].

2.6.Chapter Summary

Market information dissemination projects are studied in different approaches for many countries. In all related works, we have tried to discuss about some of the works somehow related to our work. Developing countries like Ethiopia, Kenya, India, Nigeria, South Africa and Asia have market information dissemination project. The implemented projects target higher level stakeholders. To disseminate market information for developing countries by focusing on the delivery of market information for low level stakeholders distributed information services for developing country is designed. Hence, we stick in employing market information for low level stake holders in our project too.

CHAPTER THREE

SYSTEM ANALYSIS

In this chapter the functional and non-functional requirements of the system are described and modeled using UML models.

3.1. Functional Requirements

The functional requirements of the system are:

- The system should accept user input from the user
- The system should verify user input information
- The system should receive call
- The system should allow the user to select language
- The system should allow the user to identify market information
- The system should perform speech synthesis
- The system should prompt to user multilingual market information using Amharic, Afaan-Oromo and Tigrigna local languages.
- The system enables to view call detail records
- The system should allow the user to terminate the call at any time.
- The system should provide the user, to hold up a call in progress. When the call is being held up then the hold music will be played till the call is un hold.

3.2. Non Functional Requirements

The non-functional requirements of this system include features such as security, maintainability and expandability, user friendliness and portability.

The following list of non functional requirements is expected from the system:

3.2.2. User Friendliness

Since the system is designed for illiterate and semi literate group, user interface is telephone keypad which makes the system to be user friendly. For this reason, the voice interfaces and components of the voice interfaces should be designed in a user friendly fashion to help users

interact easily with the system. In addition to this, the menu structure will be designed by collecting market information need and requirement of farmers to allow them to easily interact with the system.

3.2.3. Portability

The system should be designed in such a way that the IVR application can be accessed by any mobile device that supports Ethio telecom line for communication.

3.2.5. Performance

An underpowered IVR can cause customers to become impatient, and it may even drop calls because it cannot handle the volume of incoming traffic. It's important that our IVR system is able to handle the current number of incoming lines.

3.2.6. Customer Satisfaction

Multilingual market information IVR system should be designed with the customer in mind. Menus should be logically designed based on users need, and the options should be explained in a way that semiliterate and illiterate farmers can understand. Because it's difficult for callers to remember a long list of menu items, it's important to keep the number of options to a minimum and include the ability to repeat the choices. While it is possible to record our own IVR menus, it is often preferable to work with ECX to record the voice of the IVR to make it as clear and professional as possible. An effective way to ensure that our IVR is effective to monitor the IVR logs to see how many calls are dropped, as dropped calls are an indication of customer frustration with the phone system.

3.2. System Model

In this section the system is described by showing its functionality using a use case as shown in Figure 3.1, moreover, the static and dynamic behaviors are shown using class and sequence diagrams respectively.

3.2.1. Use Case Diagram

A use case diagram is used to describe the functionality of the system from an external point of view. The use case model is one which is considered as a functional model.

Figure 3.1 depicts the use case model.

3.2.2. Actor Description

Name: **User**

Description: A user is a person that uses the functionalities of the system like insert DTMF input, select language, access market information, terminate call, hold on call, call MMI-IVR extension.

Name: **Administrator**

Description: Administrator is a person who is responsible to start server, view call detail, and stop server.

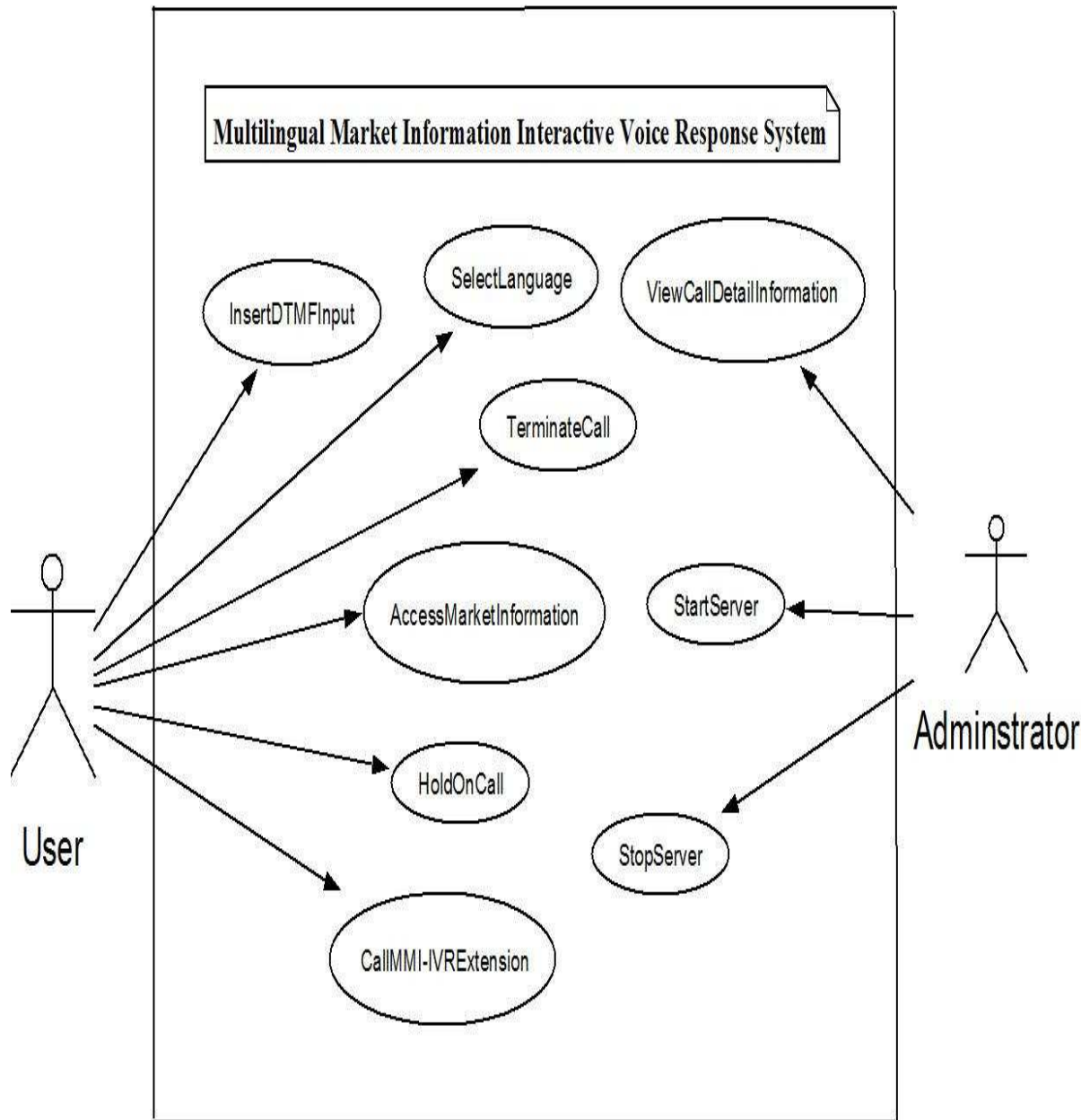


Figure 3.1: Use Case Diagram for Multilingual Market Information IVR System

3.3.2. Use Case Description

This part describes each use cases which are stated in Figure 3.1. The descriptions briefly explain how the functionalities precede using natural language in a step wise manner.

Name: AccessMarketInformation

Actor: User/Administrator

Description: Allows the user/Administrator to get market information

Precondition: 1) The user must have a mobile phone
2) The administrator must have a mobile phone

Flow of Events:

- (1) The user dials the specific IVR number.
- (2) The user will be connected to the system
- (3) The system instantly prompts the user to select a language and access market information
- (4) The user selects “1” for Amharic language, “2” for Oromiffa language, and “3” for Tigrigna language.
- (5) The user gets access to details of market information by following the instruction the system speaks.
- (6) The use case ends

Post Condition: The user gets market information

Name: StartServer

Actor: Administrator

Description: To allow the system to start server

Precondition:

- (1) Administrator must be logged in.
- (2) Administrator should have Server ID

Flow of Events:

- (1) The administrator want to start the server
- (2) The administrator completes and submits server ID [Alt 2]
- (3) The system displays the IVR server’s page
- (4) Use case ends

Alternative Flow of Events

Alternative flow Alt 2: Incorrect server ID

Alt 2.1. The system displays “Incorrect Admin ID error message and cannot start the server

Alt 2.2. Use case ends

Post Condition: The server will start service to accept call

Name: StoptServer

Actor: Administrator

Description: Used to let the administrator stop server service.

Precondition:

- (1) Administrator must be logged in.
- (2) Administrator should have Server ID

Flow of Events:

- (1) The administrator want to stop the server
- (2) The administrator inputs service stop command
- (3) Use case ends

Post Condition: The server will stop service

Name: TerminateCall

Actor: User

Description: To terminate call

Precondition:

- (1) The user must have a mobile phone
- (2) The user must be connected with the server

Flow of Events:

- (1) The user dials the specific IVR number
- (2) The user will be connected to the system
- (3) The system instantly prompts the user to select a language
- (4) The user selects “1” for Amharic language, “2” for Oromiffa language, and “3” for Tigrigna language.

- (5) The user gets access to details of market information by following the instruction the system speaks
- (6) The user cancels the dialed number
- (7) The system ends its connection to the server
- (8) The use case ends

Post Condition: The user connection with IVR system will be terminated

Name: HoldOnCall

Actor: User

Description: To hold on call

Precondition: The user must be connected with the server

Flow of Events:

- (1) The user dials the specific IVR number
- (2) The user will be connected to the system
- (3) The system instantly prompts the user to select a language
- (4) The user selects “1” for Amharic language, “2” for Oromiffa language, and “3” for Tigrigna language.
- (5) The user gets access to details of market information by following the instruction the system speaks
- (6) The user press hold on key
- (7) The system will plays hold on music
- (8) The use case ends

Post Condition: The system will play hold on music and user will hear hold on music

Name: ViewCallDetailInformation

Actor: Administrator

Description: To view call detail information

Flow of Events:

- (1) Administrator wants to view call detail information
- (2) Administrator logs in to the system [Alt 2]
- (3) Administrator start the server [Alt3]
- (4) Administrator selects to view the required call detail summary

- (4) System displays the appropriate report
- (5) Administrator prints out the report
- (6) Use case ends

Alternative Flow of Events

Alternative flow Alt 2: Administrator's password is invalid

- Alt 2.1. The system shows an error message
- Alt 2.2. Use case ends

Alternative flow Alt 3: Incorrect server ID

- Alt 3.1. The system displays "Incorrect Admin ID error message and cannot start the server"
- Alt 3.2. Use case ends

Post Condition: Users call summary information is viewed

Name: InsertDTMF

Actor: User

Description: Allows the user to navigate the system

Precondition: The user must have a mobile phone

Flow of Events:

- (1) The user dials the specific IVR number.
- (2) The user will be connected to the system
- (3) The system instantly prompts the user select a language and access market information asking to input DTMF tone.
- (4) The user selects language and gets access to details of market information inputting DTMF tone by following the instruction the system prompts
- (5) The use case ends

Post Condition: The user will navigate the system

Name: SelectLanguage

Actor: User

Description: Allows the user to select its own local language

Precondition: The user must have a mobile phone

Flow Events:

- (1) The user dials the specific IVR number.
- (2) The user will be connected to the system
- (3) The system instantly prompts the user to select language by asking to input DTMF tone.
- (4) The user selects “1” for Amharic language, “2” for Oromiffa language, and “3” for Tigrigna language.
- (5) The user gets access to details of market information inputting DTMF tone and following the instruction the system prompts
- (6) The use case ends

Post Condition: The user will access information with his own local language

Name: CallMMI-IVR

Actor: User

Description: Allows the user to call to IVR extension number

Precondition:

- (1) The user must have a mobile phone
- (2) The user must have specific IVR extension number

Flow of Events:

- (1) The user dials the specific IVR extension number.
- (2) The user will be connected to the system
- (3) The use case ends

Post Condition: The user will navigate the system

3.3.3. Class Diagram

Class diagram is used to identify domain objects or conceptual classes, relationship between conceptual classes, attributes and operations. In Figure 3.2, the class diagram for the system shows the classes with their potential attributes and methods.

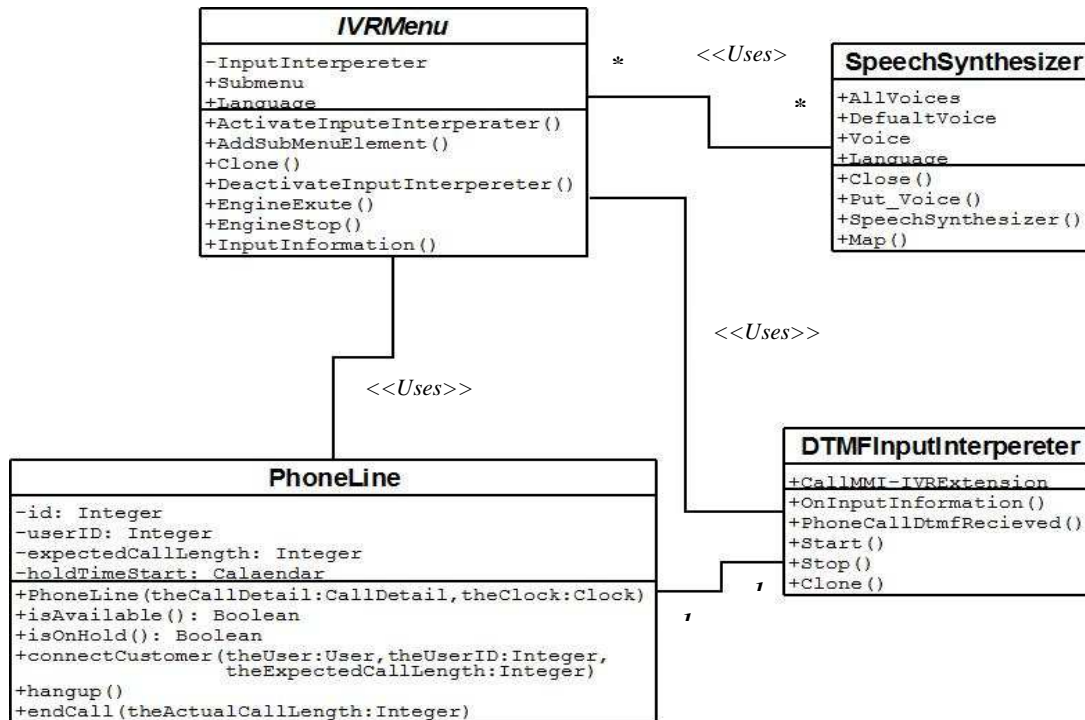


Figure 3.2: Class diagram of MMI-IVR

3.3.4. Activity Diagram

Activity diagrams show the work flow of the system. They illustrate what activities can be done in parallel, and the possibility of alternative paths through the work flow. The activity diagram for this system depicts the different activities involved through the course of the working with the system in terms of the actors involved. Figure 3.2 shows the activity diagram of the system.

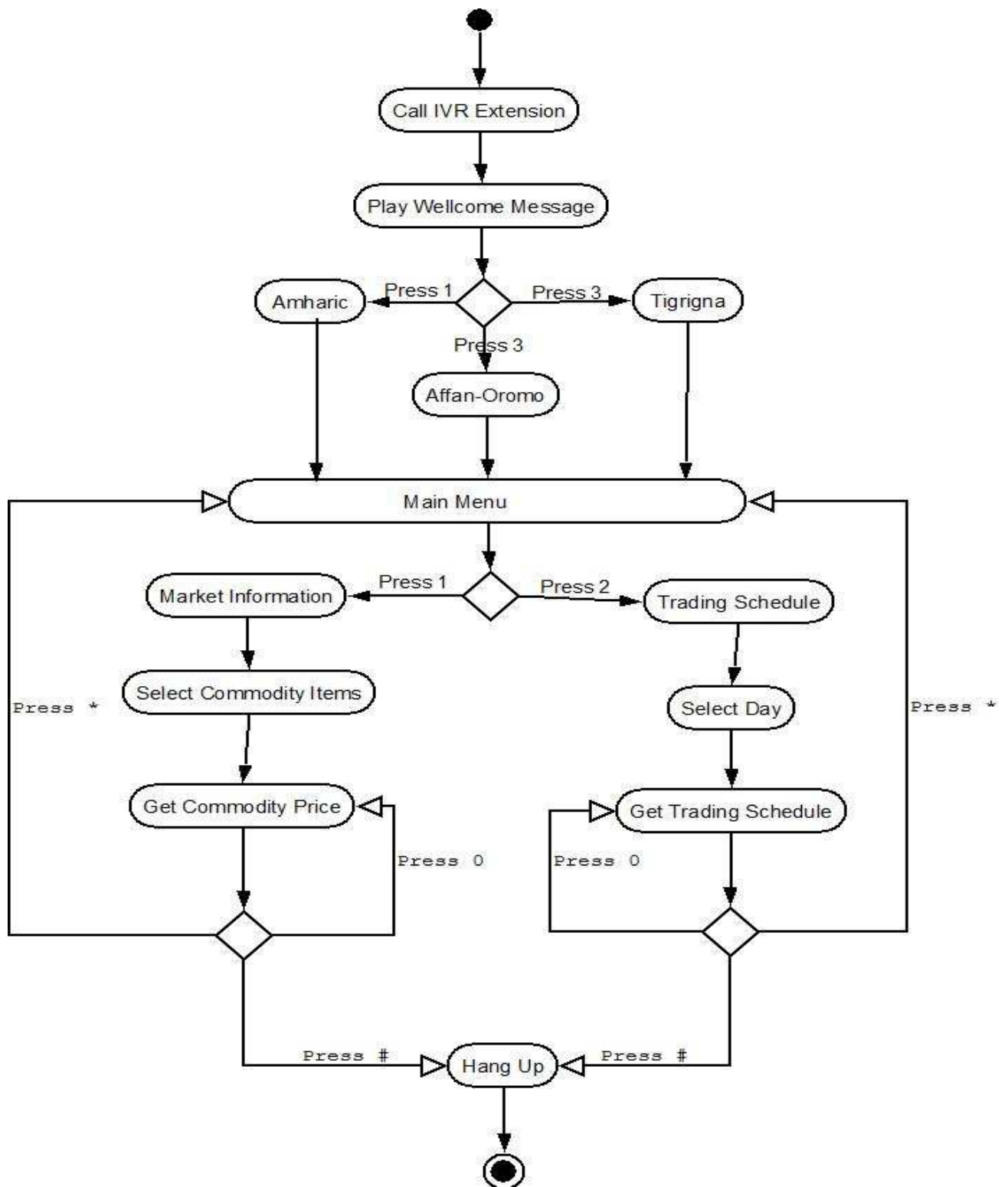


Figure 3.3: Activity diagram of MMI-IVR system

CHAPTER FOUR

SYSTEM DESIGN

In the previous chapter we have identified the functional and non-functional requirements of the system and produced the analysis model. The following are discussed in this chapter: design goals, system architecture, system decomposition, deployment and database design.

4.1. Design Goals

Design goals describe the qualities of the system that developers should optimize. Such goals are normally derived from the non-functional requirements of the system.

Design goals are grouped into five categories. These are:

Performance

IVR systems come in all shapes and sizes. An underpowered IVR can cause customers to become impatient, and it may even drop calls because it cannot handle the volume of incoming traffic. It's important that our IVR system is able to handle the current number of incoming lines at maximum capacity.

Dependability

Ethiopian Commodity Exchange wants the software system to be dependable to users. The system should be robust i.e. it should be able to survive invalid user inputs, fault tolerant, reliable and available. Since the system stores sensitive data, high emphasis is given to security to withstand malicious attacks. The system shouldn't allow unauthorized users to access members' personal data or modify.

Maintenance

The system should be easily extensible to add new functionalities at a later stage. It should also be easily modifiable to make changes to the features and functionalities.

End User Criteria

From the end users' perspective the system should be designed in such a way that it is easy to learn and use, efficient and having few errors if any. The system can be accessed just by dialing a

specific phone number. Unlike using computers, everybody knows or can easily learn how to use a telephone.

Hence, users do not need to have high technical skills; anyone who knows how to use a telephone can use the proposed Market Information System to get market information.

4.2. System Architecture

The proposed multilingual market information interactive voice response system uses three-tier architecture model, which is the fundamental framework for the logical design model, which segments an application's components into three tiers of services namely, the presentation tier, the middle tier, and the data tier. These tiers do not necessarily correspond to physical locations on various computers on a network, but rather to logical layers of the application. The presentation tier or more appropriately, user services layer, gives a user access to the application. This layer presents data to the user and permits data manipulation and data entry. The middle tier, or business services layer, consists of business and data rules of the proposed Market Information System. Also referred to as the business logic tier, it is here where all business problems and logic is implemented. The data tier, or data services layer, interacts with persistent data stored at the General IS4A database. In fact, this is the actual DBMS access layer. This layer can be accessed through the middle tier. During an application's life cycle, the three-tier approach provides benefits such as reusability, flexibility, manageability, maintainability, and scalability.

Figure 4.1 shows the architecture for a multilingual market information interactive voice response system. In the following part of the report, we discuss the components of the architecture.

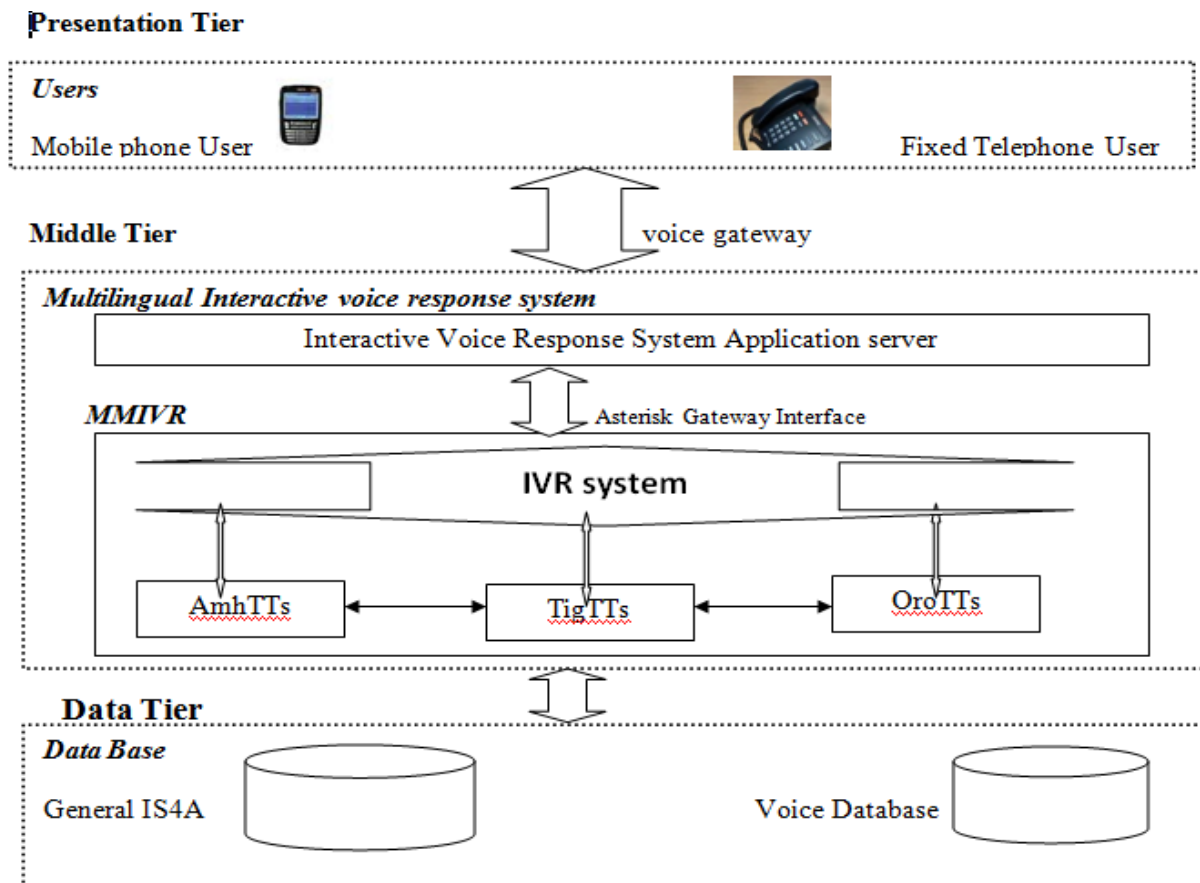


Figure 4.1: Architecture of IVR system

The top layer of the presentation logic is service delivery which is mainly used as an interface to farmers and traders, which are located at distant locations, via the telephone network. The second level of the architecture is middle tiers that accepts inputs from the user and provide required information back to the caller via voice messages. This tier accepts telephone digits from the user over the telephone network. For example, when a user presses one on the telephone keypad, telephone digit of one will be sent to the application logic via the telephone network. The application logic detects the frequency and identifies the key. Then, depending

on the voice menu level, the key pressed will be interpreted accordingly. The presentation logic has several pre-recorded vocabulary files. Numbers, names of weeks, names of months and common words used for communication, and application specific voice messages will be recorded and saved at a predefined location having a predefined file name. When market information is requested by the caller, the presentation logic reads the information from the database and uses its template files to construct voice message. To accomplish this, it uses the pre-recorded template files, and dynamically generated information which basically done in this tier by text to speech engine.

By playing voice files we can completely read the price to the caller. All messages are constructed in this manner dynamically. Hence, the first step in developing Interactive Voice Response Unit is recording template and building text to speech files. More than one language can be implemented in the system. For our demonstration purpose we use three main Ethiopian languages Amharic, Afaan Oromo and Tigrigna languages. This makes the service friendlier to the users because some inhabitants of rural communities in isolated regions of Oromia and Tigray cannot speak English or Amharic very well. The information stored in the IVR server is related to market information in order to stimulate the rural community to increase economic growth in areas such as agriculture. The proposed system can stimulate market activity in rural areas efficiently. The availability of market information to stakeholders is expected to increase production output. Sometimes rural communities who trade their output to the market center via brokers cannot sell their output optimally because they do not know the least price of their goods in the market. This problem will be reduced by making the price list information available on the proposed Market Information System. To facilitate the system menu cards can be developed and distributed to users and basic training can be provided before use.

The third tier of the architecture is data tier which consists of voice database and General IS4A database. General IS4A database contains heterogeneous collection of information about the market price information (which will be updated either online or offline), that is stored by any existing (commercial) commodity exchange initiatives. This database must also contain information on services' registry which we require for efficient service discovery as a web service. Although the schema of the database does seem complicated by the amount and

diversity of the stored information, this complexity requires no novel techniques as the design and implementation of similar databases can be considered routine work in software development.

4.3. Subsystem Decomposition

Subsystem decompositions will help reduce the complexity of the system. The subsystems can be considered as packages holding related classes/objects. From the functional requirements we identified in the system analysis section, the system is decomposed into subsystems as shown in Figure 4.2. These subsystems are further decomposed into other subsystems. The major subsystems identified are “voice interface” and “speech synthesis”.

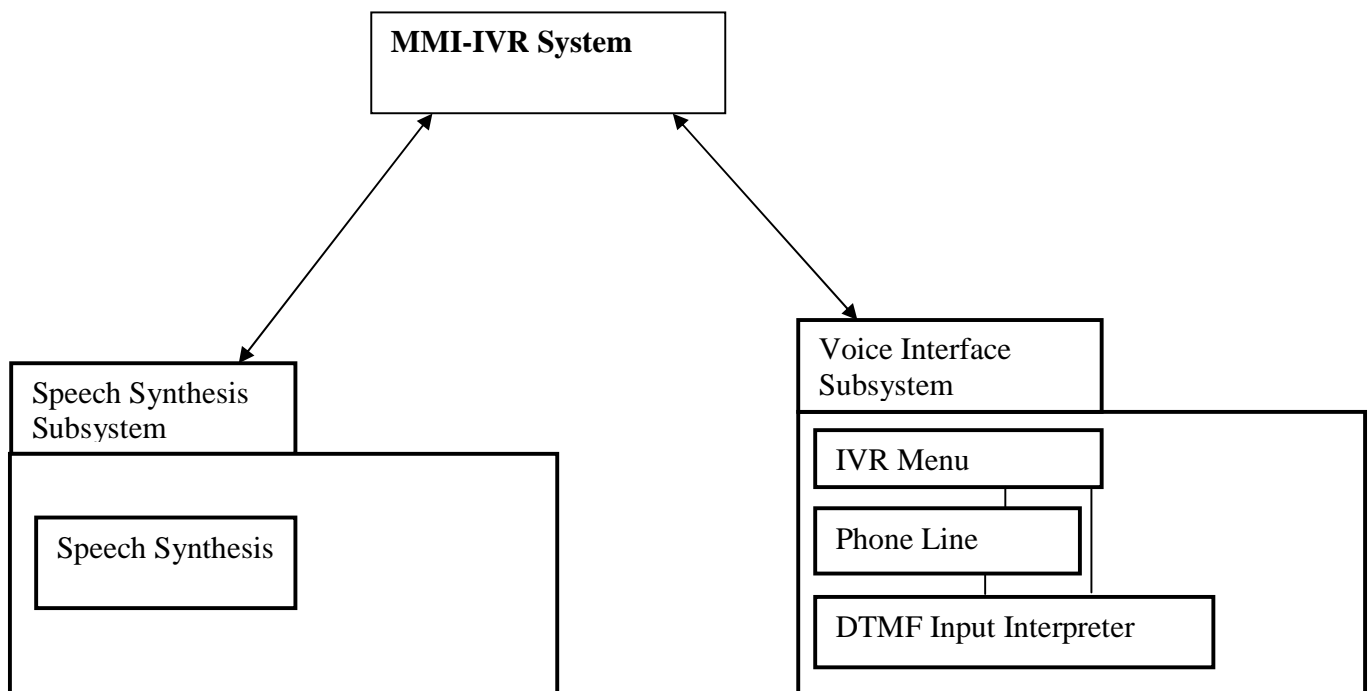


Figure 4.2: Layered Representation of the System

4.3.2. Voice Interface Subsystem

This subsystem is mainly responsible to manage issues related to voice menus handling, DTMF input interpret, reading database information and phone line handling. The subsystem also accepts telephone digits from the user and interprets the instruction and playback the requested information to the caller. The voice interface subsystem accepts inputs from the user and provides required information back to the caller via voice messages. The subsystem accepts DTMF digits via telephone keypad from the user over the telephone network. For example, when a user presses one on the telephone keypad, telephone digit of one will be sent to the subsystem via the telephone network. The subsystem detects the frequency and identifies the key. Touching a button generates a ‘tone’, which is a combination of two frequencies, one from lower band and other from upper band. For e.g. pressing push button ‘7’ transmits 852 and 1209 Hz.

Touch tone key pad

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

Figure 4.3: Typical 4 x 4 touch keypad

In the keypad ten keys of decimal digits are used to call required number. The touch-tone telephone produces decade or DTMF signals for DTMF type. The keypad produces two-tone sinusoidal outputs. Rows and columns determine the frequency. This keypad is working with different frequencies but only two frequencies are transmitted at a time. So the signal coming from this type of telephone is called Dual Tone Multi Frequency (DTMF).

Then, depending on the voice menu level, the key pressed will be interpreted accordingly. A sample interaction is presented on Figure 4.4, Figure 4.5 and Figure 4.6 using Flow chart.

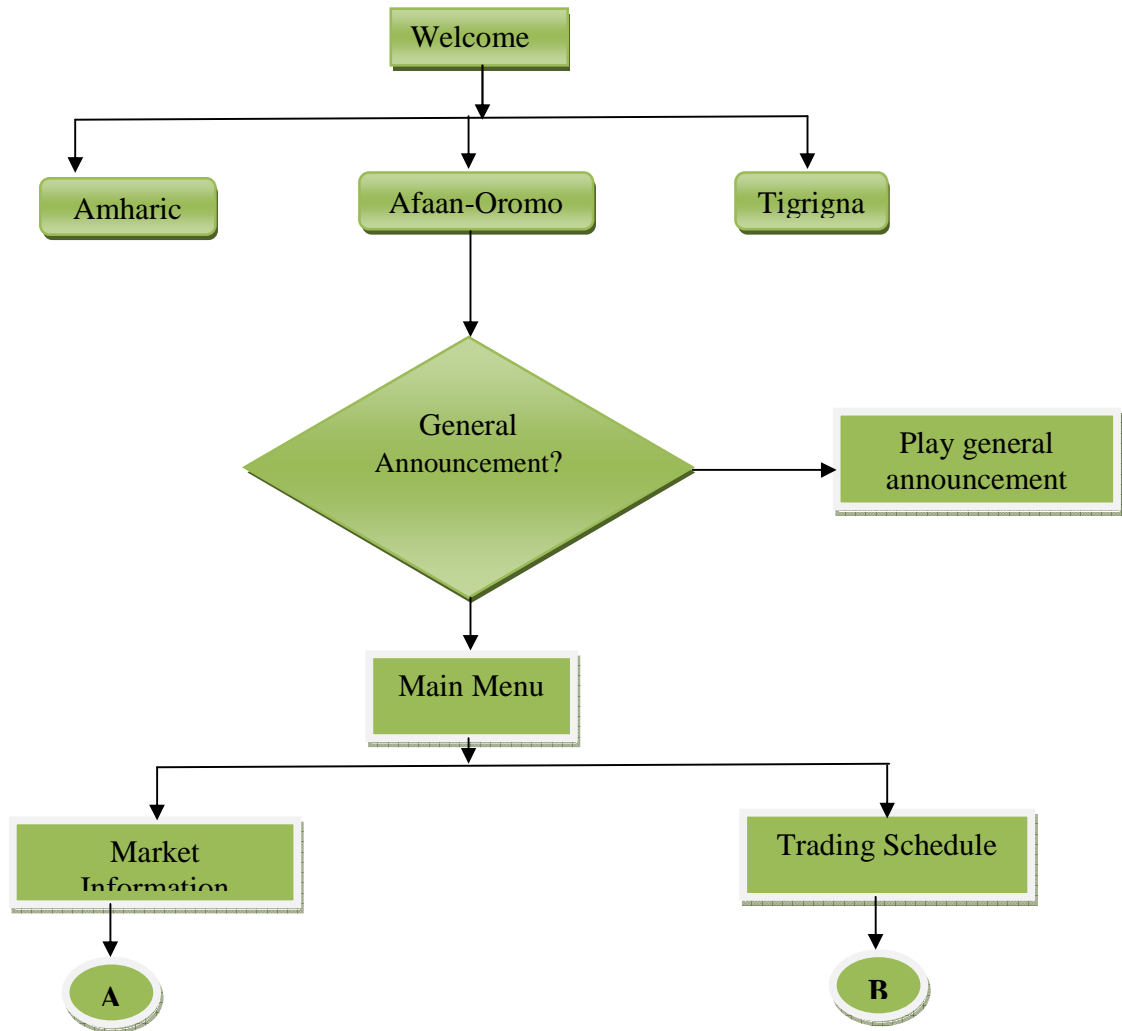


Figure 4.4: Voice Menu Flow

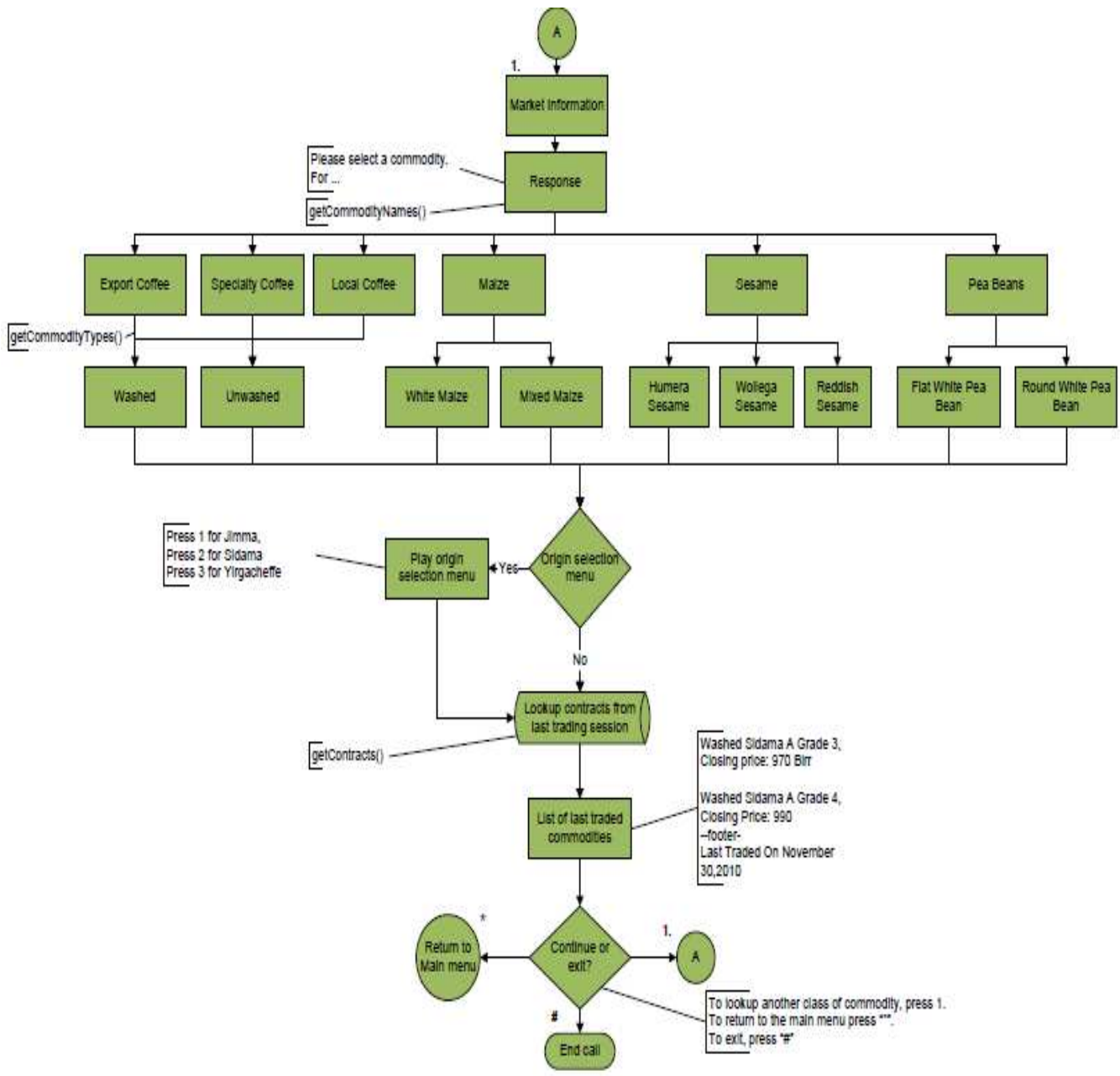


Figure 4.5: Market Information Voice Menu Flow

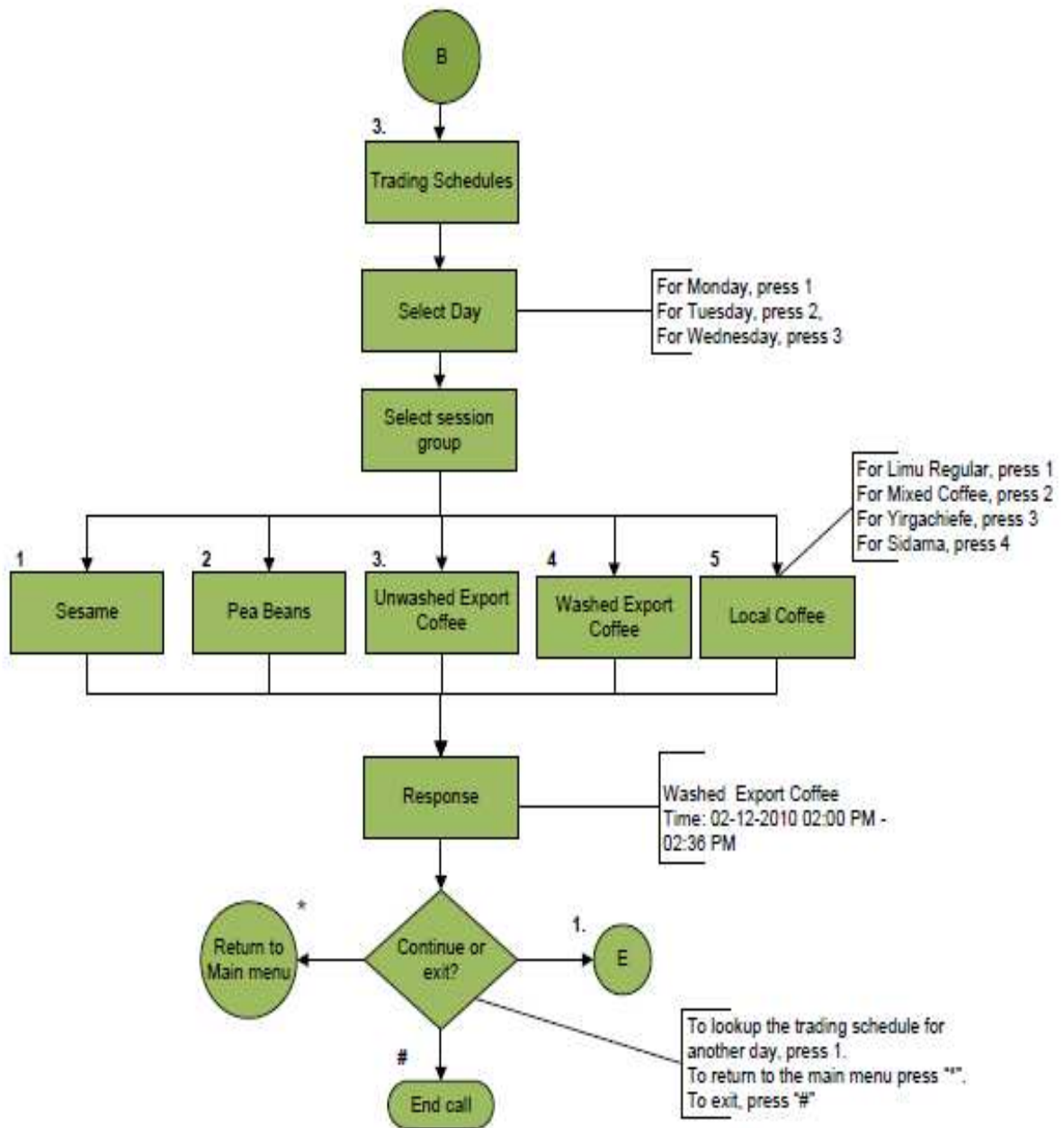


Figure 4.6: Trading Schedule Voice Menu Flow

The voice menu subsystem has several pre-recorded template files. Numbers, names of weeks, names of months, commodity items and common words related to market information, and application specific voice messages will be recorded and saved at a predefined location having a predefined file name. To understand how voice messages are built-up and played to the caller, let us assume that the user needs to know the market information for one of commodity item for specific day. To show the overall design process we need to look through starting from the immediate menu item (template file) that will be played back to the user by the IVR system. Let us assume that the price of 1 quintals of Bebek coffee for the day September five two thousand five is 1579.00 Birr and its rank is first. Amharic speaker can get the prompt information like “የ መስከረም 5 2005 ዓ.ም ዋጋ በበቃ ደረጃ አንድ የመግዥያ ዋጋ 1579 ብር : :” When this information is requested by the caller, the subsystem reads the information from the database and uses its template files to construct on voice message. More than one language can be implemented in the system. This makes the service friendlier to the users because some inhabitants of rural communities in isolated areas cannot speak English other than their local language very well.

4.3.3. Speech synthesis subsystem

This subsystem is responsible for converting text to the synthetic speech that is as close to real speech as possible according to the pronunciation norms of each language. In our system there are dynamically changing information that will be provided to the system like date, price information, type of market information. For this reason we had used speech synthesis system. In addition, all dynamic voice menus are generated by this subsystem. Synthesized speech can be created by concatenating pieces of recorded speech.

4.3.3.1. Building a unit Selection limited domain speech synthesis

Many speech applications have their speech output generated by some computed function. Although there are some truly open domains, like reading email, many systems are substantially limited. This may be as simple as slot-and filler templates, where some known set of names, prices, numbers, etc., and some standard prompts are used. Many IVR systems still use fully recorded prompts to keep quality up, at the price of resource footprint and flexibility. Our initial investigations into limited domain synthesizers were on market information. A key aspect of building a limited domain synthesizer is the design of a prompt list that adequately

covers the domain as shown below. Ideally, we like to have an explicit representation of the utterances that can be generated (e.g. the grammar or templates of the generation system) plus information about their frequency of use. From this, a prompt list can be generated to ensure frequent (and most important) forms will be well-represented, while coverage extends to all cases. Prompt design for Amharic language is shown below.

Amharic prompt template for speech synthesis:

- የ [ወረቀን ዓ.ም] ,ዋጋ , [ሀገር] ,ደረጃ , [ቁጥር] , የ መግዥያ ዋጋ , [የብር መጠን] ,ብር ::

Where:

- ወር = {መስከረም, ጥቅምት, ህዳር, ተህሳስ, ጥር, የካቲት, መጋብት, ምያዝያ, ግንቦት, ሰኔ, ሀምሌ, ነሀሴ, ጳጉሜ}
- ሀገር = {ሰዳማ, ልሙጽ, ይርጋ ጨፌ, መናጎ, ሀረር, ነቀምቴ, ጫካ, ቴፒ, ግምቤ, ከፋ, በበቃ, ጂማ}
- ቀን = {አንድ, ሁለት, ሶስት, አራት, አምስት, ስድስት, ሰባት, ስምንት, ዘጠኝ, አስር, አስራ, ሀያ, ሰላሳ}
- ዓ.ም = {ሁለት ሺህ አምስት, ሁለት ሺህ ስድስት, ሁለት ሺህ ሰባት, ሁለት ሺህ ስምንት, ሁለት ሺህ ዘጠኝ, ሁለት ሺህ አስር}
- ቁጥር = {አንድ, ሁለት, ሶስት, አራት, አምስት, ስድስት, ሰባት, ስምንት, ዘጠኝ, አስር, አስራ, ሀያ, ሰላሳ, አርባ, ሀምሳ, ስልሳ, ሰባ, ሰማንያ, ዘጠና, መቶ, ሺህ}
- የብር መጠን = {አንድ, ሁለት, ሶስት, አራት, አምስት, ስድስት, ሰባት, ስምንት, ዘጠኝ, አስር, አስራ, ሀያ, ሰላሳ, አርባ, ሀምሳ, ስልሳ, ሰባ, ሰማንያ, ዘጠና, መቶ, ሺህ}

Afan Oromo prompt template for speech synthesis:

- kan [Ji'a Guyyaa Waggaa], Gatii, [Biyya], Sadarkkaa, [Lakkofsa], Gatii Bittaa, Qarshii, [Gatii]

Where

- Ji'a = { Fulbbaana, Onkololeessa, Sadaasa, Muddee, Amajjii, Gurraandhala, Bitootessa, Eebila, Caamsaa, Waxabajji, Adooleessa, Haagayya }
- Guyyaa = { Tokko, Lama, Sadii, Afur, Shan, Ja'a, Torba, Saddeet, Sagal, Kudhan, Kudha, Digdama, Soddoma, Afurtama, Shantama, Jaatama, Torbbaatama, Saddeettama, Sagaltama, Dhibba, Kuma, Digdammii, Soddommii, Afurtammii, Shantammii, Jaatammii, Torbbatammii, Saddeettammii, Sagaltammii, }
- Waggaa = { Kuma Lamaa fi Shan, Kuma Lamaa fi ja'a, Kuma Lamaa fi torba, Kuma Lamaa fi saddet, Kuma Lamaa fi sagal, Kuma Lamaa fi kudhan }
- Biyya = { Siidaama, Limmuu, Yirggaacoffee, Wonaagoo, Harara, Naqamte, Caakkaa, Teeppii, Kafaa, Babbaqaa, Jimmaa }

- Gatii = { Tokko, Lama, Sadii, Afur, Shan, Ja'a, Torba, Saddeet, Sagal, Kudhan, Kudha, Digdama, Soddoma, Afurtama, Shantama, Jaatama, Torbbaatama, Saddeettama, Sagaltama, Dhibba, Kuma, Digdamii, Soddonii, Afurtamii, Shantamii, Jaatamii, Torbbatamii, Saddeettamii, Sagalttamii }
- Yeroo Bitta fi Gurgurtaa jalqaba [**Lakkofsa**] Sa,atii Xumura [**Lakkofsa**] Sa'atii

Where

Lakkofsa = { Tokko, Lama, Sadii, Afur, Shan, Ja'a, Torba, Saddeet, Sagal, Kudhan, Kudha }

In [40] it is defined that the development of a limited domain synthesis voice with the FestVox tools as involving the following steps:

- Design the recording corpus
- Synthesize the recording corpus with e.g. Festival
- Record the voice talent
- Label the recordings
- Extract Pitch-marks
- Extract Pitch-synchronous parameters
- Build a cluster unit selection synthesizer
- Test and Tune

For all of the limited domain systems we have built, we have recorded directly to computer files. Most commonly we use a laptop (not connected to the mains power) in a quiet room to reduce background noise. All the prompts are recorded by female native speaker with the objective to meet the desired style for the synthesizer. We have used 82 sample utterances for Amharic speech synthesis in market information domain. After recording, we label the text using a simple but effective technique based on [38]. We have labeled the speech data base thoroughly using a tool called Wave Surfer. Figure 5.2 shows sample labeled sentence using wave surfer tool.

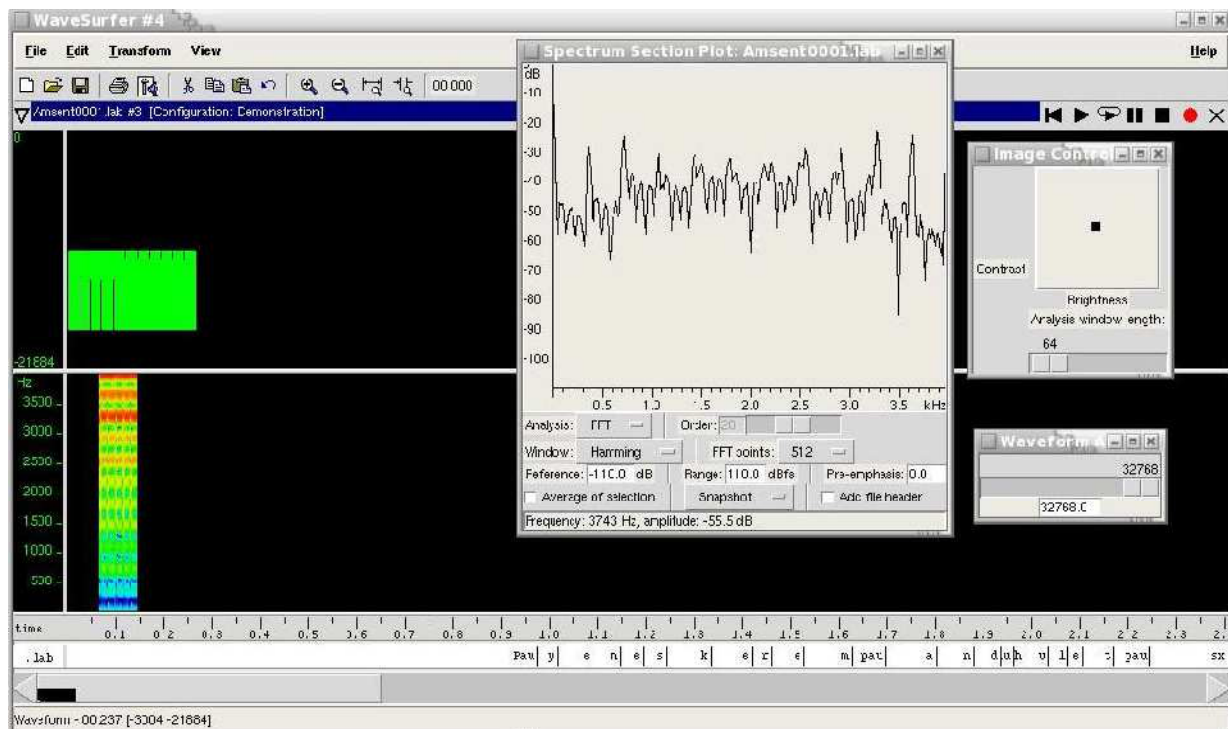


Figure 4.5: Speech analysis using wave surfer

In order to suit the requirement of Festival framework generated label files are converted into Festival label file format. Sample labeled speech is included in Appendix D. As we know the position of the labels in the synthesized prompt, we can map this onto the collected recording. This technique was originally developed for labeling diaphone data, where the phonetics are much more clearly defined, but we have found this technique perfectly adequate for this task also. In fact, there are distinct advantages of this often loose labeling over hand crafted low level phonetic labeling. The label files generated using Wave Surfer were not directly used to generate the utterance structure since there is a difference in data format needed by Festival, which are used to generate the utterance structure. Hence, in this thesis the format of the label file generated by Wave Surfer is changed by the wave surfer to corresponding data format.

Once utterance structure is generated for each utterance we have done the next step to generate speech clusters and have built the synthesizer. The final stage in building a cluster model is to collect the generated trees into a single file and dumping the catalogue, i.e., the list of unit names and their files and position in them.

4.4. Hardware / Software Mapping

One of the major tasks in system design deals with hardware/software mapping which deals with which components would be part in which hardware and software.

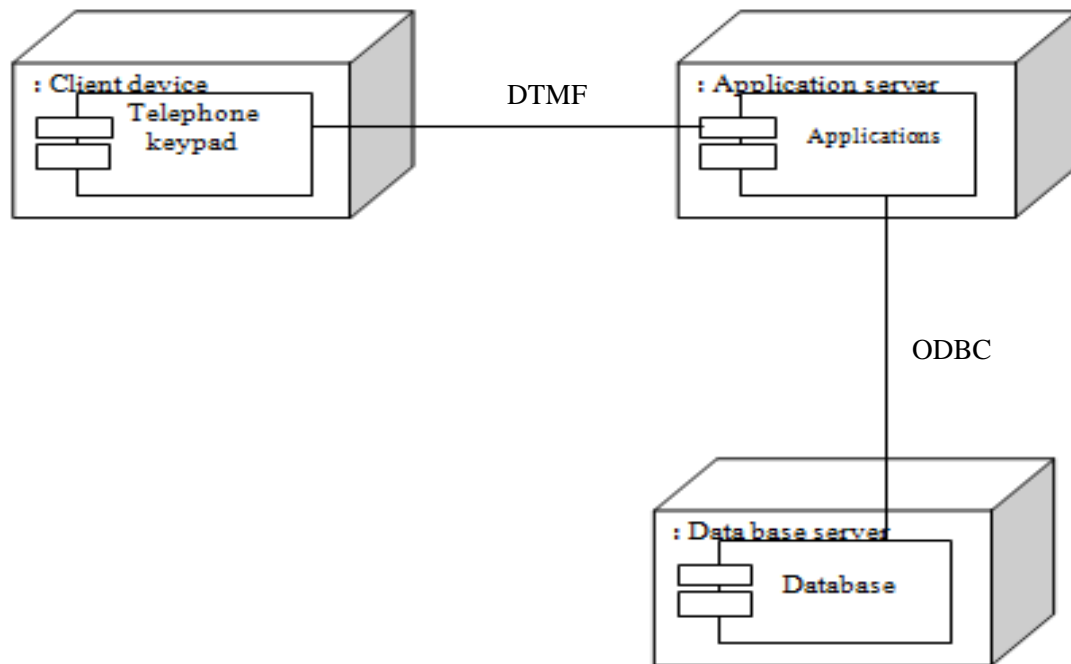


Figure 4.6: Deployment Diagram of the System

4.5. Persistent Data Management

Persistent data management deals with how the persistent data (file, database, etc) are stored and managed and it outlives a single execution of the system. Market price information has to be persistently kept in the market information database.

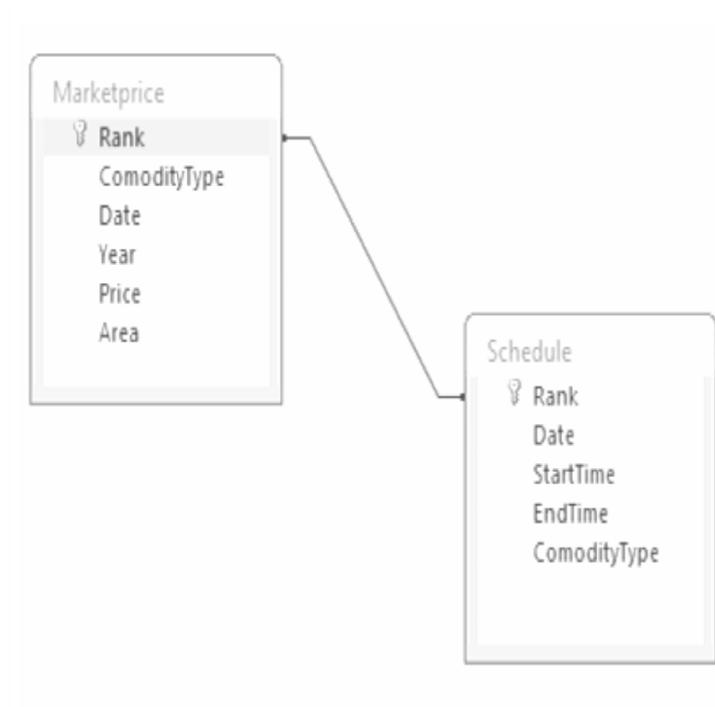


Figure 4.7: Relationship among tables

CHAPTER FIVE

IMPLEMENTATION

In this chapter, tools used in developing the prototype and the developed system are described.

6.1. System Development

Several tools and technologies were utilized for the purpose of developing the prototype implementation. The following tools are used in developing the prototype of the system.

Asterisk Server

Asterisk is an open source framework for building communications applications. Asterisk 1.8.10.1 is used to turn an ordinary computer into a communications server. For this research asterisk 1.8.10.1 has provided a wealth of functions that make it a powerful IVR system, audio playback, digit collection, database integration, and speech synthesis. For the prototype implementation of this project asterisk server is used as replacement of the traditional PBX as software for switching calls, managing routes, enabling features, and connecting callers with outside world over IP, analog lines, and digital (T1/E1) connections. We have used ubuntu 10.4 operating system for our prototype. Figure interface show asterisk server.

Dial plan language

This component is the heart of Asterisk system. In the dialplan we defined how calls flow into and out of the system. It is a form of scripting language and contains instructions that asterisk follows in response to external triggers. The dial plan is the heart of MMI-IVR system. In contrast to traditional phone systems, it is fully customizable form of scripting language, used to define how calls flow into and out of the system. The Asterisk dialplan is specified in the configuration file named *extensions.conf*. The content of “*extensions.conf*” is organized in four main sections: contexts, extensions, priorities, and applications. This can be either for static setting and definitions, or for executable dialplan components in which case they are referred to as contexts. The settings sections are general and global and the names of contexts are entirely defined by the system administrator. Every section in “*extensions.conf*” starts with the name of the section contained within square brackets. In asterisk, an extension is used to define the

unique series of steps (each containing an application) through which asterisk will take that call. Within each context, we define as many extensions as required. When dealing a particular extension is triggered (by incoming call or by digits being dialed on a channel), asterisk will follow the steps defined for that extension. It is the extensions that specify what happens to calls as they make their way through dial plan. Each extension can have multiple steps, called priorities. The priorities are numbered sequentially, starting with 1, and each executes one specific application. Applications are the workhorses of the dial plan. Each application performs a specific action on the current channel, such as playing a sound, accepting touch tone input, looking something up in database, dialing a channel, hanging up call, and so forth. In our operating environment the dial plan is located on directory */etc/asterisk/extensions.conf*. The configuration file "*extensions.conf*" contains the "dial plan" of Asterisk, the master plan of control or execution flow for all of its operations.

Asterisk Gateway Interface

Asterisk gateway interface is used as a media gateway, bridging the legacy PSTN to the expanding world of IP telephony. The Asterisk Gateway Interface (AGI) powerful interface to Asterisk used for implementing the proposed multilingual interactive voice response system in PHP programming language.

Festival (Festvox)

Festival is an open source text to speech system developed at the University of Edinburgh. Festival offers a free, portable, language independent, run-time speech synthesis engine for various platforms under various APIs. [40]. Festival is used to develop prototype of text to speech for Amharic language.

PHP

Is a programming language used to develop IVR system on AGI script, using the PHP scripting language. This is a major component of the system developed using PHP programming language. The system call flow is implemented based on the design of the multilingual IVR tree structure, shown in appendix A and appendix B. With the introduction of the Asterisk Open Source PBX, it was required to establish a method for third party programs to interact with Asterisk, for our prototype demonstration the AGI interface is used.

Asterisk Gateway Interface (AGI) enables the development of Asterisk enabled applications without the need of modifying the Asterisk core. Asterisk communicates with MMI-IVR AGI scripts via STDIN/STDOUT. When a AGI script is invoked from within the Asterisk dial-plan, the following steps always happen: Asterisk forks out and runs the MMI-IVR application in its own user space. All channel variables that were available to the Asterisk dial-plan, prior to executing the MMI-IVR AGI script are available to the AGI script. Asterisk sends out a bunch of information that must be handled before the MMI-IVR AGI script actually starts running. Finally the MMI-IVR logic runs at this point. During the implementation of MMI-IVR application we have used an AGI wrapper classes PHPAGI. PHPAGI is built from three different classes for programming AGI scripts, `phpagi.php`, `phpagi-asmanager.php` and `phpagi-fastagi.php`. Sample code for MMI-IVR AGI script is on appendix C.

X-Lite soft phone

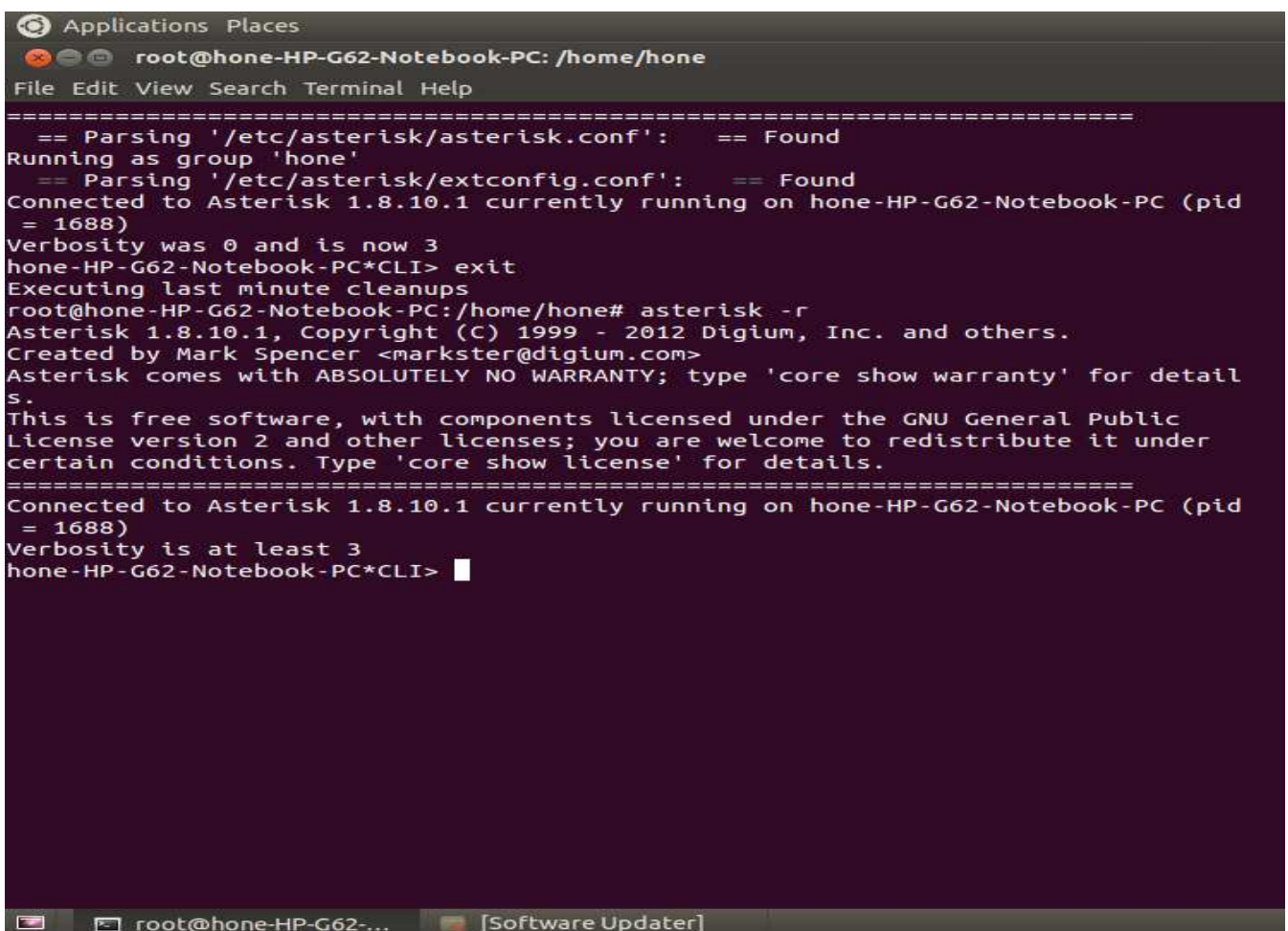
X-lite is a proprietary freeware VoIP soft phone that uses the Session Initiation Protocol. In order to test the functionality of our new system, software that emulates telephone is needed. We opted for latter while testing and used x-lite soft phone. This application used as phone interface to communicate with MMI-IVR system. It uses UDP port 5060 and TCP port 10000:20000. For our prototype implementation the soft phone is installed on windows 7 operating system machine and connected with the asterisk server via peer to peer connection.

6.2. Prototype

Here, the implemented system is described. How the user interacts with the system and some of the results of interaction with the system along with the screen shots are described. From the developer point of view multilingual market information IVR system have three major components, user, asterisk server and MMI-IVR application. In this system user interact by using telephone keypad with the asterisk server and then the asterisk server have dial plan which is used to define how calls flow into and out of the system. When messages are received on this channel to asterisk server, the message is sent to the MMI-IVR application for processing using Asterisk's Application Gateway Interface (AGI). Finally, the MMI-IVR

will interact with the user on the channel based on predefined IVR process tree on MMI-IVR application. Implementation detail is described as follows:

In order to use MMI-IVR system the Administrator must be logging to the system and then it must start service of the asterisk server. When the administrator starts service of the asterisk server, the interface shown in Figure 5.1 will be displayed which will be used to start MMI-IVR server.

A terminal window titled 'Applications Places' showing the Asterisk server startup process. The user is logged in as root on a machine named 'hone-HP-G62-Notebook-PC'. The terminal output shows the Asterisk service being started with the command 'asterisk -r'. The output includes configuration file parsing for '/etc/asterisk/asterisk.conf' and '/etc/asterisk/extconfig.conf', both found. It also shows the Asterisk version (1.8.10.1) and copyright information (1999-2012 Digium, Inc.). The user enters 'exit' to leave the Asterisk CLI, and the terminal returns to the root shell prompt. The terminal window has a menu bar with 'File Edit View Search Terminal Help' and a taskbar at the bottom showing the terminal window and a 'Software Updater' icon.

```
=====  
== Parsing '/etc/asterisk/asterisk.conf': == Found  
Running as group 'hone'  
== Parsing '/etc/asterisk/extconfig.conf': == Found  
Connected to Asterisk 1.8.10.1 currently running on hone-HP-G62-Notebook-PC (pid  
= 1688)  
Verbosity was 0 and is now 3  
hone-HP-G62-Notebook-PC*CLI> exit  
Executing last minute cleanups  
root@hone-HP-G62-Notebook-PC:/home/hone# asterisk -r  
Asterisk 1.8.10.1, Copyright (C) 1999 - 2012 Digium, Inc. and others.  
Created by Mark Spencer <markster@digium.com>  
Asterisk comes with ABSOLUTELY NO WARRANTY; type 'core show warranty' for detail  
s.  
This is free software, with components licensed under the GNU General Public  
License version 2 and other licenses; you are welcome to redistribute it under  
certain conditions. Type 'core show license' for details.  
=====  
Connected to Asterisk 1.8.10.1 currently running on hone-HP-G62-Notebook-PC (pid  
= 1688)  
Verbosity is at least 3  
hone-HP-G62-Notebook-PC*CLI> █
```

Figure 5.1: Asterisk Server after the administrator starts the service

Once the asterisk server is started, the next step is to start the AGI call transmission channel as shown in Figure 5.2 which leads MMI-IVR system to be ready to accept calls from the user.

```
Applications Places
root@hone-HP-G62-Notebook-PC: /home/hone
File Edit View Search Terminal Help
root@hone-HP-G62-Notebook-PC:/home/hone# asterisk -rv
Asterisk 1.8.10.1, Copyright (C) 1999 - 2012 Digium, Inc. and others.
Created by Mark Spencer <markster@digium.com>
Asterisk comes with ABSOLUTELY NO WARRANTY; type 'core show warranty' for details.
This is free software, with components licensed under the GNU General Public
License version 2 and other licenses; you are welcome to redistribute it under
certain conditions. Type 'core show license' for details.
=====
Running as group 'hone'
Connected to Asterisk 1.8.10.1 currently running on hone-HP-G62-Notebook-PC (pid = 1688)
Verbosity is at least 3
hone-HP-G62-Notebook-PC*CLI> agi set debug on
AGI Debugging Enabled
hone-HP-G62-Notebook-PC*CLI> █
```

Figure 5.2: Asterisk AGI enabled

User is able to access multilingual market information by dialing IVR specific number. For our demonstration we have used X-lite soft phone as shown in Figure 5.3. The user will dial the IVR number, this will enable the user to have directly connected to MMI-IVR server.



Figure 5.3: X-lite Soft phone

Snapshots taken for asterisk server are from Ubuntu 10.4 operating system and the soft phone is taken from windows 7 operating system. The two workstations are connected via peer to peer connection.

Once the user is connected to the system as shown in Figure 5.4, MMI-IVR system will prompt “ይህ የኢትዮጵያ ምርት ገበያ የገበያ ዋጋ የመረጃ መስመር ነጩ”, “kuuni seereroo odefenno omishaa geeti gaabai Ethiopiat” and “እዚ ናይ ኢትዮጵያ ምህርቲ ዕድገት ናይ መረጃ መስመር እዩ” and enable the user to select his local language by playing the prompt “ለ አማርኛ አንድን ይጫኑ” , “Afaan Oromo fi lemma geedii qabaa”, “ንናይ ትግርኛ 3 ቁፀሪ ይፀዓኑ”.

```

root@hone-HP-G62-Notebook-PC: /usr/src/xten-xtlite
root@hone-HP-G62-Notebook-PC: /home/hone

-- Time to restore hints and swap in new dialplan: 0.000003 sec
-- Time to delete the old dialplan: 0.000046 sec
-- Total time merge_contexts_delete: 0.001018 sec
== Using SIP RTP CoS mark 5
-- Executing [6001@internal:1] Answer("SIP/6001-00000005", "") in new stack
-- Executing [6001@internal:2] Wait("SIP/6001-00000005", "10") in new stack
-- Executing [6001@internal:3] Playback("SIP/6001-00000005", "1-for-am-2-for-pm") in new stack
-- <SIP/6001-00000005> Playing '1-for-am-2-for-pm.gsm' (language 'en')
-- Executing [6001@internal:4] AGI("SIP/6001-00000005", "main_agi.php") in new stack
-- Launched AGI Script /var/lib/asterisk/agi-bin/main_agi.php
<SIP/6001-00000005>AGI Tx >> agi_request: main_agi.php
<SIP/6001-00000005>AGI Tx >> agi_channel: SIP/6001-00000005
<SIP/6001-00000005>AGI Tx >> agi_language: en
<SIP/6001-00000005>AGI Tx >> agi_type: SIP
<SIP/6001-00000005>AGI Tx >> agi_uniqueid: 1366357215.5
<SIP/6001-00000005>AGI Tx >> agi_version: 1.8.10.1
<SIP/6001-00000005>AGI Tx >> agi_callerid: 6001
<SIP/6001-00000005>AGI Tx >> agi_calleridname: hone
<SIP/6001-00000005>AGI Tx >> agi_callingpres: 0
<SIP/6001-00000005>AGI Tx >> agi_callingani2: 0
<SIP/6001-00000005>AGI Tx >> agi_callington: 0
<SIP/6001-00000005>AGI Tx >> agi_callingtns: 0
<SIP/6001-00000005>AGI Tx >> agi_dnid: 6001
<SIP/6001-00000005>AGI Tx >> agi_rdnis: unknown
<SIP/6001-00000005>AGI Tx >> agi_context: internal
<SIP/6001-00000005>AGI Tx >> agi_extension: 6001
<SIP/6001-00000005>AGI Tx >> agi_priority: 4
<SIP/6001-00000005>AGI Tx >> agi_enhanced: 0.0
<SIP/6001-00000005>AGI Tx >> agi_accountcode:
<SIP/6001-00000005>AGI Tx >> agi_threadid: -1256924352
<SIP/6001-00000005>AGI Tx >>
-- <SIP/6001-00000005>AGI Script main_agi.php completed, returning 0
-- Executing [6001@internal:5] Hangup("SIP/6001-00000005", "") in new stack
== Spawn extension (internal, 6001, 5) exited non-zero on 'SIP/6001-00000005'
hone-HP-G62-Notebook-PC>

```

Figure 5.4: MMI-IVR server on call progress

The interface used to communicate the user with MMI-IVR system is using voice prompt that is designed based on the user requirement. After the user follows what the system speaks he/she will get appropriate market information by its own local language.

CHAPTER SIX

EVALUATION OF MMI-IVR

In this chapter we conducted usability test for the MMI-IVR and speech synthesis system. In the following sections we present the method and the data used to conduct the evaluation. Finally the results of the evaluation will be presented.

6.1. Usability Test

6.1.1. Methods

As explained in the introduction, all the subjects in this study were literate and semi literate farmers. To test the usability of the system we have collected questionnaire from rural area farmers. The questionnaire is prepared for MMI-IVR system which contains 13 questions in two parts as indicated in appendix E. The prepared questioners were translated to each language (Amharic, Afaan-Oromo and Tigrigna). The MMI-IVR system usability test was conducted with 37 participants recruited from rural area farmers.

The participants were selected by non probability sampling techniques through convenience sampling. However, the nature of the test was introduced to the selected participants by the researcher before collecting the questioners. They were asked to fill prepared questionnaires. We managed to recruit 15 Amharic, 13 Afaan-Oromo and 9 Tigrigna speaking participants each with a 50-50 gender mix and a good age group distribution. We looked for participants who were primarily from a non-technical background and had varied prior experience with IVR systems.

6.2. Test Result and Discussion

To test usability of the system, five scale likert questions were prepared and distributed to Amharic, Afaan Oromo and Tigrigna speaker who would use the service. Thirty seven questions were filled and collected from respondents (15 from Amharic speakers, 13 from Afaan-Oromo speakers and 9 from Tigrigna speakers). The collected data were presented in the form of tables and charts and were analyzed using descriptive statistical tools basically through averages (means) and standard deviation. The mean results of the study shows the average degree of agreement between respondents and the results of standard deviation tells that how respondents deviate from the means(averages). The results of usability test of the system from three languages are presented separately as follows;

Table 6.1: Usability result for Amharic language questioner

Questions	N	Mean	Std. Deviation
I found this service easy to use	15	4.47	.743
I felt very frustrated using this service	15	1.40	.632
I thought some of the choices were confusing	15	2.07	.884
The operators voice was very clear	15	4.60	.632
I left with good impression of that organization	15	4.27	.594
I thought the operator spoke too quickly	15	1.20	.561
The amount of information i had to input was minimal	15	4.93	.258
The menus always made sense	15	4.33	.724
I could recover easily if i made a mistake	15	4.73	.458
I was directed to the correct market information	15	4.27	1.100
Valid N	15		

Source: Survey Result (2014)

Fifteen Amharic speakers (respondents) were asked to fill the questionnaire prepared for testing the system. Accordingly, Table 6.1 shows degree of agreement to use the system; the mean result of easiness to use the service is 4.47 with a standard deviation of 0.743, the mean result of degree of frustration in using this service is 1.40 with a standard deviation of 0.632, the mean result of availability of confusing menu choices is 2.07 with a standard deviation of 0.884, the mean result of clarity of operator's voice is 4.60 with a standard deviation of 0.632, the mean result of degree of impression towards the organization is 4.27 with a standard

deviation of 0.594 , the mean result of too quick operator’s speech is 1.20 with a standard deviation of 0.561 , the mean result of minimal input information required is 4.93 with a standard deviation of 0.258, the mean result of sense of menu structure is 4.33 with a standard deviation of 0.724, the mean result of easiness of system recovery is 4.73 with a standard deviation of 0.458, and the mean result of system’s ability to the direct market information is 4.27 with a standard deviation of 1.10. Therefore, those questions having mean value greater than or equal to four shows that respondents were agreed upon the specific measures of the service functionality and the mean values results for degree of frustration in using this service, availability of confusing menu choices and too quick operator’s speech fall in strongly disagree and disagree. The standard deviation result (below one) also supports respondents were not deviated from the mean value except for ability of the system to direct market information having a standard deviation of 1.10.

Table 6.2: Usability result for Afaan Oromo language questioner

Questions	N	Mean	Std. Deviation
I found this service easy to use	13	4.69	.630
I felt very frustrated using this service	13	1.46	.660
I thought some of the choices were confusing	13	1.92	.954
The operators voice was very clear	13	4.62	.650
I left with good impression of that organization	13	4.23	.599
I thought the operator spoke too quickly	13	1.23	.439
The amount of information i had to input was minimal	13	4.85	.376
The menus always made sense	13	4.46	.660
I could recover easily if i made a mistake	13	4.77	.439
I was directed to the correct market information	13	4.62	.650
Valid N	13		

Source: Survey Result (2014)

Thirteen Afaan Oromo speakers (respondents) were asked to fill the questionnaire prepared for testing the system. Accordingly, Table 6.2 shows degree of agreement to use the system; the mean result of easiness to use the service is 4.69 with a standard deviation of 0.630, the mean result of degree of frustration in using this service is 1.46 with a standard deviation of 0.660, the mean result of availability of confusing menu choices is 1.92 with a standard deviation of 0.954, the mean result of clarity of operator’s voice is 4.62 with a standard

deviation of 0.650, the mean result of degree of impression towards the organization is 4.23 with a standard deviation of 0.599, the mean result of too quick operator's speech is 1.23 with a standard deviation of 0.439, the mean result of minimal input information required is 4.85 with a standard deviation of 0.376, the mean result of sense of menu structure is 4.46 with a standard deviation of 0.660, the mean result of easiness of system recovery is 4.77 with a standard deviation of 0.439, and the mean result of system's ability to the direct market information is 4.62 with a standard deviation of 0.650. Therefore, those questions having mean value greater than or equal to four shows that respondents were agreed upon the specific measures of the service functionality and the mean values results for degree of frustration in using this service, availability of confusing menu choices and too quick operator's speech fall in strongly disagree and disagree. The standard deviation result (below one) also supports respondents were not deviated from the mean value.

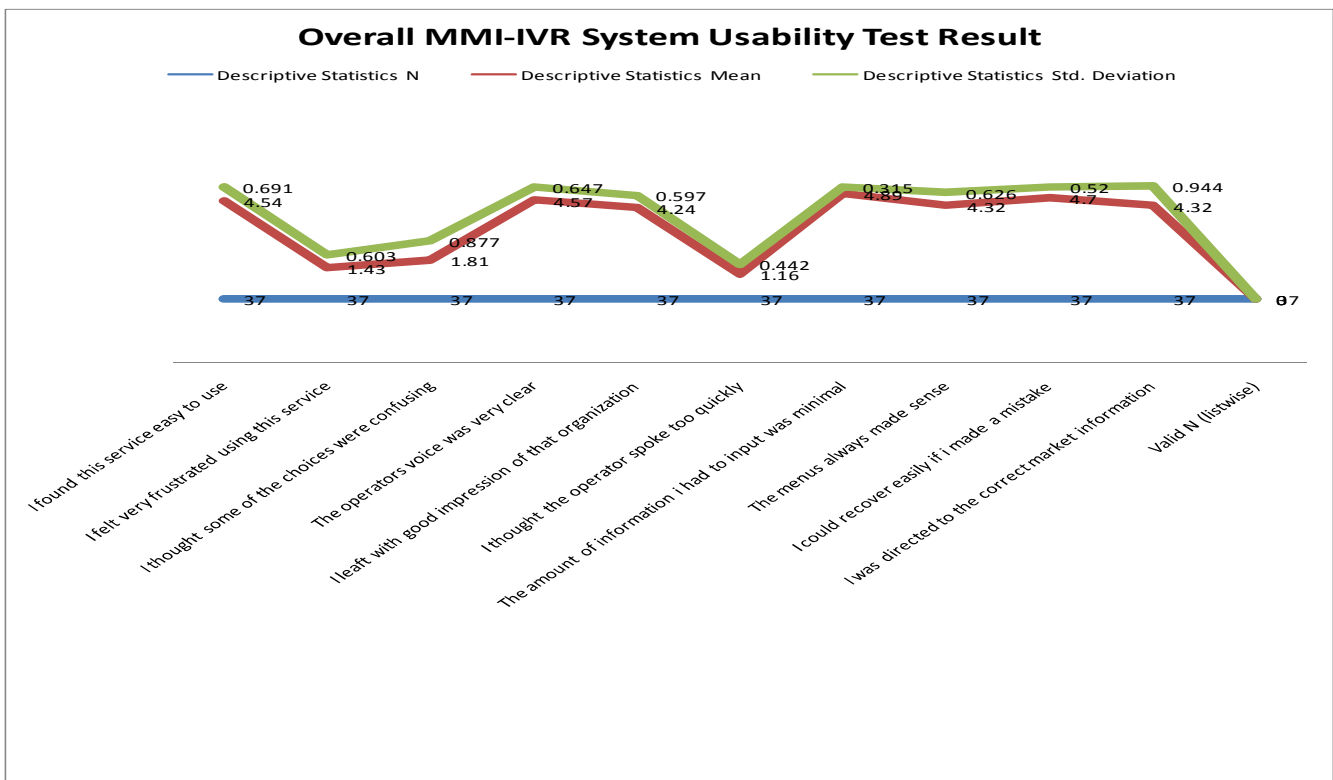
Table 6.3: Usability result for Tigrigna language questioner

Questions	N	Mean	Std. Deviation
I found this service easy to use	9	4.44	.726
I felt very frustrated using this service	9	1.44	.527
I thought some of the choices were confusing	9	1.22	.441
The operators voice was very clear	9	4.44	.726
I left with good impression of that organization	9	4.22	.667
I thought the operator spoke too quickly	9	1.00	.000
The amount of information i had to input was minimal	9	4.89	.333
The menus always made sense	9	4.11	.333
I could recover easily if i made a mistake	9	4.56	.726
I was directed to the correct market information	9	4.00	1.000
Valid N	9		

Source: Survey Result (2014)

Nine speakers (respondents) were asked to fill the questionnaire prepared for testing the system. Accordingly, Table 6.3 shows degree of agreement to use the system; the mean result of easiness to use the service is 4.44 with a standard deviation of 0.726, the mean result of degree of frustration in using this service is 1.44 with a standard deviation of 0.527, the mean result of availability of confusing menu choices is 1.22 with a standard deviation of 0.441, the mean result of clarity of operator's voice is 4.44 with a standard deviation of 0.726, the mean

result of degree of impression towards the organization is 4.22 with a standard deviation of 0.667, the mean result of too quick operator's speech is 1.00 with a standard deviation of 0.00, the mean result of minimal input information required is 4.89 with a standard deviation of 0.333, the mean result of sense of menu structure is 4.11 with a standard deviation of 0.333, the mean result of easiness of system recovery is 4.56 with a standard deviation of 0.726, and the mean result of system's ability to the direct market information is 4.00 with a standard deviation of 1.00. Therefore, those questions having mean value greater than or equal to four shows that respondents were agreed upon the specific measures of the service functionality and the mean values results for degree of frustration in using this service, availability of confusing menu choices and too quick operator's speech fall in strongly disagree and disagree. The standard deviation result (below one) also supports respondents were not deviated from the mean value.



Source: Survey Result (2014)

Figure 6.1: MMI-IVR system usability result

Thus, the overall analysis result shows, MMI-IVR system is functional in terms of speech naturalness, designed menu structure, and customer satisfaction as depicted on Figure 6.1. It is also seen that the MMI-IVR system disseminates complete, accurate and timely information for all involved stakeholders in understandable format and with relevant interface. This shall be based on rural connectivity, content applicability and capacity to scale besides being affordable and participatory and not determined by geographic proximity, while benefiting all the stakeholders who involve in agricultural innovation process. On top of this, the national and occasionally even regional variation in market information delivery is addressed by the system when compared with the existing Ethiopian Commodity IVR system.

CHAPTER SEVEN

CONCLUSION AND FUTURE WORK

7.1. CONCLUSION

Interactive Voice Response System has been the latest technology; each provides the foundation for providing convenient new IVRS services for customers as well as reduced operational costs, improved customer satisfaction and retention, increased return on investment and a stronger market presence for the IVRS services provider.

Therefore, multilingual market information interactive voice response system is designed and implemented. In order to design the MMI-IVR system architecture, the functional and non-functional requirements are identified and analyzed using the use case diagram, class diagram and activity diagram. The proposed multilingual market information interactive voice response system uses three-tier architecture model, which is the fundamental framework for the logical design model, which segments an application's components into three tiers of services namely, the presentation tier, the middle tier, and the data tier. The top layer of the presentation logic is service delivery which is mainly used as an interface to farmers and traders, which are located at distant locations, via the telephone network. The second level of the architecture is middle tiers that accepts inputs from the user and provide required information back to the caller via voice messages. This tier accepts telephone digits from the user over the telephone network. The presentation logic has several pre-recorded template files. Numbers, names of weeks, names of months and common words used for communication, and application specific voice messages will be recorded and saved at a predefined location having a predefined file name. When market information is requested by the caller, the presentation logic reads the information from the database and uses its template files to construct on voice message. To accomplish this, it uses the pre-recorded template files, and dynamically generated information which basically done in this tier by text to speech engine. For our demonstration purpose we use three main Ethiopian languages Amharic, Afaan Oromo and Tigrigna languages. The third tier of the architecture is data tier which consists General IS4A database. General IS4A database contains heterogeneous collection of information about the market price information (which will be updated either online or

offline), that is stored by any existing (commercial) commodity exchange. Therefore, we can use this data base as an input for our system.

During implementation this project has shown how easy it is for services to be created in Asterisk. It has also illustrated that these services can be extended so that they are accessible from any interface or device, integrated with text to speech engine and that they can be expanded so that their functionality reaches deep into the system, allowing the users total control over their environment. In addition, it has investigated and documented various open source systems that were used in achieving these goals, and shown that they are mature enough and stable enough to be used in the deployment of a production telephony system. The flow of MMI-IVR system looks like when the user interact by using telephone keypad with the asterisk server and then the asterisk server has dial plan which is used to define how calls flow into and out of the system. When messages are received on this channel to asterisk server, the message is sent to the MMI-IVR application for processing using Asterisk's Application Gateway Interface (AGI). Finally, the MMI-IVR will interact with the user on the channel based on predefined IVR process tree on MMI-IVR application.

Evaluation of MMI-IVR and speech synthesis is conducted by involving 37 people who are speakers of each language (15 from Amharic, 13 from Afaan-oromo and 9 from Tigrigna). MMI-IVR systems evaluation results have shown that the system provide good quality speech in terms of naturalness, is easy to navigate and functional in terms of designed menu structure, and it gives customer satisfaction. It is also seen that the MMI-IVR system disseminates complete, accurate and timely information for all involved stakeholders in understandable format and with relevant interface. This shall be based on rural connectivity, content applicability and capacity to scale besides being affordable and participatory and not determined by geographic proximity, while benefiting all the stakeholders who involve in agricultural innovation process. On top of this, the national and occasionally even regional variation in market information delivery is addressed by the system when compared with the existing Ethiopian Commodity IVR system.

7.2. FUTURE WORK

In order to increase the naturalness of IVR system and also to integrate high quality of synthetic speech to be produced by Amharic, Afan-oromo and Tigrigna speech synthesis systems. We would like to recommend the following future works:

- Since the content of the MMI-IVR system service is limited only to information on best selected commodity items, there is of course a need to extend the content so that it suits the needs of more farmers.
- The first and most important step of extending the content of the service would be to add information about livestock. As the amount of information provided in the service increases, it is even more important to maintain easy navigation within the system. One possibility might be to have separate phone numbers for different crops and livestock so that the time of the phone call will be as short as possible.
- In the future, it would be good to be able to give different information for different regions. Market information is one obvious topic that should be regionalized, but also perhaps which crops are suitable to grow in a specific area or what fertilizer should be used, which varies between different regions and climatic conditions. Regional information like this could support the farmers in enterprise selection.
- Since the content of the service is of this nature, it is likely that people with agricultural expertise rather than technological expertise will be entering information into the system. For this reason, it is necessary to create easy methods for inputting and updating the information. The intended system will be a web based with menus where extension officers can upload text information into the system or edit existing texts. The system could then input the text into the TTS to convert it to voice thus making it immediately available in the telephone service. This input could also be done at the district or provincial level so that regional information can be kept up-to-date. This is part of what makes a system like this far more efficient than making new recordings at every new input or update.

- Universal access is the key to providing information. People should be able to choose the access method that suits them. Literate people might still be more comfortable with written information, in booklets or on a web page where they can print the information they are interested in, but the need for voice information is still there, mainly for illiterate and visually impaired people.

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APPENDIX

Appendix A:

ትግርኛ

እዚ ናይ ኢትዮጵያ ምህርቲ ዕደጋ ናይ መረጃ መስመር እዩ፡፡

1. ን ናይ ትግርኛ ጭን ጭን ጭን ቁፀሪ ይፅዓኑ

1.1. ናይ ዕደጋ መረጃ እገልግሎት

1.1.1. ናይ ዕደጋ ዋጋ መረጃ

- 1.1.1.1. ናብ ወፅኢ ን ምልእክ ቡና
- 1.1.1.2. ን ሀገር ወሽጢፍጆታ ቡና
- 1.1.1.3. ን ፍሉይ ቡና
- 1.1.1.4. ን ሰሊጥ
- 1.1.1.5. ን አደጉራ
- 1.1.1.6. ን ዕፋን
- 1.1.1.7. ን ስንዳይ
- 1.1.1.8. ን ዓለምለካ
- 1.1.1.9. እንደገና ን ምዲማፅ
- 1.1.1.10. ናብ መጀመርያ መወፅኢ ኢን ምምለስ

1.1.2. ን ዋጋ ዕደጋ ነርሀ ግብሪ

- 1.1.2.1. ናይ ሰኞ
- 1.1.2.2. ናይ ማክሰኞ
- 1.1.2.3. ናይ ረቡዕ
- 1.1.2.4. ናይ ሀመስ
- 1.1.2.5. ናይ አርብ

Appendix B: IVR menu

አ ማርኛ

ይህ የኢትዮጵያ ምርት ገበያ የገበያ ዋጋ የመረጃ መስመር ነው ፡

ለ አ ማርኛ አንድን ይጫኑ

ለ ገበያ ዋጋ መረጃ አንድን ይጫኑ

ለ ቡና አንድን ይጫኑ

ለ ታጠብ ወደ ወጭለ ምላክ ቡና አንድን ይጫኑ

ለ በበቃ አንድን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ነቀምቴ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

[ደረጃ 1-9](#) የ መግዥያ ዋጋ -----ብር ፡ ፡

ምሳሌ: የ መስከረም 5 2005 ዓ.ም ዋጋ በበቃ ደረጃ አንድ የ መግዥያ ዋጋ 700 ብር ፡ ፡

ለ ነቀምቴ ሁለትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ነቀምቴ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ልመሶስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ](#)

[መደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ሲዳማ አራትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ሲዳማ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ቴፒ አምስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ቴፒ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ይርጋ ጨፌ ስድስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ይርጋ ጨፌ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ላል ታጠብ ወደ ወጭለ ምላክ ቡና ሁለትን ይጫኑ

ለ ጫክ አንድን ይጫኑ

ለ ሀረር አንድን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ሀረር ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ጂማ ሁለትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ጂማ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ከፋ ሶስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ከፋ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ነቀምቴ አራትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ነቀምቴ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ሲዳማ አምስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ሲዳማ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ይርጋ ጨፌ ስድስትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ይርጋ ጨፌ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ታጠብ ለ ሀገር ወስጥ ፍጆታ ቡና ሶስትን ይጫኑ

ለ ተረፈ ምርት አንድን ይጫኑ

ለ ጂማ አንድን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ጂማ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ለ ሲዳማ ሁለትን ይጫኑ

[የ ወረ/ቀን/ዓ.ም ዋጋ ሲዳማ ደረጃ -1-2-3-4-5-7-8-9](#) የ መዝገያ ዋጋ -----ብር ፡ ፡

ላል ታጠብ ለ ሀገር ወስጥ ፍጆታ ቡና አራትን ይጫኑ

ለ ተረፈ ምርት አንድን ይጫኑ

ለ ጫክ ቡና አንድን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ ጫካ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :
ለ ልመቡና ሁለትን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ
መደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ ሲዳማ ቡና ሶስትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ስዳማ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ ቴፒ አራትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ቴፒ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ ይርጋ ጨፌ አምስትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ይርጋ ጨፌ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ ታጠበ ለ ልዩ ቡና አምስትን ይጫኑ
ለ ልመቡና አንድን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ
መደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ ወናጎ ቡና ሁለትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ወናጎ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ላል ታጠበ ለ ልዩ ቡና ስዲስትን ይጫኑ
ለ ስዳማ ቡና አንድን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ ስዳማ ደረጃ -1-2-3-4-5-7-8-9 የ መዝግያ ቀጥ -----ብር : :

ለ አላም አቀፍ የ ቡና ቀጥ ሰባት አረብካ ስን የጫኑ
በ ---አገር---ገበያ በ ---ወር----የ ምረከብ---ቀጥ---የ አምሪካን ዶላር : :
ምሳሌ : በ ንዮሪክ ገበያ የ አረብካ ስ ቀጥ በ መስከረም የ ምረከብ 500 የ አምሪካን ዶላር : :

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ
ወደ ቀድሞ መወጫለ መመለስ የ ኮከብ ምልክትን ይጫኑ

ለ ሰልጥ ሁለትን ይጫኑ
ለ ሁመራ፤ ጎንደር ሰልጥ አንድን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ ኤ ደረጃ -1-2-3-4-5-6-7-8-9 የ መግኘያ ቀጥ -----ብር : :
ወለጋ ሰልጥ ሁለትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ደረጃ -1-2-3-4-5-6-7-8-9 የ መግኘያ ቀጥ -----ብር : :
ደረጃ -2- የ መግኘያ ቀጥ -----ብር : :
ደረጃ -3- የ መግኘያ ቀጥ -----ብር : :

ለ አላም አቀፍ የ ሰልጥ ቀጥ ሶስትን ይጫኑ
በ ---አገር---ገበያ በ ---ወር----የ ምረከብ---ቀጥ---የ አምሪካን ዶላር : :

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ
ወደ ቀድሞ መወጫለ መመለስ የ ኮከብ ምልክትን ይጫኑ

ለ በሎቄ ሶስትን ይጫኑ
ለ ዱቡልቡል ነ ጭቦ ሎቄ አንድን ይጫኑ

የ ወረ/ቀን/ዓ.ም ቀጥ ኤ ደረጃ -1-2-3-4-5-6-7-8-9 የ መግኘያ ቀጥ -----ብር : :
ደረጃ -2- የ መግኘያ ቀጥ -----ብር : :
ደረጃ -3- የ መግኘያ ቀጥ -----ብር : :

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :

ለ ጠፍጣፋ ነ ጭቦ ሎቄ ሁለትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ኤ ደረጃ -1-2-3-4-5-6-7-8-9 የ መግኘያ ቀጥ -----ብር : :
ደረጃ -2- የ መግኘያ ቀጥ -----ብር : :
ደረጃ -3- የ መግኘያ ቀጥ -----ብር : :

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :

ለ ጠፍጣፋ ነ ጭቦ ሎቄ ሁለትን ይጫኑ
የ ወረ/ቀን/ዓ.ም ቀጥ ኤ ደረጃ -1-2-3-4-5-6-7-8-9 የ መግኘያ ቀጥ -----ብር : :
ደረጃ -2- የ መግኘያ ቀጥ -----ብር : :
ደረጃ -3- የ መግኘያ ቀጥ -----ብር : :

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :

ወደ ቀድሞ መወጫ ለመመለስ የ ኮከብ ምልክትን ይጫኑ

አላ ም አቀፍ የ ሰልጥ ሞጋ ሶስትን ይጫኑ

በ ---አገር--- ስያ በ ---ወር የ ምረክብ ሞጋ የ አምሪካን ዶላር ::

ለ ቦቆሎ አራትን ይጫኑ

ለ ስንዴ አምስትን ይጫኑ

የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ

ወደ ቀድሞ መወጫ ለመመለስ የ ኮከብ ምልክትን ይጫኑ

> ለ ግብይት መርሀ ግብር ሁለትን ይጫኑ

• ለ ሰኞ አንድን ይጫኑ

o ለ ቡና አንድን ይጫኑ

• ለ ሀገር ወሲጥ ፍጆታ ቡና አንድን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

• ወደ ወጭለ ምላክ የ ታጠበ ቡና ሁለትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

• ወደ ወጭለ ምላክ ላል ታጠበ ቡና ሶስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ሰልጥ ሁለትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ቦሎቄ ሶስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ቦቆሎ አራትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ስንዴ አምስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ ::

o የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ ::

o ወደ ቀድሞ መወጫ ለመመለስ የ ኮከብ ምልክትን ይጫኑ ::

• ለ ማክሰኞ ሁለትን ይጫኑ

o ለ ቡና አንድን ይጫኑ

• ለ ሀገር ወሲጥ ፍጆታ ቡና አንድን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

• ወደ ወጭለ ምላክ የ ታጠበ ቡና ሁለትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

• ወደ ወጭለ ምላክ ላል ታጠበ ቡና ሶስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ሰልጥ ሁለትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ቦሎቄ ሶስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ቦቆሎ አራትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o ለ ስንዴ አምስትን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

o የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ ::

o የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ ::

o ወደ ቀድሞ መወጫ ለመመለስ የ ኮከብ ምልክትን ይጫኑ ::

• ለ ረቡዕ

o ለ ቡና አንድን ይጫኑ

• ለ ሀገር ወሲጥ ፍጆታ ቡና አንድን ይጫኑ

የ መገባደጃ ክፍለ ግዜ የ ምጅምረ ወ. 1-12 ሰዓት የ ምያልቀወ. 1-12 ሰዓት ::

• ወደ ወጭለ ምላክ የ ታጠበ ቡና ሁለትን ይጫኑ

- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ወደ ወጭለ ምላክ ላል ታጠበ ቡና ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ሰ ል ጥ ሁለ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦ ሎቄ ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦቆሎ አራትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ስንዴ አምስትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
 - የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :
 - ወደ ቀድሞ መወጫለ መመለስ የ ኮከብ ምልክትን ይጫኑ : :
 - ለ ሀ መስ
 - ለ ቡና አንድን ይጫኑ
 - ለ ሀገር ወሲጥ ፍጆታ ቡና አንድን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ወደ ወጭለ ምላክ የ ታጠበ ቡና ሁለ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ወደ ወጭለ ምላክ ላል ታጠበ ቡና ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ሰ ል ጥ ሁለ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦ ሎቄ ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦቆሎ አራትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ስንዴ አምስትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
 - የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :
 - ወደ ቀድሞ መወጫለ መመለስ የ ኮከብ ምልክትን ይጫኑ : :
 - ለ አርብ
 - ለ ቡና አንድን ይጫኑ
 - ለ ሀገር ወሲጥ ፍጆታ ቡና አንድን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ወደ ወጭለ ምላክ የ ታጠበ ቡና ሁለ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ወደ ወጭለ ምላክ ላል ታጠበ ቡና ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ሰ ል ጥ ሁለ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦ ሎቄ ሰ ስ ትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ቦቆሎ አራትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - ለ ስንዴ አምስትን ይጫኑ
- የ መገባያ ክፍለ ጊዜ የ ምጀምረ ወ. 1-12 ሰዓት የ ምያልቀ ወ. 1-12 ሰዓት : :
 - የ አሁኑን የ ማወጫዝርዝር አንደገና ለ ማዳመጥ ዜሮን ይጫኑ : :
 - የ ሌላ ቀን የ ግብይት መርሀ ግብር ለ መፈለግ አንድን ይጫኑ : :

Appendix C:

Sample MMI-IVR AGI script

```
#!/usr/bin/php -q
<?php
set_time_limit(30);
require('include/phpagi.php');
require_once ('include/phpagi.php');
require_once ('include/phpagi-asmanager.php');
error_reporting(E_ALL);
$agi = new AGI();
$agi->answer();
function read($n,$position)
{
    else if($position==1)
    {
        else if($n==7)
            $result="70";
        else if($n==9)
            $result="90";
    }
    else if($position==2)
    {
        $agi->stream_file(read($n,0));
        $result="100";
    }
    else if($position==3){
        $agi->stream_file(read($n,0));
        $result="1000";
    }
    return $result;
}
function main($n){
    $size=0;
    if($n/1000>0)
        $size=4;
    else if($n/1000<=0 && $n/100>0)
        $size=3;
    else if($n/100<=0 && $n/10>0)
        $size=2;
    else if($n/10<=0 && $n>0)
        $size=1;
    $i;
    for($i=0;$n!=0;$i++)
    {
        $elts[$i]=$n%10;
        $n=$n/10;
    }
    for($i=$size-1;$i>=0;$i--){
        if($i==1 && $elts[$i]==1 && $elts[0]==0)
            $agi->stream_file("10");
        else
```

```

    $agi->stream_file(read($elts[$i],$i));
    }
    }
$agi->stream_file("main");
$agi->stream_file("Am");
$agi->stream_file("Oro");
$filename='Tig';
$result=$agi->get_data($filename, 10000,1);
$key = $result['result'];
//main
if($key=="1")
{
    $result2=$agi->get_data("Geb",40000,1);//gebeya waga[1]....gibiyit...so on
    $key2 = $result2['result'];
    if($key2=="1"){
        $result3=$agi->get_data("Gebeya",40000,1);//bunna[1],selit...sinde
        $key3 = $result3['result'];
        if($key3=="1")
        {
            $result4=$agi->get_data("sent10",40000,1);//letatebe[1]...laltatebe..
            if($result4['result']=="1"){

                $result5=$agi->get_data("Sentence14",40000,1);//sidama[1]...bebeka...
                if($result5['result']=="1")
                {
                    $hostname = "127.0.0.1";
                    $dbname = "IVR";
                    $username = "root";
                    $password = "password";
                    //$var = $AGI->database_get('IVR', 'Name');
                    $mySql = mysql_connect($hostname, $username, $password) or die (mysql_error());
                    mysql_select_db($dbname, $mySql) or die(mysql_error());
                    $query = "select * from CommodityPrice where Name='sidama'";
                    $r = sqlQuery($query, $mySql);
                    $result5=$agi->get_data('sidama');
                    $result5=$agi->get_data($r[0]['Name']);

                    main($result[0]['Date']);
                    main($result[0]['Year']);
                    $agi->stream_file($result[0]['Name']);
                    main($result[0]['Rank']);
                    main($result[0]['Price']);
                }
            }
        }
        elseif($key3=="2"){
            $result3=$agi->stream_file("selit",40000,1);
        }
    }
    elseif($key2=="2")
        $agi->stream_file("Gibiyit"); }
elseif($key=="2")
$agi->stream_file("vm-goodbye");//oro
elseif($key=="3")
$agi->stream_file("Sentence14");//Tig

```

\$agi->hangup();
?>

Appendix D:

0.2200 100 pau
0.2754 100 y
0.4587 100 iy
0.6787 100 pau
0.7573 100 t
0.8062 100 ih
0.8769 100 r
0.9437 100 aa
1.0082 100 r
1.1011 100 ae
1.1681 100 t
1.2321 100 hh
1.3582 100 uw
1.4361 100 l
1.4893 100 ih
1.5563 100 t
1.6441 100 s
1.7333 100 k
1.8233 100 s
1.8786 100 ih
1.9773 100 ae
2.0589 100 m
2.1261 100 ih
2.2151 100 s
2.2807 100 t
2.3901 100 ae
2.4716 100 m
2.5462 100 iy
2.6144 100 t
2.6667 100 m
2.8243 100 ay
2.8974 100 hh
2.9824 100 iy
3.0811 100 er
3.2316 100 eh
3.3247 100 t
3.5447 100 pau
3.6067 100 w
3.7448 100 ae
3.8430 100 g
3.9384 100 ax
4.1584 100 pau
4.2262 100 n
4.3187 100 eh

4.4042 100 k
4.4967 100 eh
4.5941 100 m
4.6719 100 t
4.8552 100 iy
5.0752 100 pau
5.1401 100 d
5.2327 100 eh
5.2797 100 r
5.3528 100 iy
5.4730 100 jh
5.5684 100 ax
5.7884 100 pau
5.8584 100 aa
5.9264 100 r
6.0356 100 ae
6.1218 100 t
6.1744 100 y
6.2858 100 eh
6.3506 100 m
6.4051 100 ax
6.4767 100 g
6.5458 100 ih
6.6114 100 z
6.6856 100 k
6.7756 100 s
6.8178 100 ax
6.8949 100 w
7.0330 100 ae
7.1312 100 g
7.2266 100 ax
7.4466 100 pau
7.5416 100 z
7.6341 100 eh
7.7188 100 k
7.8328 100 s
7.8942 100 ih
7.9396 100 g
8.0137 100 k
8.0790 100 s
8.1527 100 m
8.2569 100 eh
8.3449 100 t
8.4907 100 ow
8.7107 100 pau
8.8017 100 b
8.8987 100 er
9.1187 100 pau
9.3387 100 pau

Appendix E:

Usability Questionnaire

On the scale from one to five shown below, indicate if you agree or disagree with the nineteen statements on this page.

Participant Number _____

I. General

Please rate each item according to the scale below:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

N/A = Not Applicable

II. Questionnaire

1. I found this service easy to use.....1 2 3 4 5 N/A
2. I felt very frustrated using this service.....1 2 3 4 5 N/A
3. I felt in control while using this service.....1 2 3 4 5 N/A
4. I thought some of the choices were confusing.....1 2 3 4 5 N/A
5. The operators voice was very clear.....1 2 3 4 5 N/A
6. I am left with a good impression of that organization.....1 2 3 4 5 N/A
7. I sometimes felt lost while using this service.....1 2 3 4 5 N/A
8. I enjoyed using this service.....1 2 3 4 5 N/A
9. I thought the operator spoke too quickly.....1 2 3 4 5 N/A
10. The non-verbal audio was helpful.....1 2 3 4 5 N/A
11. It was easy for me to find what I wanted.....1 2 3 4 5 N/A
12. The amount of information I had to input was minimal.....1 2 3 4 5 N/A
13. The menus always made sense.....1 2 3 4 5 N/A
14. I could recover easily if I made a mistake..... 1 2 3 4 5 N/A
15. I was directed to the correct market information.....1 2 3 4 5 N/A

III. Written Response

1. What was the biggest challenge you faced when using the IVR?

2. What did you like most about the IVR?

3. What was going on in your head when you were doing the task?

4. Do you have any other comments you would like to add about this task?

Declaration

I, the undersigned, declare that this research is my original work and has not been presented for degree in any other university, and that all sources of materials used for the project have been acknowledged.

Declared by:

Name: **Honelet Endale**

Signature: _____

Date: _____

Confirmed by advisor:

Name: **Dr Sebsibe Haile Mariam**

Signature: _____

Date: _____

Place and date of submission: Addis Ababa University, January, 2014.