On the Development of the Mobile based Agricultural Extension System in Tanzania: A Technological Perspective

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ABSTRACT

Agriculture is the back bone of Tanzania's Economy. For it to contribute significantly to the economy, farmers need access to agricultural information and knowledge in timely, complete and quality manner. The traditional practice for delivering agricultural information in Tanzania is mainly through farmer-to-farmer visits, farmers' own experience and extension officers. The practice requires extension officers to visits farmers in order to give advisory services. Thus due to the few number of extension officers, the system is overstretched which necessitates the urgent need to find an alternative method to improve extension services. This paper presents a mobile based Farmers' Advisory Information System (M-FAIS) aimed at improving the coverage of extension services in Tanzania. The philosophy behind this initiative is on capacitating the extension officers to serve many farmers anywhere anytime. The study contributes to the approach for testing complex system in agricultural informatics. The approach integrates the conventional system testing approaches (technology-centric approach) and extends it to include consideration of system usability (user-centric testing approach) prior to system release.

Categories and Subject Descriptors: K.3.1 [**Computers and Education**] Computer Uses in Education;
K.6.1 [**Management of Computing and Information Systems**] Project and People Management.

General Terms: Management

Additional Keywords and Phrases: Mobile phone, Farmers advisory information system, Agriculture, Agricultural extension services, Farmers, user and technology centric approaches

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1. INTRODUCTION

The agricultural sector in Tanzania constitutes a quarter of the national GDP and accounts for 75% of rural households' income (WB, 2011). Agricultural productivity is low and total cereal yields are below the levels in neighboring countries such as Zambia, Malawi and Zambia (WB, 2014). The monitoring of poverty in Tanzania during the last decade, indicates a decrease in the proportion of the population below the national poverty line, but in rural areas, the decrease has been rather limited (Haug and Hella 2014). Poverty among male and female farmers is due to; poor agricultural information facilities and inadequate access of agricultural information and knowledge by farmers (Iraba and Venter, 2011). According to Sunden and Wicander (2003), the majority of the smallholder farmers live in

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information-deserted areas which are placs where availability of agricultural information is limited. Due to limited agricultural information, most rural people in developing countries face difficulties in decision making regarding their economic activities such as crop production, livestock keeping and marketing information (Obayeluand Ogunlade, 2006). As result, the proportion of poverty among rural people decreases despite the many efforts done to reduce it (Grindle, 2004). Several of the recent policies and strategies launched by Government of Tanzania emphasize improving access to agricultural information, extension and training for small scale men and women farmers. In this respect, there are are several initiatives and programmes such as Kilimo Kwanza, National Strategy for Growth and Reduction of Poverty II (NSGRP II) (or MKUKUTA II in Kiswahili acronym), Agricultural Sector Development Programme (ASDP), Tanzania Agriculture and Food Security Investment Plan (TAFSIP) under the Comprehensive Africa Agriculture Development Programme (CAADP), Feed the Future Programme, Southern Agriculture Growth Corridor of Tanzania (SAGCOT) (Haug and Hella, 2014). The level of awareness among most farmers on agricultural innovations emanating from these Government initiatives is very low due to limited information, leading to poor decisions on the effective utilization of scarce resources, farming technologies and existing market potential. Manda (2002) pointed out that the majority of farmers do not necessarily make critical agricultural decisions on the basis of scientific, technical and marketing information. It is for this reason that technological advancement and the emergence of new markets have no great impact on the lives of most rural farmers in developing countries. Farmers need to be empowered using the available mobile technology (Ginige and Richards 2012). Thus, this is the area which has been proposed to be one of the researchable topic on the development of mobile based information systems in agriculture (Gichamba and Lukandu 2012).

1.1 The role of ICTs in Agricultural Information dissemination and communication

Information and Communication Technologies (ICTs) have been thought as the best method for bridging the information gap for rural farmers with respect to information related to innovative practices, technologies, Government policies, credit facilities, and markets (Chilimo and Sanga, 2006). Several media and communication channels are used to communicate agricultural information in rural areas. Maru (2003) and Etta et al. (2001) mention radio, mobile phones, television, fax, Internet and digital technologies, print (products of the press) and computer based or computer mediated modes as common media used in information dissemination and communication.

The case for the mobile phones being more important especially in disseminating and communicating agricultural information in order to improve agricultural extension services in developing countries, has been argued by researchers and practitioners that are deploying ICT tool for development (Sanga et al. 2014a). For instance, in India mobile phones based system have been opted as a means of reaching rural farmers in which a small, but relevant amount of data is transferred to farmers via SMS (short message service) text messaging (Veeraraghavan et al. 2009).

1.2 Mobile phone usage in Tanzania

A mobile phone (also known as a cellular phone or cell phone or a hand phone) is a device that can make and receive telephone calls over a radio link while moving around a wide geographic area. It does so by connecting to a cellular network provided by a mobile phone operator, allowing access to the public telephone network. By contrast, a cordless telephone is used only within the short range of a single, private base station. In addition to telephony, modern mobile phones also support a wide variety of other services such as text messaging, multimedia messaging service (MMS), elecronic mail (email), Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming and photography. Mobile phones that offer these and more general computing capabilities are referred to as smart phones (Raento et al. 2009).

In Tanzania, mobile telephony is the fastest growing ICT sub-sector, with estimation that over 28 million Tanzanians own a mobile phone with a penetration rate of about 62 per cent (TCRA 2012). Mpogole et al. (2008) argue that the increasing competition among network providers in Tanzania has resulted in reduction of costs for mobile phone services and hence, increases significantly the number of mobile phone users. Studies by Forlin (2008); Rashid and Elder (2009) recommended that an increased growth rates of mobile phones usage have been attributed by many factors including: the liberalization of telecommunication markets; user-friendliness of the phones; the need for basic literacy in using the phones; pre-payment modes; and usage of local languages in communication. On the other hand, the reasons for owning or using a mobile phone by rural farmers are to communicate with friends and family members, maintain relationships, emergency situations, help in job search, help in income generating activities and business networking (Samuel et al. 2005, Chakraborty 2005; de Silva & Zainudeen 2007).

1.3 The mobilephone and socio economic development

Access to telecommunication has been cited as a factor for soci- economic development especially in rural areas (Samuel et al. 2005). Mobile communication increases economic growth, alleviates poverty, and helps in overcoming the perceived digital divide (Chakraborty, 2005). De Silva and Zainudeen (2007) also argue that the use of mobile phones in the right way and for the right purpose can have a significant outcome in addressing specific social and economic developmental goals. Sife et al. (2010) say mobile phones can contribute significantly in improving rural livelihoods and reduce poverty in Tanzania.

1.4 Research Justification

In Tanzania, ICTs are among the best tools used for improvement of delivery of agricultural extension service particularly in communicating information related to agricultural production and marketing information (Mtega 2012). Some of ICT facilities employed are the use of telecenters, ward agricultural resource centres and community radios [James 2010]. These ICT facilities however face a number of problems in communicating agricultural information and knowledge for sustainable agricultural development in Tanzania. Some of the problems are: lack of funds, high operational costs, illiteracy, long distance to telecentres, language barrier, lack of electricity, frequent power cuts, fewer local agricultural information content and sustainability issues. Further, most of the managers of these facilities are not aware of the farmers' information needs, which constrain them from meeting related farmers needs (Chilimo, 2008). Due to the aforementioned problems, there is an increased use of mobile technologies which has over-shadowed some forms of public access to the mentioned ICTs facilities in rural areas [Lwoga 2010]. Some researchers have termed the revolution of mobile phones has brought a negative effect called possessive individualism (http://gurstein.wordpress.com/2012/07/21/the-mobile-revolution-and-the-rise-and-rise-of-possessive-individualism/).

According to Veeraraghavan et al (2009), mobile phone promises to unlock most of problems facing telecentre, ward agricultural resource centres and community radio. Kapange (2004) also reported that, the mobile phones mushrooming in Tanzania are increasingly becoming affordable and make communication easier even to the rural poor. Hence, they can be used to strengthen the agriculture extension services to smallholder farmers. Tanzania Communications Regulatory Authority's statistics shows that more than 28 million (62%) Tanzanians own mobile phone (TCRA, 2012). Given the fact that mobile phones have penetrated even to rural areas, it is an opportunity to take advantage of mobile phones to address the problem of poor coverage of agricultural extension services (Mvuna 2010). Therefore, this study presents work towards developing a mobile based farmers' advisory information system (M-FAIS). The ultimate goal is to use mobile phone as effective ICT tool to enhance delivery of agricultural extension services to different actors in maize value chain in Kilosa, Tanzania.

1.5 Related Work

Parikh et al. (2007) define value chains as the series activities that extend from farmers to consumers. Also, they state that in between there are intermediaries who add value to agricultural food products in various ways, including processing, packaging, certifying, transporting, distributing, whole selling and retailing to the end consumer (Parikh et al. 2007). In this paper, Parikh et al's definition was adopted. The analysis of different agricultural knowledge and information systems (AKIS) which have already been implemented to support agricultural value chains in Tanzania was done accordign to Parikhet al.(2007) who mentioned four types of information systems which need to be integrated to enhance the information flow in any agricultural value chain. Accroding to Parikn et al. the systems are: (i) Marketing information systems (ii) Agricultural extension systems (iii) Procurement and traceability systems and (iv) Inspection and certification systems.

Among the four mentioned systems, in Tanzania there are marketing information system which is workable (Mapunda, 2011; Mwakalinga 2005). Also, there is an SMS based system to communicate market prices weekly. This system is under pilot at Kilosa Rural Services and Electronic Centre (KIRSEC). In addition, FrontlineSMS is used by Kilosa Community Radio to send and receive bulk text messages from listeners during radio presentation of different radio programmes. Furthermore, there is a web based livestock marketing Information System called "Livestock Information Network Knowledge System (LINKS)" which enables farmers through their mobile phones to access the prices of livestock and livestock products in various markets located in different regions of Tanzania. Furthermore, there are *TigoKilimo and Z-Kilimo which provide farmers with relevant and timely agricultural information from their mobile

*http://www.itu.int/ITU-D/sis/newslog/2012/08/20/TigoLaunchesMobilePhoneFarmingProgrammeTanzania.aspx phones. They are SMS-based applications which enable the farmers get real-time information on weather forecast and agricultural tips. Their disadvantage is that it is meant for dissemination of agricultural advisory service. From our analysis, we found that the communication aspect is not implemented in Tigo Kilimo and Z-Kilimo. Also, they are not interactive compared to M-FAIS. Furthermore, the agricultural contents in Tigo Kilimo and Z-Kilimo are not catering for the agricultural information needs for a specific location in Tanzania (i.e. they are generalized). Thus, to harness the potential of ICTs in linking different systems to support information needs of different actors of agricultural value chains there is a call for more researches to explore how ICT systems can be implemented to fill the identified gap in knowledge. It is in this view that this paper tries to present the M-FAIS.

The main objective of this study was to develop the M-FAIS to enhance agricultural extension services delivery. To meet this objective, the literature review was done to assess different architecture of mobile phone based information system and analyze how the current agricultural extension system that delivers advisory services to farmers can be supported by mobile phones.

Based on challenges facing agricultural extension services in Tanzania (Obinne 1997; Swanson et al.1998; Suzuki 2000; Sonoko 2001; Rutatora and Matee 2001; Arokoyo 2003; URT 2006; World Bank 2008; Mvumi 2010), the research question set for this study was "How can mobile phone improve the delivery of extension services in Tanzania using cost effective architectural design?". This study answers the question from an ICT technological perspective. It differs from our early articles which answered the same question using socio-technical perspectives (Sanga et al 2014a; Sanga et al. 2014b; Sanga et al. 2014c; Sanga et al 2014d).

2 MOBILE PHONE BASED SYSTEMS

2.1 An overview

Mobile based information system users send and receive services over mobile network via short message service (SMS). When two mobile phones exchange SMS, the SMS from the sending mobile is first stored in a short message center (SMSC) of a mobile operator which then forwards it to the destination mobile. The SMSC handles routing of SMS through several other SMSC and regulates traffic of wireless SMS until it reaches the desired recipient. This means that in case that the recipient is not available; the SMS is stored and can be sent later when the recipient is available. SMS supports national and international roaming. This means that you can send SMS to any other GSM mobile user around the world. According to Mavrakis (2004), there are two types of SMS namely Short message Mobile Terminated (SMT) and Short message Mobile Originated (SMO). SMT is the ability of a network to transmit a SMS to a mobile phone. The message can be sent by phone or by a software application. In other hand, SMO is the ability of a network to transmit a SMS sent by a mobile phone. The message can be sent to a phone or to a software application as shown in the Figure 1 below.

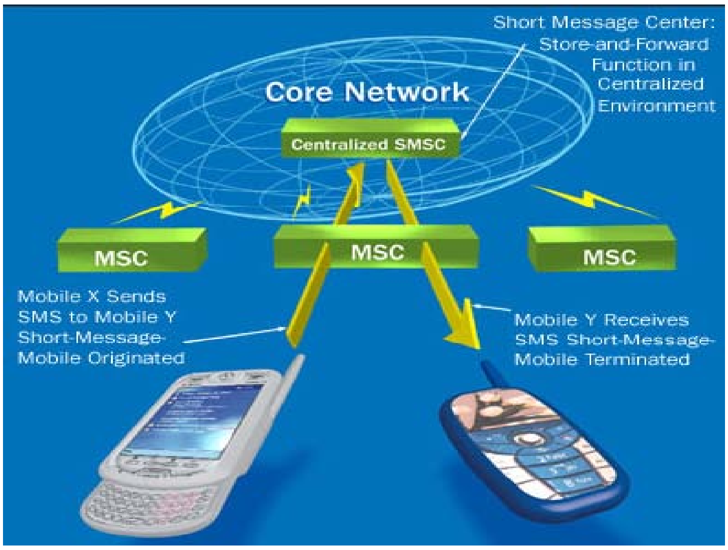

Figure 1: Sending and receiving SMS via mobile network

SMS applications are widely used in two methods, Pull and Push. A PUSH SMS application disseminates information to users without their prior requests. For instance SMS based result checking system that sends results to farmers without the farmers' prompt. Advantage of this method is farmers receive their agricultural market information as soon as they are out. PULL SMS application requires the user to send a request for the given information, and then the system process the request and sends back the result. This approach is based on service invocation as standardized through web-service technology.

2.2 Componential architectures of Mobile based system

There are several componential architectures of mobile based information system which are distinguished in terms of devices and technologies used. The following section discusses different architectures, presents comparison and finally, provides the evaluation of suitable architecture for the developing of M-FAIS.

2.2.1 Mobile based information system using a GSM modem

According to Zhang et al. (2008), the architecture of mobile based information system using a GSM modem is as shown in Figure 2 below:

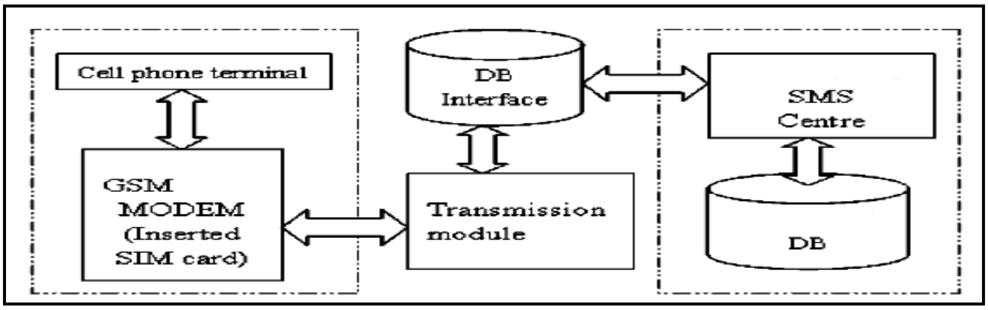

Figure 2: Architecture of Mobile based information system based on a GSM modem (Adapted from Zhang et al. 2008)

The main components of the system as described by Zhang et al (2008) is as follows:-

a. **Cell phone terminal:** A device capable of sending and receiving SMS. SMS is a technology that enables the sending and receiving of messages between mobile phones. A major advantage of SMS is that it is supported by 100% of GSM modems.
b. **GSM Modem:** Connect a GSM modem to a computer system and use AT commands to capture and send SMS text messages. In terms of programming, sending and receiving SMS messages through a GSM modem are similar since instructions are sent to the GSM modem in the form of AT commands.
c. **Transmission Module:** Since the GSM modem is connected to the computer through the serial port, the system requires a good mechanism to finish message transmission. Double buffering is a technique used by many device drivers to minimize the delay in input/output operations which use a buffer. Within this, the data acquisition device is able to write data at the same time as the application is reading data out.
d. **Database interface module:** This module connects the transmission module and the database. The database interface should possess the following data tables: a receiving data table, a sending data table, a sending unsuccessful data table, a sending successful data table. Top application software can use this database interface to perform additional functions.
e. **Database**: A database information management system manages database and rearranging the database information and communicates with users using a database interface. It means that the information management system is an application based on the GSM modem SMS.

2.2.2 Mobile based information system using Wireless Application Protocol (WAP) technology

The architecture of mobile based information system using WAP technology is shown in Figure 3 (Ismail 2009). From the Figure 3 below, a user sends requests and receives information using mobile phone via WAP gateway. WAP gateway is the system that enables WAP supporting devices such as mobile phones to communicate directly with any system that delivers contents to WAP devices via Internet Protocol (IP) networks. The WAP Gateway then communicates with the server (WAP Content) installed in the mobile network. The server (WAP Content) communicates with the web server which finally extracts information from the information system.

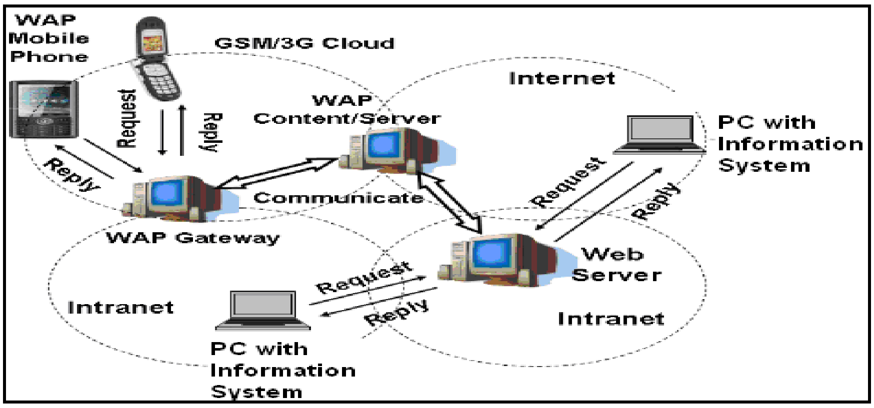

Figure 3: Architecture of Mobile based information system based on WAP technology (adapted from Ismail 2009)

2.2.3 Mobile based information system using IP SMS connection for real time retrieval of data

The architecture of mobile based information system using IP SMS connection according to Chakravati and Bhattacharyya (2009) is shown in Figure 4 below:-

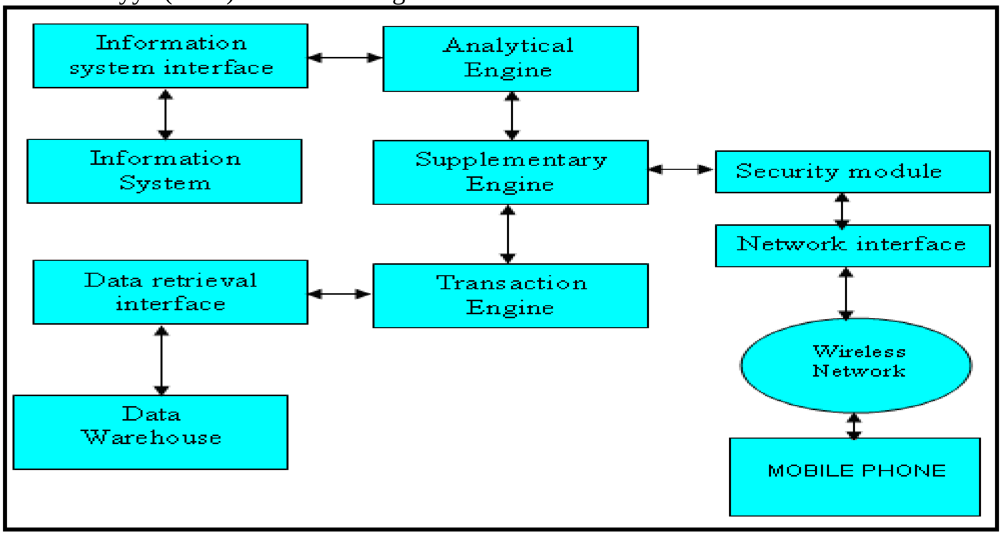

Figure 4: Architecture of Mobile based information system using IP SMS connect (adapted from Chakravati and Bhattacharyya, 2009)

The system shown above consists of the following key components:-

- Analytical engine: analyzes data interpret them and send information. The analytical engine is rule based and also pre-set.
- Transaction engine: display data, search data and process data on the basis of the request
- Supplemental engine: process data for data warehousing
- Security module: takes care of the confidentiality and privacy requirements
- Interfaces: connects system with information system, wireless network and data warehousing.

2.2.4 Mobile based information system based on Java 2 Platform Micro edition (J2ME) and Windows Embedded Compact (CE) applications

J2ME and Windows CE have the ability to wirelessly connect a mobile application to the Internet and wirelessly send and receive data (Figure 5). Such mobile application can be a client in a client/server multi-tier system, or it can be a standalone application without a connection to the server. J2ME and Windows CE provide the best platform for the implementation of business logic on the client (Fertalj and Horvat, 2007).

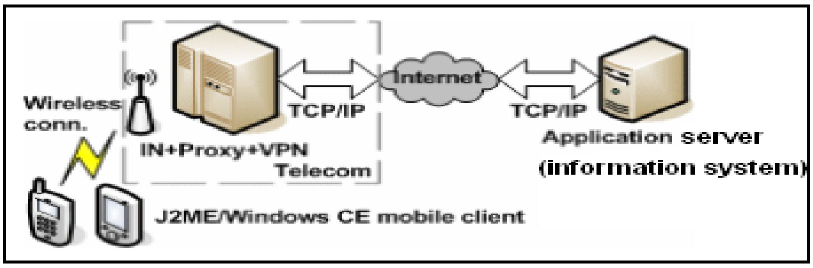

Figure 5: Architecture of Mobile based information system using J2ME and Windows CE applications (Adapted from Fertalj and Horvat, 2007)

2.2.5 Comparison of componential architectures of mobile based information systems

The great advantage of using GSM modem for mobile based information system is that, Internet outages will not stop the system from sending or receiving messages while other architectures need the mobile network and all other devices to be working perfectly. GSM modem based SMS information systems are cost efficient in the sense that it is very easy to find a price plan, with low or zero cost SMS tariffs, while other architecture like the one using IP SMS connection and WAP technology are expensive. With the GSM modem, wireless SMS systems can be setup in a very short time while with others architectures like the one using WAP technology and IP SMS connection can be time-consuming in finding the appropriate mobile network operator to allow the system to connect to the appropriate short message service center [Zhang et al. 2008]. GSM modem architecture works with all types of mobile phones while other architecture like the one using WAP technology works only with WAP supporting mobile phones.

The Internet SMS connection architectures offer enormous advantages over the other architectures such as high speed connection, high signal strength, no physical device needed for connection and can serve more SMS messages per second. According to Milan [2010], WAP based architecture offer more functionality such as web browsing and multimedia applications. With WAP protocol data are transferred more efficiently in client server environment than in TCP/IP.

2.3 Service architectures of Mobile based system

There are two kinds of services which can be built to distribute the information through SMS namely: independent service and dependent service architectures.

2.3.1 Independent service architecture (ISA)

This architecture as shown in Figure 6 allows the use of a regular Subscriber Identity Module (SIM) card in which the system does not need to have any direct connection with phone operators SMSC or Aggregator Service for direct routing of packets. ISA based system allows SMS communication from all mobile operators. According to Adagunodo et al. (2009), this option is easy and fast to set up, it does not require authorization of the service provider or connection to any third party and the user is charged a standard SMS tariff.

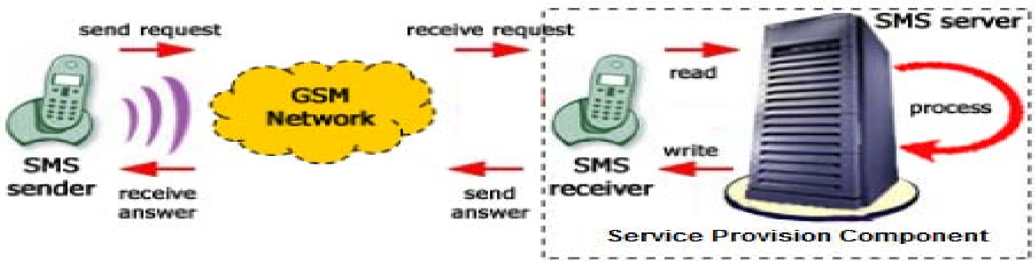

Figure 6: Independent Service Architecture (ISA)

2.3.2 Dependent Service Architecture (DSA)

This involves having the application server connect to the service providers SMS Center (SMSC) through a constant Internet connection. When users send their request, it goes to the SMSC, which automatically forwards the message to the application server over the Internet. The organization's SMS servers are connected to the SMS network through specialized connectors and gateways connected to the SMSC of mobile operators thus, messages can be communicated through connected mobile operators only. This option provides benefits such as the service provider can provide a special tariff and a dedicated line for the system. Also, it supports even a very heavy load (i.e. up to millions of SMS messages in a short time) [Mavrakis 2004]. The Figure 7 below illustrates the DSA.

Figure 7: Dependent service architecture (DSA)

From the above review, the mobile based information system using a GSM modem and ISA is more appropriate in this research study since it is cost effective, support all kinds of mobile phones and does not depend on the particular mobile network operators (Msanjila and Muhiche, 2011).
The proposed system is different from that of Tigo called Tigo kilimo and also, that of Zantel telecommunication company called Z-Kilimo*. These systems are static, thus different from the M-FAIS which is dynamic.

3. DESIGN OF THE M-FAIS

3.1 General Architectural Design

M-FAIS was designed using a GSM modem and ISA. It uses both push and pull methods depending on nature of information. The Figure 8 below illustrates.

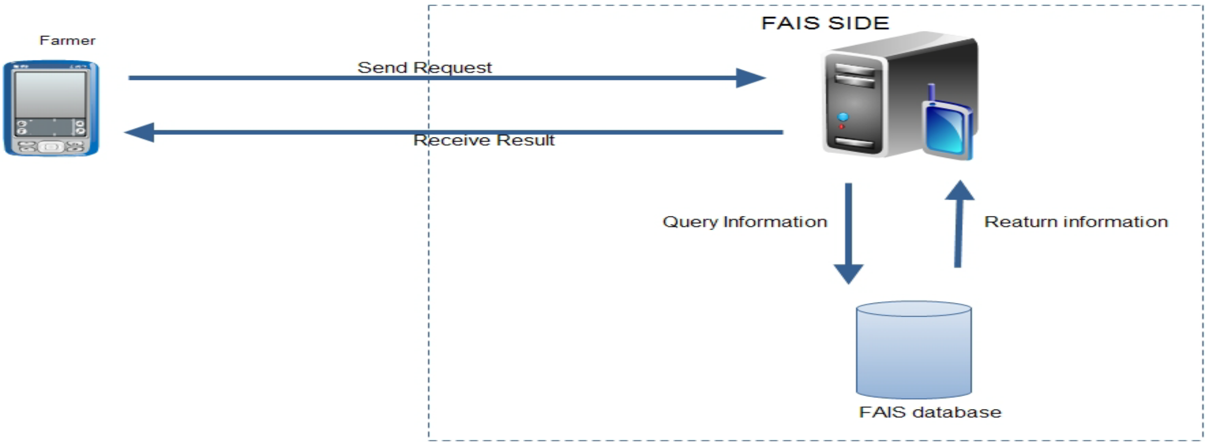

Figure 8: General architecture of M- FAIS

* http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/03/mAgri-Seminar-at-MWC-2014_Service-Profiles.pdf#page=1&zoom=auto,0,843

3.2 M-FAIS Componential Design

There are many encapsulated components and nodes that need to work in harmony so that M-FAIS works effective. FAISmain (SmsInfo) thread plays the centre role for this purpose. It launches the system GUI for input/output operations, SmSender for message sending, SmsReceiver for receiving requests and DbHandler for communicating with the database. On the other hand, the system will use javax.com library to facilitate serial communication with the Modem. The system depends on third party software (SerialSplitter) for splitting com ports for SMS sending and receiving operations. Not only this but also there is another module for handling information searching, this is done by database module. Figure 9 below presentes a pictorial view of M-FAIS componential structure.

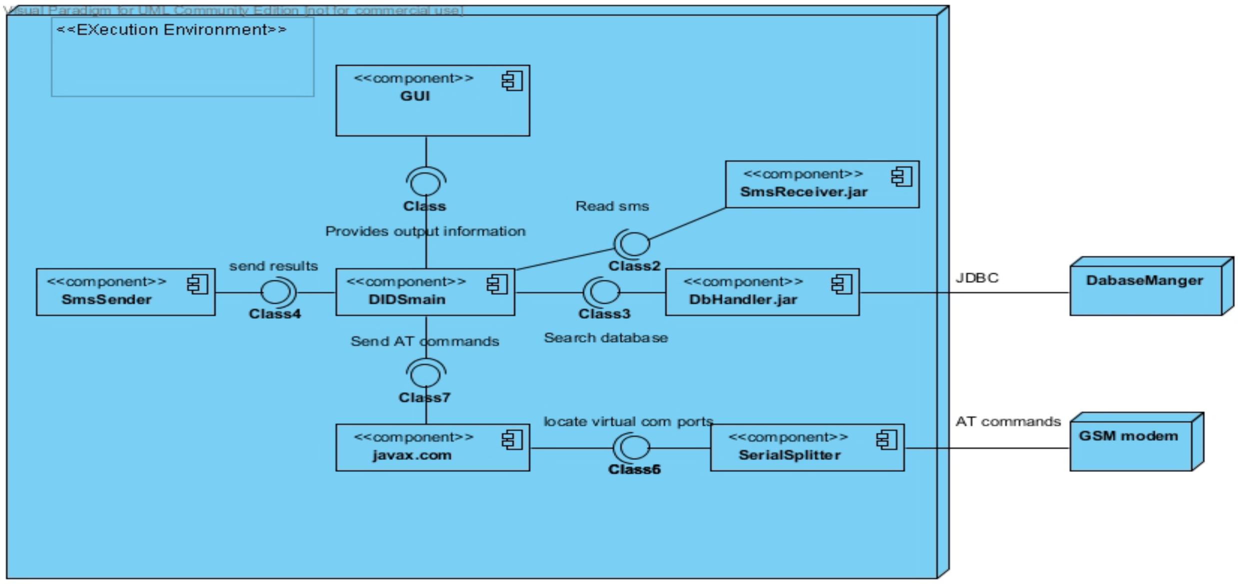

Figure 9: M-FAIS Componential Architectural diagram

Since the SMS receiving and SMSreplying components are the ones that interact with the user, they are further described as follows:

3.2.1 SMS receiving component

The mechanism developed for receiving messages continuously listens to dedicated GSM modems serial ports for incoming messages. If message received at the port is the user SMS request, its type is set to “sms” and formatted to specific internal system template (CnmiSms) for easy retrieval of its contents (username, password, message, phone number). The formatted message is added in the list of received SMS waiting to be processed, in the SMS array (SmsReceived). Otherwise, the system will set received message type to “system” and leave it for being processed with other objects. Figure 10 shows algorithm for the receiving SMS component.

3.2.2 SMS replying component

The mechanism for sending replies to users (SmsSender) continuously checks for availability of message waiting to be sent in waiting queue. When there is a message, the system retrieves it and extracting recipient number, the message content and consequently sends the message. If message sent status is successfully the thread system involves a service for reporting the sent successfully status, if the status of the message which was sent is failure due to insufficient credit, the system invoke the service for sending alert to the administrator. Figure 11 shows algorithm for replying SMS component.

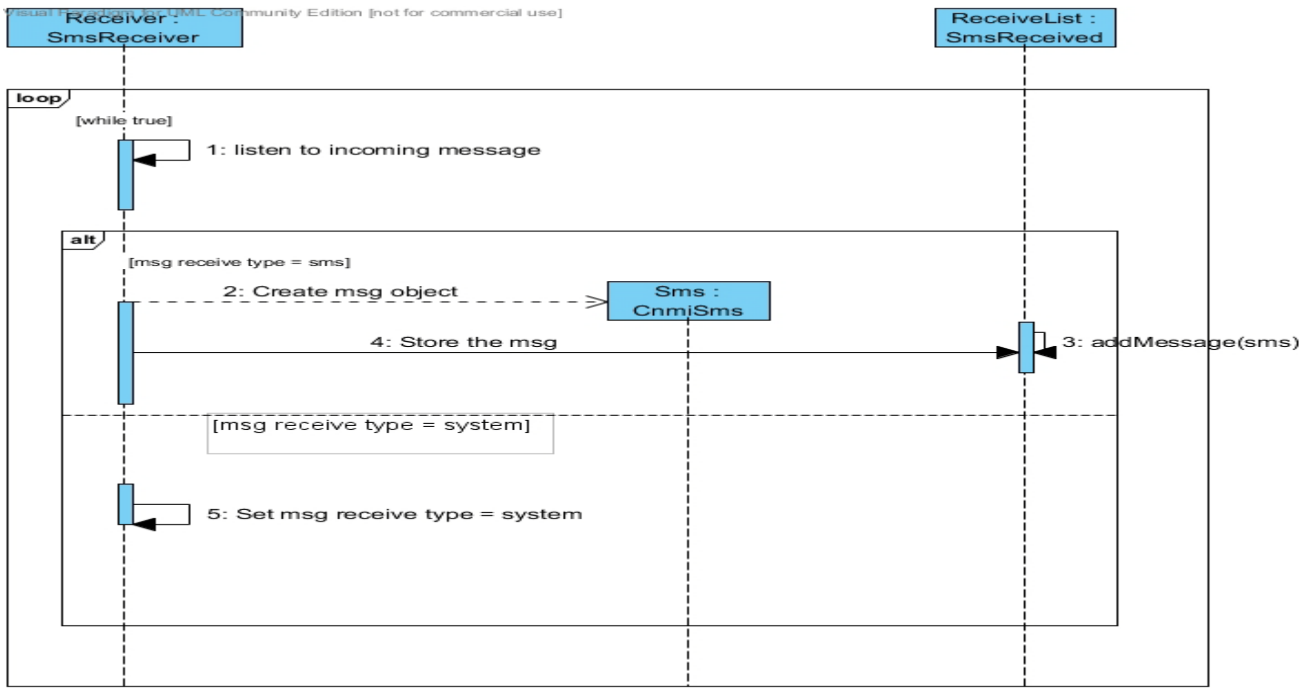

Figure 10:SMS receiving algorithm

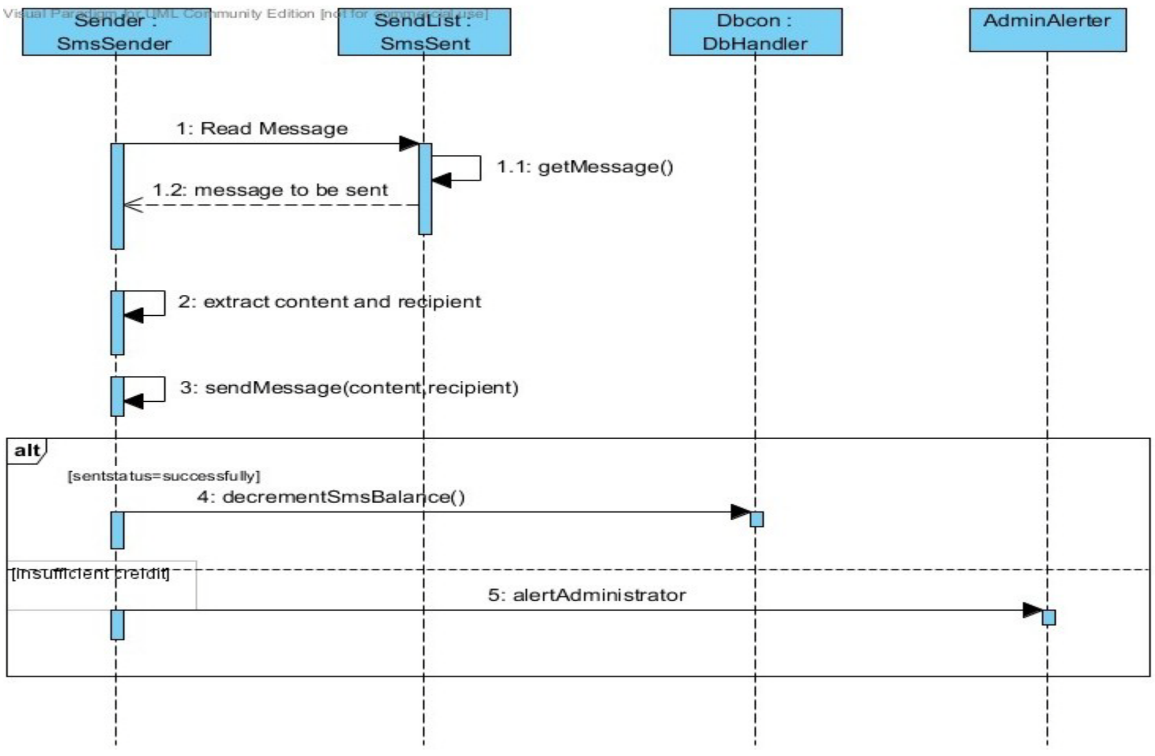

Figure 11: SMS replying mechanism

3.3 Design for Security and Error Handling

Though website and emails may be implemented by secure HTTPs for authentication, their use in public network with open systems protocols, as a backbone, make the stored information vulnerable to malicious attack. The developed M-FAIS used private network (Mobile Service Operator network) as infrastructure for transmission of information. On the other hand, the level and application of security in SMS based system depends on the nature of the system, if the system is meant for public use they do not need user authentication. The example for this system is the Google SMS applications which serve as search engines.

To account for reliability the system was designed such that it checks feedback of sent messages through request/response approach as standardizes in the web service technology. For example, if delivery failure occurs due to insufficient credit the system will notify the administrator by either beeping or sending alert message to his/her mobile phone. In case of error messages from the user, the system sends him/her relevant information about the error and the possible causes.

4. M-FAIS IMPLEMENTATION

The M-FAIS allows farmers to get advice in various agricultural issues such as agronomic practices, post-harvest operations, livestock husbandry, forestry, veterinary services, market and financial support services. The M-FAIS has two parts, namely: Web-based FAIS (W-FAIS) and Mobile-based FAIS (M-FAIS) (Sanga et al. 2014c). With an interactive mobile and web based system, farmers will be able to submit their request for information / knowledge by SMS and those questions will be stored in a database. The tele-centre officer or agricultural extension officer will answer the questions from farmers. This is for the case when they have an answer, otherwise – if the question is complex the system will forward the question to Knowledge Resource Centres (KRCs). This will be done through a web based system. The experts in KRCs will then answer the farmers' questions directly. These functionalities have been implemented in W-FAIS and M-FAIS (Sanga et al. 2014b). The validation of the agricultural contents which was uploaded in W-FAIS and M-FAIS was done by developing maize promo which was aired in Kilosa Community Radio. This was also meant for those farmers who cannot use mobile phones.

Otherwise, the SMS module of this system serves as main channel of communication between farmers and experts. The technologies used for implementing the system are Apache, Java and MySQL as the Web server, server-side programming and database support respectively. Moreover, Huawei GSM/GPRS was used to connect M-FAIS and mobile phones and exchange messages.

4.1 M-FAIS Database

On building the system, MySQL DBMS was used to implement the database schema as shown in Figure 12 below.

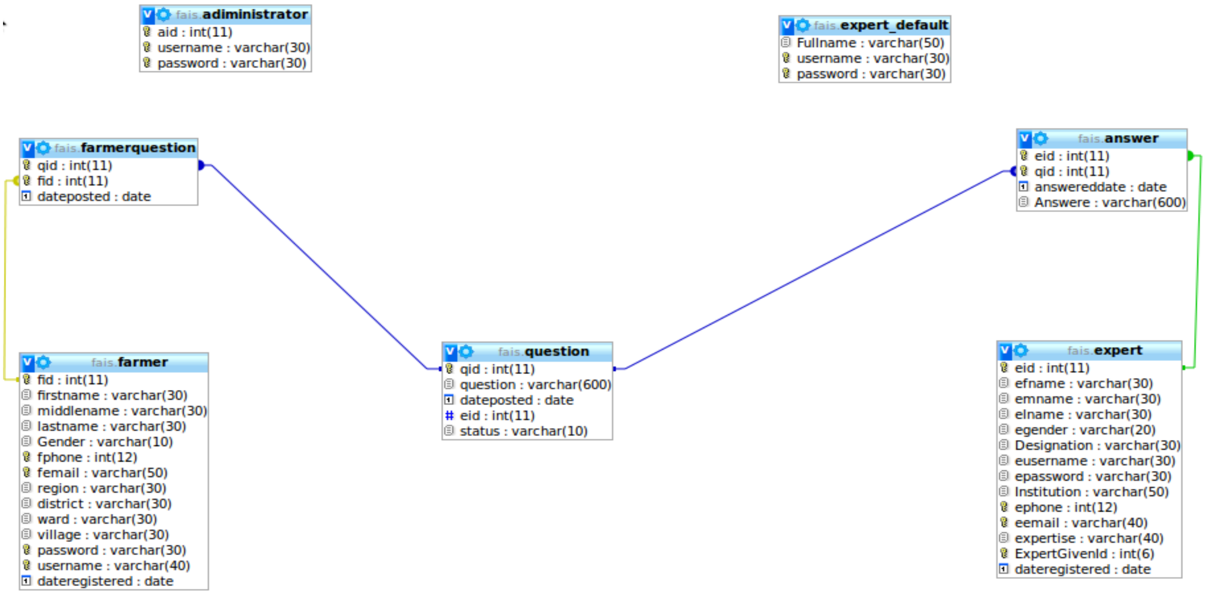

Figure 12: M-FAIS Database schema (Adapted from Sanga et al. 2014c)

4.2 M-FAIS User Interfaces

The system involves three types of users namely farmer (people or group of people seeking advisory services in agriculture), expert and administrator. The main window of M-FAIS is as shown in Figure 13 below.

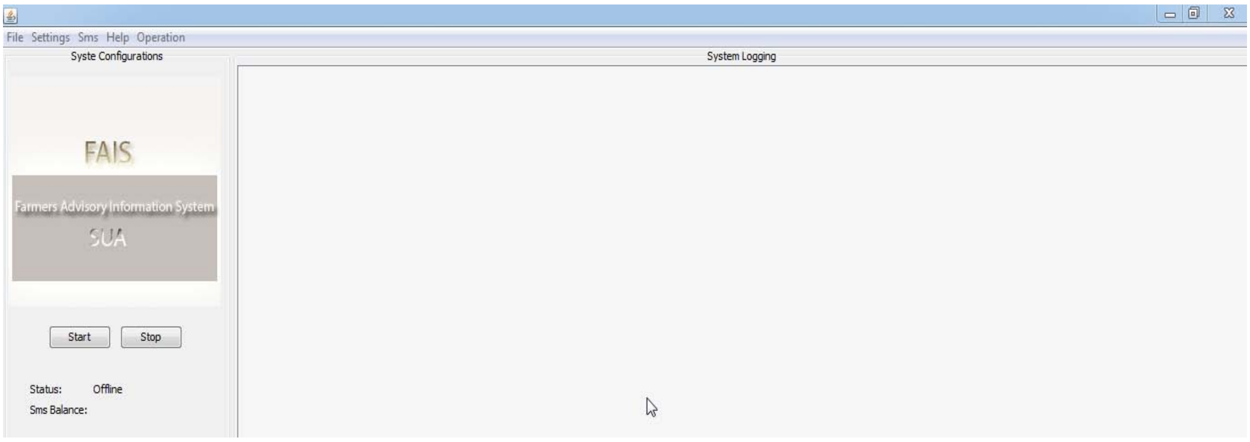

Figure 13: Main Window

4.2.1 Farmer

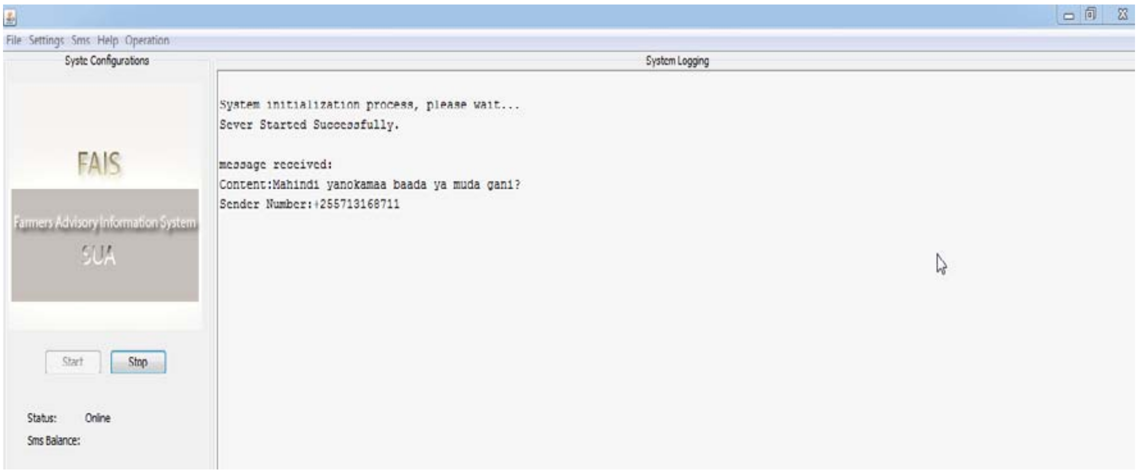

Figure 14: Sending SMS question by a farmer

A farmer sends an SMS based question asking the expert about question of his/her interest in real time. After the question has been sent it will be received by the server as can beseen in the Figure 14 above. When the farmer asks the question which has already been asked before, the system will provide the desired result (if the question has already answer). Communication between farmer and the expert is completely done through SMS. So, mobile phone SMS program is used as input/output device during the conversation.

4.2.2 Administrator

Administrator is responsible for configuring the system and making sure that the system runs in effective and efficient manner.Administrator tasks include configuration of the system and operate it. The Figures 15, 16 and 17 show port configuration, configuration completion and real time AT command windows.

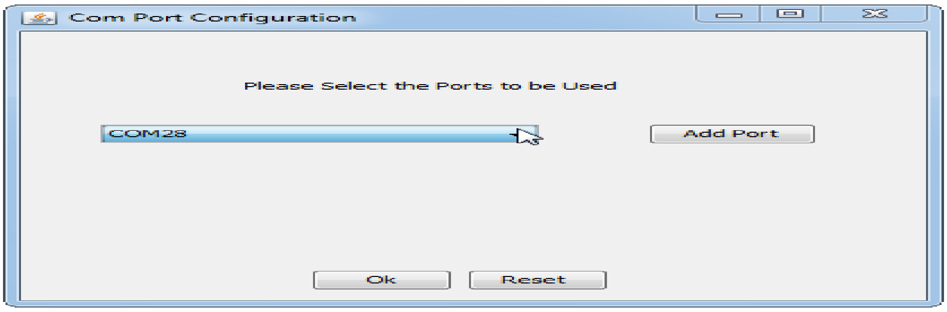

Figure 15: Port configuration

Figure 16: Configuration completed

Figure 17: Real time AT commands log of the system

4.2.3 Expert

An expert receives a question from the farmer on prompt as SMS messages in their mobile phones. The expert answers the farmer question through SMS and sends back the result to be relayed to farmer's mobile phone. After the message has been sent to the system, the message will be received by the system and forwarded to respective farmer as shown in the Figure 18 below.

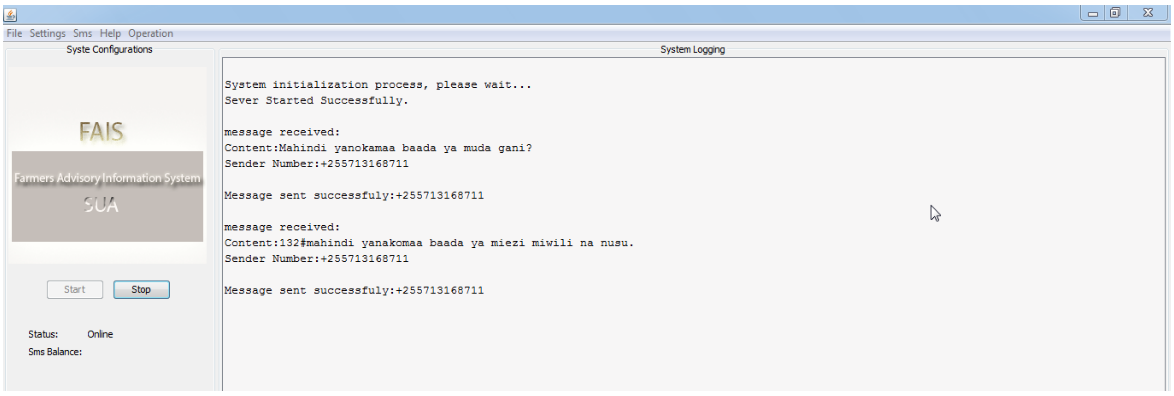

Figure 18: Expert answer message successfully sent to the system and farmer

5. TESTING OF M-FAIS

To identify the correctness, completeness, security and quality of developed system, the unit test was conducted first. The system was then put through load tests in which it was hit with a number of simultaneous requests. The server handled up to 85 simultaneous requests without any problem. The average time to process the 30 requests is six seconds. The average time to prepare the connection between computer and mobile phone is three seconds and the average time to find the answer from database sent it to the mobile phone is two seconds. The obtained results meet the requirements of the context in which the system was intended to operate.

5.1 Advantages of M-FAIS are similar to those provided by W-FAIS (Sanga et al. 2014c):

- Convenience – Farmers ask questions and get answered at their own convenience.
- Accessibility – Farmers and experts can communicate through the system from any location (as long as they are within a network service reception area).
- Portability – All types of mobile phones support SMS.
- Saves time – SMS reduces the throughput as websites are sometimes unavailable due to congestion, or server down time. SMS provides a faster means of sending and receiving information.
- Cheaper – SMS is generally economical, and it is sometimes provided as a free service (at least for certain periods) by the service provider. Most providers also do not charge when users receive SMS.
- Less human resources required – Query results from farmers are processed automatically
- Mobility – It is obvious that most mobile phone users have their phones with them everywhere they go, most people often leave their computer as home, or work sometimes, but they will always have their phone on them.

5.2 The limitations of M-FAIS are:

- It is difficult to certify SMS results unlike paper results which are stamped. However, mobile operators provide numbers that bear a name of company or institution. This way user can be sure that the message originated from the right source.
- As a rule, length of a SMS message is 160 characters. This is a limitation in SMS technology. Therefore the messages are abbreviated depending on the availability of the space.
- The SMS technology does not guarantee set transmission times or guaranteed delivery of the message, therefore some messages may be delayed, blocked or lost in transmission.
- The cost of the message might be transferred to the sender (although toll-free lines can be acquired) and this is network dependent. It is also possible to reimburse such cost, and to operate volume based tariffs.
- Service operators might not have coverage in some areas, and some locations may be prevented with mobile-phone jammers and therefore preventing users from getting service signals.
- Not all farmers will have a mobile phone. However, this is negligible considering the amount of mobile phone owners.
- Not all farmers are literate, but illiterate farmers might get assistance from others in the family/community who are literate. In our case, Kilosa Community Radio was used to air the same agriculture information used in M-FAIS and W-FAIS.
- Gender difference in access and use of mobile phone is also a limiting factor. This is from the fact that men, women, including some disadvantaged groups (e.g. those with disability) might not secure equal access to agricultural information through mobile phones.

Despite of the above limitations still the authors found that mobile phones are very useful in dissemination and communicating agricultural information and knowledge. The justification for this being:

a. Distances or remoteness of the farmers who need to be visited by few extension officers.
b. Low Government budget to employ more extension officers.
c. Few extension officers coupled with limited resources for them.
d. Novelty of information and knowledge related to agricultural from researchers.
e. Presence of many markets and therefore difficult to aunthenticate the reliability of market information circulating to differnt farmers in differnt location.
f. Technological development (e.g. mushrooming of TV, community radio stations, mobile phones).
g. Variability of information needs of different stakeholders / actors in various agricultural value chains.
h. Booming of markets with different information flow systems

i. Obsolete agricultural information – This calls for a unified way of collecting, aggregating, processing, diseminating and communicating agricultural information using low cost devices which are readily available to rural farmers.

6. CONCLUSION

The developed system can help farmers get diverse agricultural information from the actual source at their own convenient time through their cell phones. The system was developed using GSM modem independent service architecture. Apache, Java and Mysql were used as web server, server side programming language and DBMS respectively. The system was tested and it provided a promising performance which demonstrates its capability to support the conventional agricultural extension services through mobile phone. One peculiar characteristic of M-FAIS is that it runs to all different types of mobile phones. Thus, we recommend further testing of the system to evaluate its usefulness to the agriculture extension service delivery to farmers. Thus, the main contribution of this paper is on development of tool to support agriculture extension service through low cost mobile phone. The developed system was developed and tested using the concept of Living Lab (Cunningham et al. 2011) whereby researchers from Sokoine University of Agriculture, Norwegian University of Life Sciences, Uyole Agricultural Research Institute (ARI), Ministry of Agriculture, Cooperative and Food, Kilosa District, famers, Kilosa community radio, IT administrator from KIRSEC (community telecentre – owned by private sector and Ilonga ARI were involved in a partipatory action research (PAR) study (Sanga et al 2014a; Sanga et al 2014b; Sanga et al 2014c; Sanga et al 2014d). These researchers participatory involved from exploratory study, stakeholders analysis, inception workshop, baseline survey, system (M-FAIS and W-FAIS) development and testing as well as monitoring and evaluation.

Another avenue for further study is on assessment of how the system delivers extension services in an efficient way as perceived by the target group (i.e. farmers and other actors in maize value chain). To what degree men and women farmers are willing to pay for such a system or what kind of payment arrangement could be put in place also need to be studied.

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