Strategy for the adoption and effective utilization of mobile phone technologies in smallholder agriculture in Zimbabwe

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ABSTRACT There is a growth in research on the benefits and use of mobile phone technology in the whole world. Zimbabwe as a country has seen that this is a feasible route to explore. This paper explores how other countries are using this technology to improve agriculture yields. It analyses factors that are hindering mobile phone technology use and adoption among smallholder farmers in Zimbabwe. The paper employed qualitative research design, guided by inductive approach underpinned by interpretivism philosophy. Findings from the gathered data showed that smallholder farmers are willing to make use of mobile phone technologies in their farming context. The cost of gathering data, lack of training and poor infrastructure was seen as the main hindrances to adopting mobile technology in agriculture. The paper then designs a strategy that can be used for mobile technology adoption and effective utilization by smallholder farmers in Zimbabwe. Recommendations such as farmer training, government involvement and infrastructure development in rural areas were suggested. This research adds to the existing body of literature since there was no known research in Zimbabwe which focused on developing a mobile phone strategy for smallholder farmers.

Keywords: Smallholder farmers, Mobile phone, Rural, Interpretivism, Strategy, Adoption of Technology.

1. Introduction

Agriculture is the backbone of the economic growth and poverty eradication solutions especially in the rural areas of Zimbabwe (Muchati, 2014). The majority of the country's population owns a mobile device known as cell phone that is being used for communication (Musungwini, 2016). Mobile ICT is one of the trending technologies that are providing solutions to problems encountered in any industry such as education, health and agriculture. The use of mobile devices do offer great potential in improving level of services and reducing costs in most industries. After investing huge amounts of money in mobile ICT technologies, if the mobile devices are used for communication purpose only (such as making calls and texting) they will be underutilized. This research develops a strategy for adoption and effective utilization of mobile phone technologies by small holder farmers in Zimbabwe in order to

improve the living conditions of smallholder farmers. Mobile technology and mobile phone technology is used in this research to mean mobile and cellular communication devices and services. These terms are used interchangeably to mean those technologies that can be moved from one place to another when accessing information.

2. Background and Context

Mobile phone technology is one of the many ICT technologies that have evolved in the recent years (ICT4Ag project 2014-2015). Asongu (2015) and Aker and Mbiti, (2010) highlighted that the fast penetration of ICT will bring in new opportunities for African farmers in improving their knowledge and lifestyles. Mobile phone based services have been developed in recent years, to provide marketing information and for use in agriculture (Gakuru et al 2009; Quiang et al, 2011). More so researchers have discovered that mobile phones have a positive impact on poverty reduction (Silarszky et al, 2008). However adoption of these mobile phone technologies and their utilization are low in developing countries and there is need to design adoption and utilization strategies for specific groups (Aguilar-Gallegos et al, 2015).

Mobile phone technology has become the most omnipresent technology in developing countries (Aker & Mbiti, 2010b; Musungwini, Zhou, & Ruvinga, 2014). Mobile devices such as mobile phones that are normally being used to communicate with family members can be used for agriculture business. As a result it can help transform businesses including the agriculture sector (Deloitte, 2012; Ewing et al 2014). Nyamba & Mlozi (2012) and Oladele (2015), research have shown that mobile phone technologies can improve production among rural area small holder farmers. Small holder farmers in rural areas require information on weather, markets, cultivation timing among others and mobile phone technology has been used in other countries so that this information reach farmers (Chisita & Malapela 2012).

In Sub- Saharan Africa mobile phone applications in agriculture are being used to monitor rainfall tracking, soil composition, maps, and inventory management. According to the World Bank about 67.72% of the people in Zimbabwe live in rural areas and these people depend on agriculture for survival. An increase in the number of base stations in rural areas has been noted in the past year (POTRAZ 2017). Base stations are needed for one to be able to utilize mobile phones or cell phones; therefore mobile phone technology plays a significant role in improving the livelihood of smallholder farmers in Zimbabwe.

Chisita & Malapela (2012) agrees that mobile technology adoption is providing agriculture industry with opportunities to extend their services to those who are disadvantaged and geographically dispersed especially in rural areas. According to researches done in countries such as Tanzania, Uganda, China, Ethiopia, Kenya, mobile technology plays an important role in providing information to farmers (Furuholt & Matotay, 2011; Gichamba, Lukandu, & Lukandu, 2012; Martin & Abbott, 2011; Nickitas, 2011; Qiang, Kuek, Dymond, & Esselaar, 2011; Tadesse & Bahiigwa, 2015).

In Zimbabwe some mobile phone technologies are there for agriculture but there is slower adoption because of lack of strategies. These include mobile services and apps for agriculture. The following are some of the mobile phone technologies in Zimbabwe agriculture sector:

- EMkambo Nest – this is a mobile app for Zimbabwe's agriculture sector which complements SMS, call centers and face to face knowledge sharing among farmers.

- Kurima Mari – this is an e-extension mobile farming App created for small holder farmers and extension workers.
- E-Hurudza Africa – a market driven platform developed by the Hurudza team to provide information to farmers regarding different markets and agriculture activities.
- Eco-Farmer – an ECONET owned mobile farming platform used to deliver farming tips and advice through SMS's
- Agro Axess – a mobile app developed by XDS (eXpert Decision Systems) that provides farmers and merchants with an input –output management solution.

At the time of carrying out this research many articles had been published on adoption and use of ICTs particularly mobile phones adoption and use by smallholder farmers in Sub-Saharan Africa. However, we established that, the diffusion models are at the epicentre of ongoing efforts to scale ICT use in agriculture. At the time of carrying out this research there was still debate on how best to achieve effective use of mobile phones in smallholder agriculture with no end in sight. Even in the developed countries the adoption and use of mobile phones is not extensive, maybe because the technology play more of a complementary role whereas in the developing countries it is the only technology available. Usually, research on the diffusion of technology is used when the researcher seeks to understand how the spread of an innovation happens among certain groups in a given environment.

At the time of carrying out this research there was no known research which specifically focused of development of a strategy for the adoption and effective utilization of mobile phones by smallholder farmers.

3. Strategy Formulation

A strategy is concerned with the future. It can be explained as a roadmap to achieve future goals. To come up with an effective strategy in the adoption of mobile phone technologies among smallholder farmers the following strategy formulation phases as explained by (Wheelen and Hunger, 2006) will be explained:

- Diagnosis
- Formulation
- Strategy implementation

The research will assist in coming up with a strategy for the adoption and effective utilization of mobile phone technology in smallholder agriculture in Zimbabwe. The mobile phone technologies are there but not known by smallholder farmers in Zimbabwe.

4. Problem Statement

(Aguilar-Gallegos et al, 2015) highlighted that adoption of mobile phone technologies and their utilization among smallholder farmers are low in developing countries and there is need to design adoption and utilization strategies for specific groups. With that in mind this can be seen as the best time to come up with strategies that can enhance adoption and use of mobile phone ICT in agriculture.

5. Research Objective

The main objective of the research is to develop a strategy for the adoption and effective utilization of mobile phone technologies by smallholder agriculture in Zimbabwe.

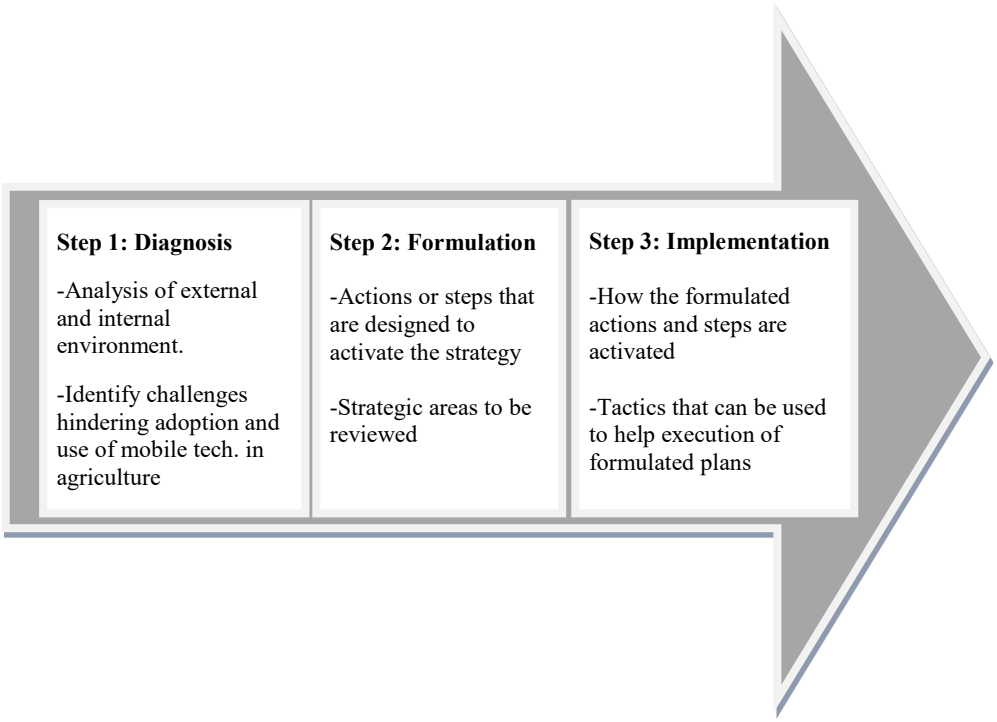

Figure 1: Strategy formulation steps

6. Research Methodology

In order to meet the research objective, the methodology employed is based on an exploratory research in the agriculture sector in Zimbabwe, involving deployment of semi-structured interviews and questionnaires. The research was done in accordance with the case study guidelines as explained by Yin (2014). Case studies do allow for the use of multiple sources of evidence. The impact of Mobile technology adoption and use in the agriculture sector in Zimbabwe is the real life phenomenon. Zimbabwe was chosen because it is a developing country which relies on agriculture and because of the new strategy of command agriculture that has been introduced. The portion of the population that the researchers used is the accessible population (Korb, 2012). Smallholder farmers in the Midlands province were used for this research because the province has a high number of populations as compared to others and the population is diverse. In this research snowball sampling was employed were participants with the required characteristics identify other participants. The results from such a study can however be generalised to other African countries which have the same context as Zimbabwe.

7. Data Collection

Data collection involved the use of semi-structured interviews with small holder farmers and agriculture extension workers. The interviews were held in Midlands's province and this included 10 extension workers and 2 supervisors. Other small scale farmers were interviewed to give their view on mobile technology use in agriculture. Most of the small scale farmers filled in the given questionnaires. A total of 40 hard copy questionnaires were distributed to different small holder farmers through their extension workers. The main aim of questionnaires was to find out which media is used by farmers to get agriculture information and the challenges

they face when using mobile technology for agriculture purposes. Of the 40 questionnaires distributed 5 were not returned giving 87.5% response rate from small holder farmers.

8. Data Analysis

Gathered data was analysed using a thematic analysis method. Braun and Clarke (2012) explained this way of analysing data as involving identifying themes and patterns within the gathered data. In cases were responses from interviewees and those who answered questionnaires pointed to a common aspect a general phrase was identified. The phrase provided a collective description to the unstructured data. Relevant aspects of the research are explained in the following section were the strategy is developed.

9. Strategy Development

To come up with an effective strategy in the adoption of mobile phone technologies among smallholder farmers the following strategy formulation phases that is Diagnosis, Formulation and implementation as explained by Wheelen and Hunger (2006) will be explained.

9.1– Diagnosis

This involves an analysis of external and internal environment. A look at the challenges hindering adoption and use of mobile technology in agriculture. Diagnosis was done through engaging farmers and other stakeholders in environmental scanning. This helped in identifying challenges that are hindering mobile technology use in agriculture, gaps and weaknesses that are there in the agriculture sector. From the environmental scanning and assessment, the results were placed into 5 groups titled diagnostics (D). These are as follows:

D1: Poor Infrastructure: Internet challenges, expensive mobile services and power shortage were seen as the main factors that affect the use of mobile technology in agriculture. Since mobile technology requires power and mobile network facilities such as base stations, most respondents highlighted the challenges in these infrastructures and the highly priced mobile services as hindrances to mobile technology use in agriculture. From this diagnostic it can be seen that there is a problem in the infrastructure and enabling services.

D2: Poor Human Skills: The second diagnostic was the issue of Human skills. The level of education, lack of technological skills of the farmers and involved stakeholders keep them away from utilizing mobile technologies for agriculture. Most stakeholders in the agriculture sector especially farmers only understand that mobile phones and technology are used for making calls and texting and they are not familiar with other functions on these mobile devices.

D3: Poor Content and Information Collaboration: The third diagnostic looks at the information and content needed by the famers. There is a high demand for high quality agricultural information to the smallholder farmers. Provision of quality information through the mobile phone can increase production. Appropriate information which is related to farmers needs in terms of its relevance and format is needed. Information related to best crop selection, access to inputs, sound management of the farming activities and post-harvest techniques should be available to all smallholder farmers. Since they believe mostly information provided by the government and the ministry of agriculture as their main sources of information, these stakeholders should be part and parcel of information delivery. Content should be created from reliable sources. Local languages and local content should be taken into considerations. This

information should be mobilized and packed to meet different users. Smallholder rural communities' information should be widely shared.

D4: Policies and Regulations: Implementations of policy that govern Mobile ICTs have an impact on technology diffusion and use. There is need to restore international relations with other mobile ICT providers so as to increase competition among the service providers. Foreign investment is also needed in our country to increase the use of mobile ICT among farmers. Poor or lack of strategic alignment between the ICT policies and ministry of agriculture policies is a challenge in this sector. If these two ministries work hand in hand they can achieve the goal of mobile technology use in agriculture.

D5: Financial Resources: With all the above mentioned areas finance should be included as well. As a country we suffer from under capitalization of projects and to get profits from those projects it becomes difficult. This under capitalization affects mobile phone apps and services developers to be reluctant in providing good apps and services. To this end high pricing strategy is being used so that those providing for mobile service can profit as well. Mobile data and devises are highly priced to the extent that few farmers can afford these.

9.2 – Formulation and implementation

To be able to solve and respond to the given diagnostics, gaps and challenges, action plans need to be identified for the five diagnostics. The following action plans can assist in solving the highlighted challenges.

Action Plan 1 (AP1): Poor infrastructure was identified as a challenge and factor that hinder adoption and use of mobile technology in agriculture in Zimbabwe. The suggested action plan is enhancement of the rural infrastructure. Electricity should be availed to rural citizens and it should be consistent and reliable. Mobile technologies and internet should be deployed to even the most remote areas at an affordable price.

Action Plan 2 (AP2): Poor human skills were identified as a challenge in the agriculture sector and the action plan suggested will be training of famers. Training can be done on extension workers and model farmers, and these can act as change agents. This training will involve training of different functions that are found on mobile phones. Weather information is found on mobile devices but very few can interpret their meanings. With training farmers are likely to be exposed and to be empowered thereby making proper use of mobile phones for agriculture purposes. Adult literacy programs and capacity building programs sponsored by mobile phone service providers and the government can enhance the literacy rate.

Action plan 3 (AP3): Content and information collaboration problem can be solved by rural councils. These can assist in establishing coordination among farmers, extension workers, ICT providers and agriculture institutions. If these are well coordinated relevant content will be passed through the use of mobile phones. When there is good coordination extension workers can sensitize smallholder farmers on the effectiveness of mobile phone technology in their farming activities. This helps in creating awareness

Action plan 4 (AP4): Policies should be created by the ministry of agriculture to aid mobile phone use in agriculture. Government, ministry of Agriculture and ICT should support mobile-Agriculture applications. Results from gathered data showed that most initiatives are donor based and when these are no longer there, there is no one to continue with the initiative.

Nationwide initiatives are needed that makes use of mobile phone-based systems among smallholder farmers and agriculture practitioners. Policies that guide continuation after donor-based initiatives can help curb technology use problems.

Action plan 5 (AP5): In the case of finances Subsidizing mobile devices and services can assist in higher adoption and utilization since most of them indicated that the cost of the technology is on the higher side. This can only be achieved if mobile phone service providers work hand in hand with the government and ICT ministry. Subsidizing of prices of data bundles, internet charges can also assist in utilization of mobile technology. Various actors in the value chain such as buyers of output products and sellers of inputs should also be engaged. Technology cost to farmers in rural areas should be affordable. In this case banks and mobile money service providers should consider interest free loans on mobile phone purchases to farmers and the repayments should be easy instalments.

Figure 2 summarises the challenges for adoption and use of mobile technology in agriculture, the action plans that can be used to aid adoption and how these plans can be executed.

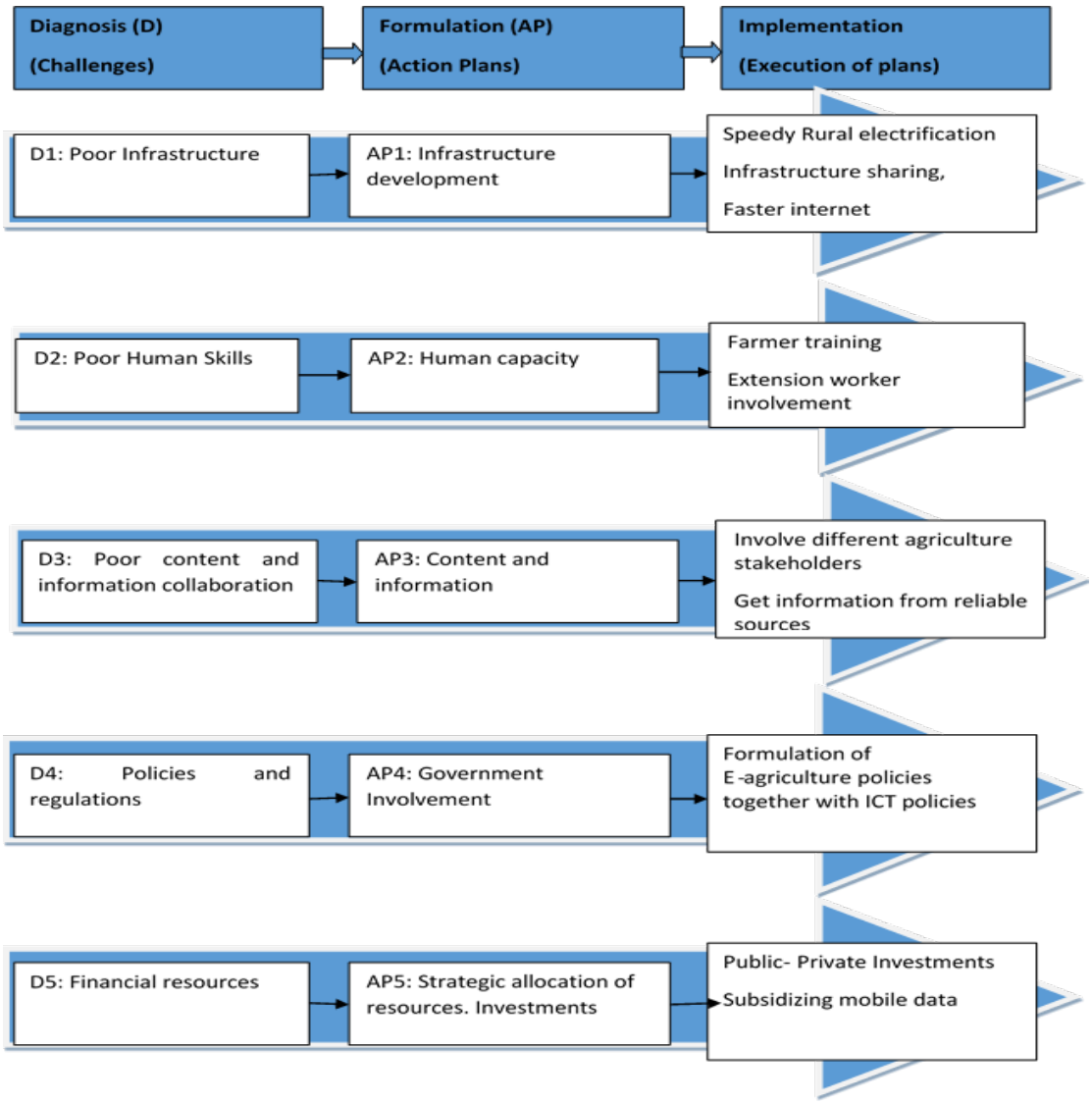

Figure 2: Summary of the five courses of diagnosis, planning, and implementation.

10. Conclusion

This research looked at the benefits and factors that affect the adoption and use of mobile technologies in agriculture. A strategy was proposed to encourage the adoption and utilization of mobile technology among smallholder farmers in Zimbabwe. Further research to test how the strategy will operate in a real environment can be done.

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Using Mobile Phones to improve Veterinary Service Delivery and provision of First Aid Information for Livestock Owners in Nakasongola Uganda

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ABSTRACT Delays or any constraints on the access to quality veterinary services can lead to loss of livestock. For farmers in rural areas this is a big challenge as professionals such as para-veterinarians and veterinarians on the ground are few. Attempts have been made to bridge this gap using IT; however, a lot of challenges have been met. These IT solutions are biased to using desktop computers. In the rural setting power is a big challenge if this is to operate. Secondly, the mobility of pastoralist cannot allow them to use computers. Some developing countries use Community Animal Health workers to treat animals and capture infections details. This study investigates how to use mobile phones to improve veterinary service delivery and provide first aid information to livestock owners, especially in rural setting in the developing world.

1. Introduction

According to the International Telecommunications Union, global interconnectedness continues to grow rapidly, with 95% of the world's population living in an area covered by a mobile network, and the majority of Internet users now located in developing countries (Holmstrom and Beckham, 2017). Network services and mobile devices are also becoming more affordable and their usage across the globe is increasing. As of November 2016, there were 7.5 billion mobile device subscriptions worldwide with smartphone subscriptions accounting for the majority of these source. Information technologies are rapidly advancing the way in which animal health data and information are collected, analyzed and shared in order to support animal health management, disease surveillance and response plus decision-making (Holmstrom and Beckham, 2017). Mobile devices have been used to perform mobile health technologies, or mHealth technologies, these include handheld devices such as mobile phones, smartphones, and tablets that allow data to be collected at the location and time at which animals are examined (Gichamba and Lukandu, 2012; EllyssaKrosk, 2008). Mobile phone health technologies avail for the collection of data and ability to reach to big numbers of people at a low cost. By the portable nature of such technologies, they can be used in rural areas of developing countries where livestock and pastoralism are commonly practiced. Mobile phone health technologies provide data collectors with the ability to quickly reach large numbers of people at a low cost. In addition, such technologies, by their portable nature, can be utilized in

rural areas of developed and developing countries where livestock are commonly located (Karimuriboet al., 2016). Furthermore, they enable all members of an animal health enterprise (e.g. livestock owners, community animal health workers and technicians, veterinarians, etc.) to be active participants in bidirectional information exchange (Holmstrom and Beckham, 2017, pp. 527-529).

The key problem that is encountered in treatment and control of endemic diseases within the pastoral communities of Uganda is the delay in the disease reporting. By the time a disease is reported it is already out of control. Second, there is a very long distance between the veterinarians and the nomadic pastoral lands. Cars and motorcycles cannot access the pastoral lands and most times the veterinarians a left to walk long distances without marked roads or access. The main means of transport used to move to those distant places are walking and riding a bicycle. Farmers noted that sometimes it takes them two to three days on the way to reach the drug shop and market places. This study investigates on how to integrate Mobile phone devices in IT solutions to reinforce efficient delivery of veterinary services especially to rural setting in the developing world. The research further explores the use of mobile devices and a mobile application to report symptoms, diseases and areas where there is an outbreak to the online system. The farmers are provided with a mobile application to send symptoms to the veterinary system, where the information is processed. The system indicates the location of the farmer and avail him with first aid information and nearby veterinarian's contact information if any. This information is stored in database to be used to analyze areas that are most affected with diseases. Besides the aim of giving first aid information to the farmers, the system also has the capability of giving an early warning for disease outbreak in some areas.

This paper is organized into 5 sections. In Section 2, a brief overview of the related studies is provided. Section 3 presents methodology used to accomplish the study. Section 4 provides findings and the proposed system. The paper ends with section 5 which presents discussions, conclusion and recommendations.

2. Related Work

A lot of literature exits about work that has applied livestock disease management using ICT as an extension services delivery tool. A review was done on different models developed to control, monitor, record and analyze livestock diseases. The first model reviewed in this study is Animal Resource Information System (ARIS) which was developed by African Union's Interafrican Bureau for Animal Resources (AU-IBAR) with the aim of providing a comprehensive information system within its member states (Chibeu, 2011). The idea of ARIS was founded by the Pan African Program for the Control of Epizootics (PACE). ARIS provides "early warning and rapid response, allocating resources, assessing the level of livestock contribution to livelihoods and GDP, and formulating policies" (Chibeu, 2011). ARIS is a multilevel and multiple usage system that integrates all Animal Resources information; allowing for visualization of information in the form of tables, and maps. The system was developed using Oracle as the database engine technology (Chibeu, 2011).

The second model reviewed is Transboundary Animal Disease Information (TADinfo) System which is a veterinary data management system deployed at the Epidiomology Unit offices in Entebbe Uganda. It was designed to provide national veterinary officers with a tool capable to enhance epidemiological analysis and decision making (Kamata, 2011). In 1994 FAO launched a program known as Emergency Prevention Systems (EMPRES) for Trans-boundary Animal

and 32 Plants Pests and Diseases that led to the development of TADinfo. The system has five data entry modules to record all the events related to animal health and these include Field Observations, Abattoir Observations, Active Surveillance, Vaccination and Census. TADinfo also has the capability of presenting vaccination coverage, sero-prevalence or distribution of outbreaks on a map, and export data for further analysis with minimal data (Kamata, 2011).

The third model is the World Animal Health Information System (WAHIS) is an international early warning and response system for human and animal diseases. It is used in monitoring exceptional epidemiological situations, and any detected exceptional epidemiological event occurring in a given territory or country in real time (Jebara,2011).WAHIS is owned and operated by the OIE, in the case of disease reporting, the system is limited to a country representative from member countries who feeds into it the information (Vallat et al., 2013). For monitoring the disease WAHIS also depends on disease intelligence. Disease intelligence is the tracking of unofficial information using channels like the media, to update disease outbreaks and other animal information (Jebara, 2011).

The fourth model reviewed is a web-based GIS system, ArcIMS, that establish interactive mapping capability that allows veterinarians to use the internet for remote data entry. Davies et al. (2007) describe this system which was created for the surveillance of diseases, primarily PRRS, in swine farms in Minnesota, USA, and that it uses publicly available high-resolution aerial photography as a platform for mapping. The system lets authorized veterinarians "edit specific client farm data including location, disease and other attributes (editing limited to one veterinarian to per farm)" and for authorized members of an organization to view farm data related to them (Davies et al., 2007, p. 735).

However, all the above models have been developed putting much emphasis on disease reporting with little or nothing to the provision of timely veterinary service delivery within the pastoral lands. Given the challenges and difficult to access the nomadic pastoral areas, the proposed model intends to avail online veterinary services responding to the farmers request.

3. Methodology

3.1 – Requirement gathering and analysis

The study used Nakasongola district as a case study and this was from June to September 2015. The district has about 20 villages. Due to resource constrains, we gathered data from two villages. We used purposive selection of subjects. Fifty (50) respondents were identified as potential sources of data needed for the study. The respondents were in three categories: (1) five Veterinary officers; (2) five community health workers; and (3) forty farmers. We used both interviews and questionnaire as data collection techniques. From the five veterinary officers we captured data on; common cattle infections, frequency of consultations from the community, and challenges. For community animal health workers we managed to get five subjects. Community health works are society members who have completed at least senior four and have been trained to provide first aid and forward serious cases to veterinary officers. From these we were interested in; common diseases, frequency of visits by veterinary officers, description of first aid they provide, and the challenges faced. Now we went to farmers. These farmers owned 50 to 100 cattle. For these farmers, cattle are taken as reservoirs of their wealth and because of this, they guard their cattle enviously. Unfortunately few farmers could speak English a common medium of communication to Ugandans especially the elite. We managed

to collect data from 20 farmers. The farmers provided information on: (1) common diseases attacking their cattle; (2) how often are they visited to get help from veterinary officer and community animal health workers; and (3) challenges faced. These data were analyzed using descriptive statistics as detailed in the later section entitled Findings from the requirement gathering.

3.2 – Development methodology:

Rapid application development (RAD) was used as the methodology to design the model. The method uses minimal planning in favor of rapid prototyping (Beynon-Davies, 2000). In RAD model the components or functions are developed in parallel as if they were mini projects. The method helps in integration from very beginning to solve a lot of integration issues (Mbaluka & Okeyo, 2016). The model was divided into two, the web application that was developed independently and later mobile applications of which were integrated. For a better understanding, a prototype was presented and examined by the users to prevent misunderstandings and miscommunications between them and us developers.

4. Findings and the proposed system

4.1 – Findings from the requirement gathering

The initial investigation of the study shows that 2 of the 5 veterinarians assert that the method used to report livestock disease outbreak is not sufficient, one of the veterinarians feel that farmers are in places which cannot be easily accessed making it difficult to control diseases and provide timely veterinary services, one of the veterinarians feel that phone calls from the farmer have helped in livestock disease control and one thinks some farmers use traditional medicine rather than reporting which hinder sufficient disease control.

Three of the five CAHWs feel that the current system of veterinary service delivery is not sufficient enough to save livestock while two prefer it.

Further in the study 65% of the animal owners and herdsmen felt that the method in place is poor for veterinary service delivery and disease reporting, and that it requires improvement. 15% (i.e. 3/20) where ok with the current method and 20% of the animal owners and herdsmen gave no answer to this question.

4.2 – Proposed system

The proposed Model architectural design was developed based on the challenges highlighted and opportunities identified as presented in the section entitled *findings from the requirement gathering*. Based on this, A mobile application was developed to allow CAHWs report diseases and receive first aid information to rescue the farmers' livestock before the veterinarians show their way. The CAHW farmer uses the mobile application to report his location, type of infected livestock; symptoms, total livestock and number of infect livestock. The system is able to process the received information and in return the farmer is sent the proposed first aid and the nearby or available veterinarian's contact information. The information is then directed to the database and it is displayed on the veterinarians' phone or desktop using the web interface. Diseases and symptoms are stored on the database for decision making.

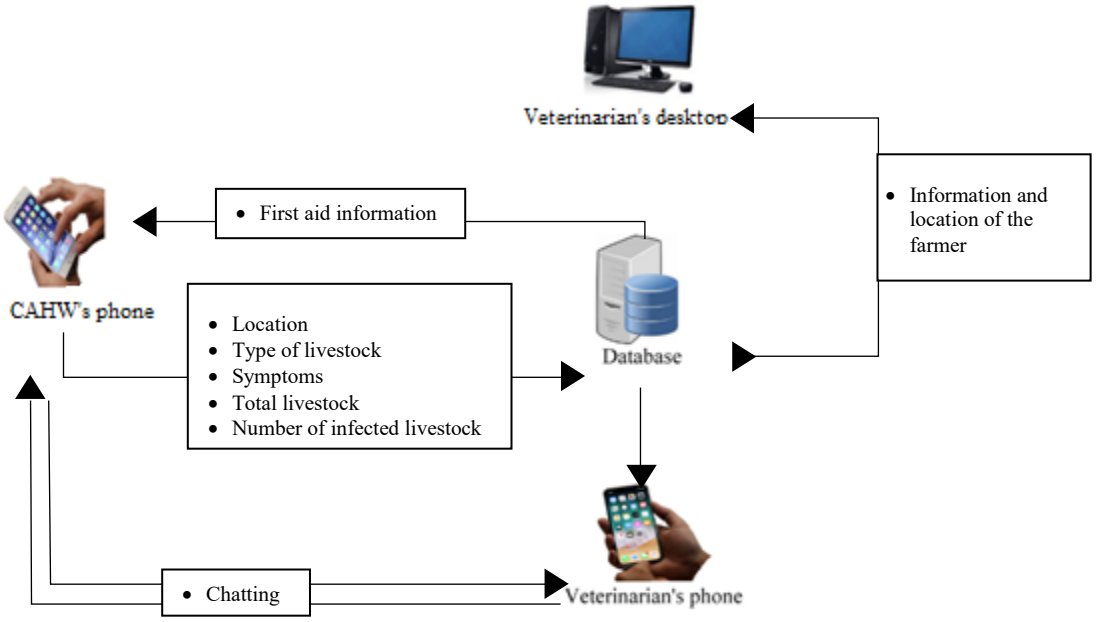

Figure 1: Model architectural design

4.3 – Mobile app

The mobile application is used by CAHWs, field veterinarians and farmers who are able to read and write. The screen shoots present the login interface (Figure 2), CAHW's and farmer's complaint form (Figure 3), and system returned first aid information and available veterinarian's contact details

Figure 2: Startup menu with four login buttons: DVO Panel, CAHW Panel, Field Veterinarian Panel, and Farmer Panel.

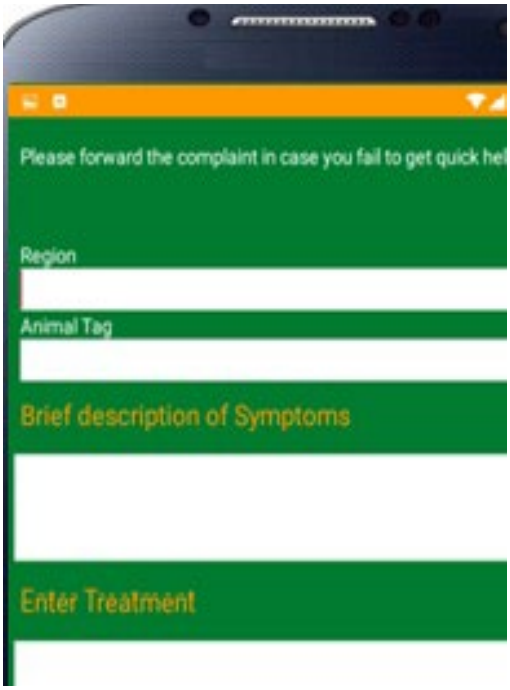

Figure 3: CAHW complaint form

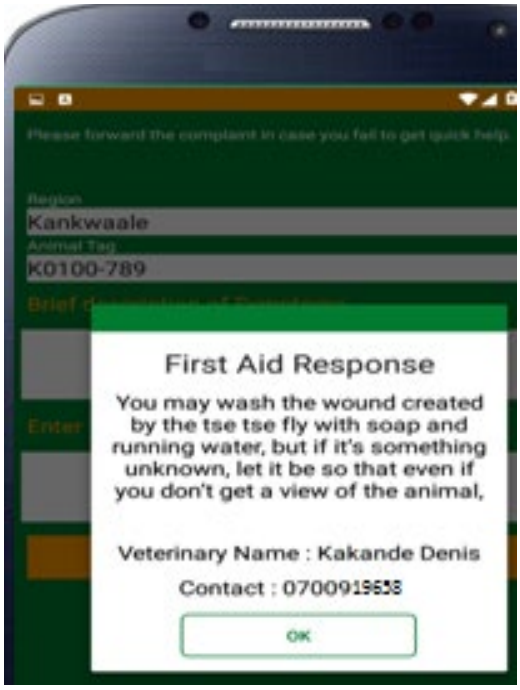

Figure 4: First aid information

4.4 – Validation of design

Due to resource constraints (time & facilitation), the prototype was validated according to the available means.

Three members were involved in solution evaluation and these include: two technical persons and one veterinarians. These were guided and allowed to interact with the prototype. They were asked to assess the system on four aspects: (1) improved veterinary service delivery; (2) fast disease reporting; (3) reducing gap between veterinarian and farmers; and (4) reporting of disease outbreaks.

Finally, they were asked to provide the overall percentage on all these aspects combined: This was given as percentages (75%, 80% and 80%, respectively) of fully satisfactorily; by which an "average" of perceived usefulness could be calculated: 78%.

5. Discussion, conclusion and recommendations

5.1 – Discussion

The study set out to exploit mobile technology to aid in providing first aid and treatment of cattle in rural setting. When the solution was subjected to the technical evaluation, the technical responsible was awarded to over 75% satisfactory. The users scored the system 80%. The average score was 78.3%. This provides some level of confidence that if the system is deployed based on this prototype would help address the observed challeng. This study relates to investigation carried by (Mbaluka & Okeyo, 2016) as highlighted in the related work. Like any other study, the research registered limitations. First due to time and resource constraints, the solution was tested with limited number of subjects. Before deployment of a solution based on this ideology, it is worthwhile to validate the prototype with more subject.

5.2 – Conclusion

This study investigated the use of mobile application in veterinary service delivery and livestock disease management. This was in relation to reducing on animal deaths and controlling diseases in the pastoral areas of Nakasongola district. Findings with developed mobile app demonstrated the usefulness of mobile technology in facilitating disease reporting, recording, monitoring, controlling and giving first aid information to the in animal owners and herdsmen. This is important in this era of increasing penetration of phone and this makes the solution viable to an ordinary man.

5.3 – Recommendations

Stakeholders can consider how this trial can be deployed to the ground. Future work can consider exploring other services which can be brought closer to ordinary man through mobile technology.

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YAY Garden: A conceptual study for a system supporting exchange of agricultural practical experience

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ABSTRACT Farmers encounter unique and useful experiences from the time they prepare to plant crops until harvesting. These experiences can be instrumental in improving agriculture production if shared among farmers that grow similar crops at the same time/ in the same season. There is no documented computerized system to enable sharing of such experiences. The purpose of this study is to design a system, You And Your Garden (YAY Garden) to enable sharing of garden experiences among farmers. We focused on graduate farmers that own 1 to 3 acres of land in Wakiso District Uganda and these farmers are formerly employed in organizations in Kampala city. Requirements of the system were collected using semi-structured interviews. These requirements were transformed into a design for YAY Garden. The design was specified using Unified Modeling Language (UML) use case and class diagrams. When this system is implemented and made to run on mobile phones, it will enable sharing of farmer experiences among themselves and with agricultural extension workers.

1. Introduction

Farmers encounter useful and practical experiences that may not be documented anywhere for others to learn from. These experiences that individual farmers encounter in their gardens are a rich learning experience for other farmers in similar circumstances growing similar crops (Barret, nd). These rich individual experiences remain in the individual gardens of individual farmers without being shared. So, we need a means to share such experiences.

Farmers face challenges during crop growth (in the crop value chain) on which they need advice from fellow farmers growing similar crops. Although such advice could be provided by extension workers who train and visit such farmers, such extension workers are few in developing countries like Uganda. In addition, even if these extension workers were many, they cannot visit farmers' gardens periodically from cultivation time to harvest time because of limited time and money.

Farmers that grow similar crops may greatly learn from one another and address many challenges they face if they form an online community that enables them to share vivid practical

experiences they encounter from cultivation time to harvest time. Similar crops need the same handling for proper growth and if they are attacked by pests and diseases, they need similar care. When information about pests that have attacked crops in one garden is shared among a community of farmers currently growing a similar crop, it may help to prevent similar pests from attacking another garden. If certain methods of farming have yielded better crops such methods can be shared and applied by farmers to their similar crops for better yields in real time.

Despite the value that accrues to sharing of vivid practical experiences among farmers that grow similar crops, these experiences are not shared. We have not found any implemented and documented IT system that enables such experience sharing among farmers. This research seeks to develop an IT system You And Yours (YAY) Garden that supports farmers to share vivid experiences from which other farmers can learn and answer many of their challenges.

In this conceptual study, we claim that an IT application with specified requirements will enhance farmers' sharing of experiences and learning from one another. This study is to lay the foundations for such an IT application through establishing requirements and designing the application. Using this design, other IT specialists can implement such a system.

2. Literature Review

The purpose of this section is to show evidence that there are software applications that have been developed to enable farmer experience sharing and/or learning. These applications, especially web based, are documented, evaluated and their strengths and weaknesses highlighted. We analyse these weaknesses to establish a gap that this research attempts to fill.

"Many small-scale farmers in the developing world learn how to grow crops and raise livestock in a very practical way: by working in the fields and by tending animals. They grow food for their families and sell any extra to visiting traders or at the local market. But they have never studied farming in school." (Ferris et al., 2015). Their fields are their schools. Each farmer has a field as a teaching aid. Farmers can increase their learning experience by learning from their own field and from the fields of other farmers especially those that grow crops similar to theirs. There are software applications that have been developed to aid farmers sharing of field experiences and learn from one another. This section of literature review intends to review such software applications and identify the gap these applications have not yet filled.

Many applications developed are mobile based and these targets sharing of information especially using text messages (FAO, 2012; Oxfam, 2011). These applications are expected to increase farmers' incomes. This is because they provide exchange capital and mobile information services thus enabling access to critical, targeted information on commodity prices, weather, disease outbreaks, etc., and helpline services providing key tips and real-time advice (FAO, 2012; Oxfam, 2011).

Although there are mobile applications that provide real-time advice to farmers, many mobile applications have targeted providing mobile financial services, including mobile money, to small-scale farmers. Such financial applications are Agrinet Uganda and M-PESA in Kenya (FAO, 2012).

In Uganda, there are web platforms intended to support farmers. A collaboration between USTA, UNADA and CropLife have developed a platform in Uganda to help farmers make a choice of high quality inputs (seed, fertilizers and crop protection products) available every

season, reliably and on time (CropLife Uganda, 2018). This platform is essential in providing information about agricultural inputs, but its interactive nature is limited. Interactivity on the web is a feature that is of growing interest today encouraging not only provision of text information but also rich information like pictures, videos, audios and enhanced interactivity.

Radios and Televisions are among other popular ICTs that support farmers' information sharing and learning. Although these technologies are popular and widely used by farmers, they are not fundamentally interactive. Other avenues available for farmer information sharing and learning are regular workshops and annual expos organized for example by Central Broadcasting Service (CBS) radio station and Vision group publishing company. These workshops and expos enable information sharing and learning but they do not enable farmers to obtain perennial support in case they need it. These expos remain at the general level without enabling individual farmer especially farmers growing similar crops to have ad hoc requested support and interaction from fellow farmers. These expos have limited mechanisms of establishing or following up to ascertain if the information obtained is put in practice.

Videos combined with participatory processes have shown great potential in agricultural training and increasing productivity (FAO, 2012). These technologies are influential in information dissemination and peer-to-peer learning. Digital Green's innovation is one such example of these technologies (FAO, 2012). Studies have shown that the practice of using videos is seven times more likely to encourage farmers to adopt new practices compared to conventional agricultural extension systems (FAO, 2012). This same high success record can be expected in farmer to farmer information sharing and learning. Digital Green produces videos that are useful for farmer learning and information sharing in India. This technology is becoming attractive to farmers in Ethiopia and Ghana (FAO, 2012).

There are Community Knowledge Workers (CKWs) in Uganda that provide real-time information on agricultural topics, including market prices, to farmers using mobile phones (FAO, 2012). These CKWs are supported by a call center and they produce and document content in local languages. These CKWs work in connection with TECA ("technologies and practices for agricultural producers"). TECA is an online platform that provides information for smallholder producers around the world (FAO, 2012).

Wang et al., 2016 classified ICT systems that are used in agriculture and came up with the following categories:

(i) Portals: These are collections of links to other resources that farmers may need.

(ii) Voice-based Service: Information dissemination through telephone, i.e. call centers.

(iii) Text (SMS)-Based Service: Information dissemination through text message of mobile phones.

(iv) Self-support online community: This is where a community provides information services to its members. This means of information provision requires stakeholders to subscribe. It involves members sharing and exchanging information through interactive service platforms.

(v) Interactive video conferencing services: This is provision of information using online multimedia technologies.

(vi) Mobile internetbased service: This is provision of information using smart phone services.

(vii) Unified multi-Channel Service Model: This is provision of information using multiple methods or technologies like telephones, computers, and mobile phones.

These methods of providing information as categorized by Zhang et al., 2016 are useful but they (authors) do not follow the same yardstick in categorizing these methods. For example (iii) is based on technology while (iv) is based on who owns the methods of information provision. The system proposed in this study will have elements of self-support online community and web portal.

The different modes of developing, deploying and managing such information dissemination systems and present government led, market driven and community self-support (Mittal and Mehar, 2015).

There are different requirements that Zhang et al., 2016 suggest for information systems intended for farmers. We have focused on those highlighted for web portals and online community for their closeness to the system that this study is to deliver. For the web portal, these requirements or operational features include comprehensive management and maintenance, ability to provide diversified content to meet farmers' needs, and high quality service standards in terms of information quality and security. For the inline community, the operational features include rigorous management in form of hierarchical structure to ensure information reliability, smooth contact system, reliable system with authenticated information, constant improvement of service quality in terms of system improvements to meet the needs of the farmers.

We reviewed a number of ICT applications that provide advisory services to farmers. We review these applications with one focus, ascertaining if they are fine in offering advisory services to farmers. So, we seek for their strengths and weaknesses. Below are some of the applications reviewed and lessons that we obtained.

Table 1: Applications that provide advisory services

Application	**Location/country**	**Main functionalities**	**Strengths**	**Weaknesses**
Agrinet Uganda Ltd	Uganda http://www.agrinetug.net/	-Provides market linkages	-Videos -Audios -Pictures	-No evidence of support to farmer in crop lifecycle. -No evidence of farmer to farmer experience sharing and learning
CafeDirect Producer Foundation (CPF)	International http://producersfoundation.org/	-Farmer to farmer knowledge sharing platform (mobile based)	- Use of pictures	-Little evidence of farmer to farmer interactions. -The interaction is not farmer-led. -Minimal evidence of farmer to farmer discussion
CropLife Uganda	Africa and Middle East http://croplifeafrica.org/	Validating agro-inputs to establish if they are genuine (Uganda)	- Use of pictures	-Does not foster farmer to farmer discussion, experience sharing and learning - No focus on crop life cycle
Digital Green	India http://www.digitalgreen.org	- Trains farmers using short instructional videos.	-farmers share experiences and	- No evidence of farmer to farmer support in the crop development lifecycle.

			stories from the field. -Farmers learn from what they do, and what others do. -Uses videos (community videos)	-No crop development follow up among farmers
e-Arik	India http://www.earik.in	Use of ICT for agriculture extension	-Use of pictures	-No farmer support along the crop development lifecycle.
e-Choupal	India https://www.echoupal.com/	-Links and empowers farmers	-Uses videos -Use of pictures	-No crop development follow up among farmers.
ESOKO	Africa	-Provides weekly advisory services -Uses call centres, audios, and field visits	-Uses multi-media for providing advisory services -Farmer to expert interactions are real	-No evidence of farmer to farmer interactions. -Farmers' fields are not prioritized as learning experiences. -Farmers come to the system "without their gardens!"
Freedom Fone	International	- creates interactive, voice-based communication services	-Uses multi-media technologies - Fosters interaction	-No evidence of farmer to farmer interactions to share experiences -No crop development follow up among farmers.
Frontline SMS	International http://www.frontlinesms.com	Enable farmer use of their ingenuity to craft solutions and create positive change in their own communities using mobile technology.	- Fosters interaction -Use of pictures	-No focus on the field/garden as a teaching aid -No crop development follow up among farmers
Honey Bee Network	India http://www.worldchanging.com/archives/006333.html	Enable local and farmer innovation processes.	- Fosters interaction -Use of pictures	-No focus on the field/garden as a teaching aid -No crop development follow up among farmers
ICAAP	India www.advanceagriculturalpractice.in	- An e-portal that documents best practices at farmer level	-Use of pictures - Evidence of interaction among users of the e-portal	- No evidence of garden presence in the content of the e-portal -No coupling of farmer and garden
iCow	Kenya http://www.icow.co.ke	- Empowers small-holder dairy farmers and helps them to manage their cows to have a greater profit.	-Use of pictures -Interaction between farmers and extension workers	-Takes advantage of only text not video, audio. -No evidence of garden presence in the content. -No evidence of farmer to farmer interaction.
ICTforAg.org/video	International http://ictforag.org/video	A toolkit for practitioners: enables use of low cost	-Fosters creation of extension	-No evidence of use of a garden as a learning aid.

		videos for information sharing.	videos by farmers. -Has multimedia content	-Farmer to farmer interactions are not the focus -No crop development lifecycle follow up
Intelligent Advisory System for Farmers (IASF)	India http://iasf.cdacmumbai.in/ias/jsp/about.jsp	-Expert system answering farmer queries.	-Farmer to farmer interaction present -There is use of pictures	-No crop development lifecycle follow up
KUZA Doctor	Kenya	Enables basic mobile phone based sharing of agricultural information	-Fosters farmer to farmer interaction	-No crop development lifecycle follow up
LifeLines	India http://lifelines-india.net/LifeLines/agriculture	-Provides pedagogical support in rural and remote areas. -Brings agri-advisory services to the field of the farmer.	-Evidence of farmer to expert interaction. -Evidence of farmer-farmer interactions	-Farmers garden is not put to light even if one has a problem in the garden, only textual explanations are used. -No use of a garden as a teaching experience. -No focus on a crop at a time and its life cycle as it grows in the garden.
mKisan	India http://ilriclippings.wordpress.com/2012/06/26/m-kisan-launch	Enable use of mobile technologies to strengthen farmer-extension-expert-linkages in India -Provides agro-advisory service for smallholders using mobile devices.	-Evidence of farmer-farmer interactions -Use of pictures	-No use of a garden as a teaching experience. -No crop development lifecycle follow up
Pasture Promise Tv	UK http://www.pasturepromise.tv/farming.html	Enable posting of videos relevant to pasture management	-Use of multimedia is noted	-Does not enable farmer to farmer interaction based on their gardens
Prolinnova	International http://www.prolinnova.net	Fosters ecologically oriented agriculture and natural resource management (NRM). - Promotes Local innovation	-Uses multimedia technologies -Encourages interactions	-Does not enable farmer to farmer interaction based on their gardens -No crop development lifecycle follow up
Talking Books	International http://www.literacybridge.org/talking-book/#intro-video	Enables agricultural information sharing	-Uses multimedia technologies	-Does not enable farmer to farmer interaction based on their gardens -No crop development lifecycle follow up
Tambero	International http://www.tambero.com	Software that tracks information about land parcels cattle	-Encourages interactions	-Does not enable farmer to farmer interaction based on their gardens

TECA	International http://www.teca.fao.org	A platform that combines a knowledge repository with a tool for discussions.	-Enables discussion among farmers	-No focus on crop development life cycle. -No vivid garden experience sharing.
Ukulima.net	Kenya http://ukulima.net	A mobile web platform that allows farmers to connect and interact on topics of similar agriculture interests.	-Focus on farmers with similar interests -A social network for farmers -There is evidence of sharing ideas among farmers	-No focus on a crop at a time and its life cycle as it grows in the garden.
VERCON	International http://km.fao.org/vercon	A plat form that enables collaborative techniques and innovative methods of communication.	-There is evidence of sharing ideas among farmers	-No focus on a crop at a time and its life cycle as it grows in the garden.
YenKasa Africa (our talk)	Ghana http://yenkasa-africa.amarc.org/en/node/36	A platform that enables knowledge and experience sharing among farmers	-There is evidence of experience sharing -Facilitates dialogue	-No focus on a crop at a time and its life cycle as it grows in the garden.
GADC (Gulu Agricultural Development Company)	Uganda https://www.gadc.co.ug/	Providing market access to smallholder farmers in northern Uganda.	-Evidence of use of multimedia technologies -The firm/garden is present in the system	-No focus on a crop at a time and its life cycle as it grows in the garden.

The reviewed systems have strength of enabling interaction and use of pictures and multimedia technologies. Nevertheless, among the weaknesses of the reviewed systems, the issue of lack of use of the garden as a teaching aid has been recurring. Another important loophole in those systems has been inability to provide extension services, along a crop life cycle, to farmers growing a similar crop in the same season. There are no documented systems that provide such a service.

3. Methodology

The primary purpose of this research was to design a mobile based system to enable farmers who grow similar crops to share agricultural advisory information among themselves based on their own garden experiences and to seek advisory services from agricultural extension workers. This study was primarily a case study where a complex phenomenon is studies in its context (Baxter and Jack, 2008). Our study followed a corresponding participants approach (Gatt and Ingold, 2013). This approach was followed to enable interactivity in knowledge creation which contributes to deeper understanding of phenomena. Data was gathered from graduate farmers who own land between one and three acres in Wakiso district. These farmers formerly employed in different organisations in Kampala city and have just acquired land not more than 15 years ago. We target these farmers because they need extension information since

they studied in towns and are working in Kampala city making them to be with little or no prior experience in growing crops when compared to their counterparts who grew up in villages with farms as conditions sine qua non of their homes.

The researcher conducted semi structured, open ended interviews with 50 respondents. 40 of these were farmers and 10 were extension workers. The interviews were both face to face and on phone. The essence of the interviews was to understand how farmers share information/experiences and to obtain key issues encountered in sharing information with other farmers growing the same crop at the same time. This information provided a foundation for eliciting requirements and then a design for a YAY Garden. Data gathered was qualitative in nature. The data was thus analyzed qualitatively with thematic analysis (Boyatzis, 1998).

4. Findings

One of the key issues the farmers aired out was limited awareness of other farmers that grow the same crops in a given season.

"When I grow a given crop, I have no idea who else is growing the same crop as I grow at the same time or in a given season. Even if I face issues in the process I cannot get advice from such counterparts because I am unaware of them. I also rarely think about extension workers in case I face a problem in agriculture, I do not know them, I have not seen them around my garden …. I do not know how to find and contact them" (Respondent).

One of the other problems highlighted was cost of access to advice in case a farmer faces an issue in the garden, unfamiliarity with seeking for advice from fellow farmers and/or extension workers, a tendency to feel that the farmers have nothing to offer to other farmers (lack of trust in themselves). Extension workers also aired out the issue of awareness as key. Farmers are not aware that they are entitled to obtain services from extension workers. Another issue the extension workers posited was that they are few compared to the farmers they are supposed to offer services to. In addition, these farmers are highly dispersed, growing different crops and the issue of lack of organized farmer groups that can request for advisory services as a group. In a group, farmers get more bargaining power and credibility making it easy to receive advisory services easily. All farmers interviewed had smart phones, ability to buy data and/or had access to internet from their work places and/or at their homes. Table 2 represents the key requirements of the YAY Garden as provided by the analysis of the responses from respondents.

Table 2: A summary of key requirements of the YAY Garden

Actor	**What the actor does with the system**	**System functionality /use case**	**Sub-use cases**
Extension worker, Farmer	Chat	Manage chats	Start Handle-posts Handle-chat-sessions Manage-chat-data Handle-chat-attributes
Extension work	Respond to farmer	Manage response to garden issues	Search-issue Display-issue Enable-response-composition Post-response

Farmer	Make inquiry	Process inquiries	Load-issue Enable-description Categorize-issue Assign-issue Display-issue Archive-issue Retrieve-issue
Farmer, extension worker	Registers	Manage registration	Capture-registration-details Process-registration-details Archive-registration-details Display-registration-details Provide-registration-feedback

Column one of Table 2 shows the external actors that interact with the YAY Garden. Column two shows the task that the actors perform with the system (YAY Garden). This information was sought and obtained from respondents during the interviews. This information (tasks that actors perform with the system) was used to derive system functionalities (which we call functional requirements of the YAY garden). This was done through simple reasoning, for example, if a farmer comes to register with the YAY Garden, the component in the system that will be responsible for that is a registration component whose role is to manage registration (see column three of Table 2).Through the same ratiocination, key class names were derived or obtained (see column four). In all these functionalities of the system, respondents show that farmers need help from extension workers or/and fellow farmers about how to handle diseases that come in the crop development life cycle, advice on how to look for crops for better yields and how to arrest situations on their crops before they can go out of hand. This information is required by these farmers in form of interactive multimedia content.

4.1– System Design

System design is a specification of the system based on requirements. In this research we use Unified Modelling Language (UML) to specify the YAY Garden. The major use cases for the YAY Garden system are: Register, make inquiry, respond to farmer and chat. The major actors are extension worker and farmer. Each of the use cases has a starting and end condition. The actors come to use the system with a goal in mind, which when it is fulfilled, they leave the system. For example, a farmer comes to make inquiry and goes through different interactions with the system until this inquiry is done, then he leaves the system with a submitted inquiry.

Based on the use cases stated, it is clear that farmers are enabled by the YAY Garden to fulfil goals like chat, view responses and make inquiry as indicated in the methods or behavior of the farmer class in Figure 1. In the same way, the agricultural extension workers are able to achieve goals like respond to inquiries from farmers and to view chats.

Issues that were articulated by respondents can be easily addressed by the YAY Garden system. For example, the issue of limited awareness of farmers about the other farmers that grow the same crops in a given season has can be addition addressed through the registration use case. Users of the YAY Garden register and specify the crops they grow at a given time. From this information any farmer can become aware of which farmers grow which crops in what season.

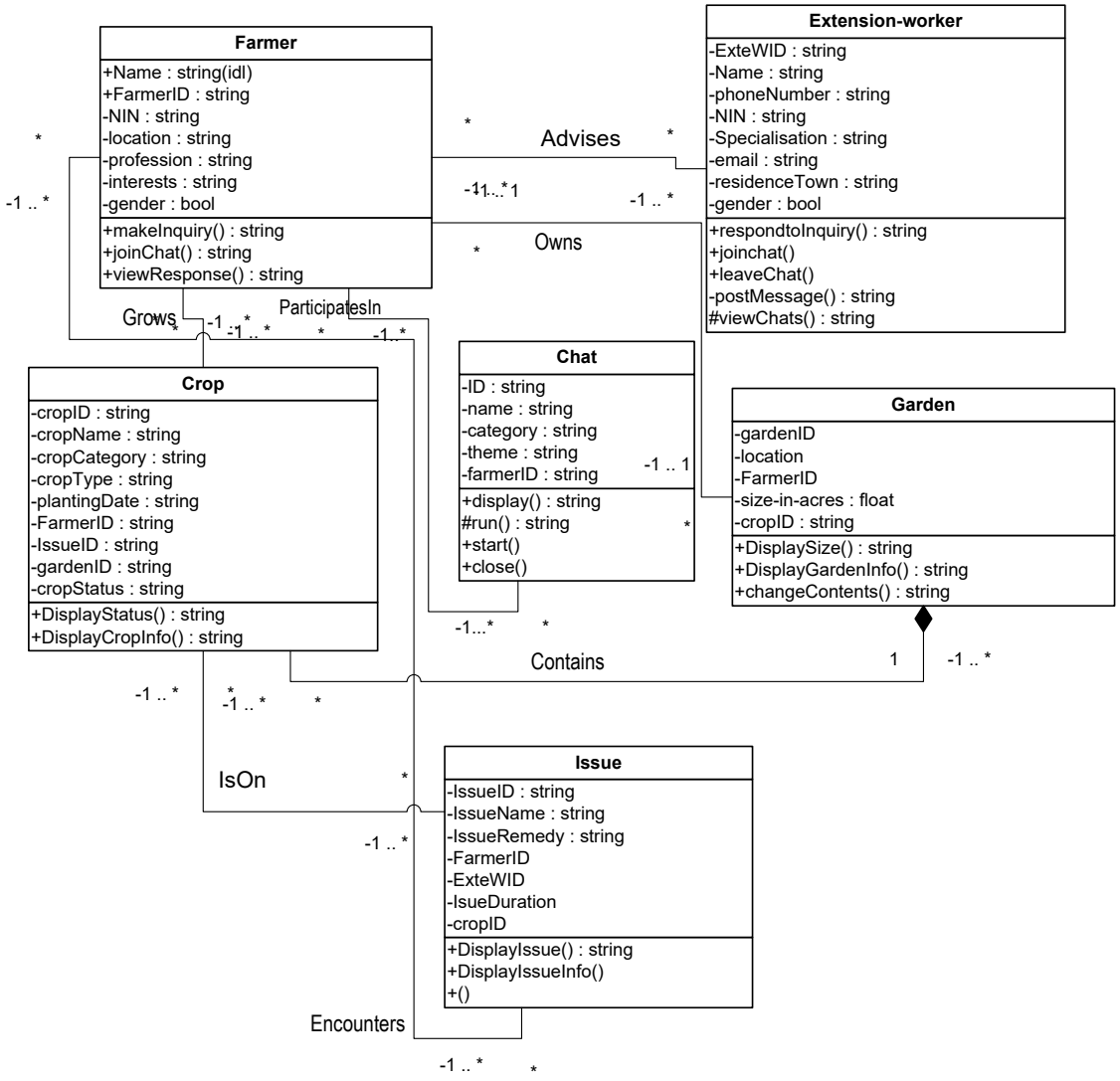

Figure 1: Class diagram of the YAY Garden system

5. Conclusions

The purpose of this research paper was to design a YAY Garden that enables farmers share vivid experiences with their fellow farmers growing the same crop at the same time or in the same season. The design of this system has been presented and what remains is the implementation of such a system in order to run on mobile phones.

6. Limitations of the Study

The design of YAY Garden has been based on farmers in Wakiso District that have formal employment in Kampala. These are graduate farmers that own land between one to three acres having owned it for not more than 15 years. This design can be improved to cater for other farmers in other districts in Uganda.

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Heuristic Evaluation of an Eye-Free Android Application

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ABSTRACT The Android app Eye+ is an eye-free interface designed for visually impaired users. Its second version (V2) is currently available on Google Play Store with 4700+ app downloads and, with music player and multi-lingual support. The development team felt a dire need for usability evaluation six months after the launch of Eye+ V2. The heuristic evaluation method has been selected as it is quicker as well as simpler method to execute, especially for expert from accessibility computing. It is an expert-based summative evaluation method, which also facilitates app redesigning and versioning. The major problems identified include unavailability of app / audio disabling facility, non-compliance of app to accessibility guidelines, unavailability of Internet or Wi-Fi connectivity within the app, no provision of audio instruction repetition, lack of event completion feedback, need for user feedback within app and additional multilingual support needed. These usability problems will be resolved in near-future to design the next version, V3, of Eye+.

1. Introduction

Today, mobile phones are the most vital devices for personal communication as well as information sharing all over the globe. As per report from Telecom Regulatory Authority of India (TRAI) in November 2017, there are about **1162 million mobile phone subscribers** in India [12]. These mobile phone users are of two types - normally sighted or regular users and visually impaired users. A visual impairment can be defined as 'loss of sight', i. e. total visual impairment or reduced vision [2]. The estimates of World Health Organization (WHO) indicate that there are 253 million visually impaired people in the world, out of which 36 million are totally visually impaired people [14]. Almost one third of these people i. e. **12 million blind people** reside in India [6]. These blind and visually impaired people always have tough time in interacting with touchscreen mobile phones.

The visually impaired users cannot provide enough visual attention during their interaction with user interfaces (UI); hence accessibility features become vital. The problems faced by visually impaired users with mobile phones include their struggle in locating interface options / items, difficulty in text data entry, insufficient feedback and inability to read data [11, p. 292]. To provide solutions to these problems, it is essential to design an accessible interface such as an eye-free interface, which enables users to interact with devices without visual attention. Hence, such an Android-based Application (App) named 'Eye+' has been designed by lead

authors**. Eye+ is an eye-free interface designed for visually impaired users and its name suggests that it provides added or extra vision to its users.** Its first version (V1) with messaging and calling functionalities was made available on Google Play Store in 2015-2016. Its second version (V2) was published on Play Store with music player and multi-lingual support around mid-2017 [4]. It has used 'Speech to Text' and 'Text to Speech' converters for user interaction mainly through audio. Figure 1 depicts a sample screen of Eye+ app with four keys in grey scale.

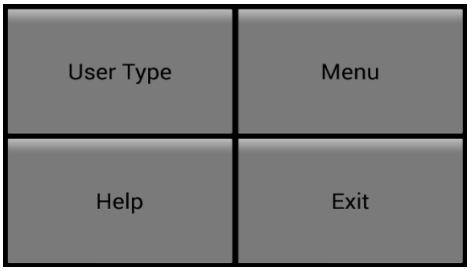

Figure 1: Sample screen of Eye+ app with four-key User Interface (UI)

The important features of Eye+ include:

- 'Phone Shake' feature to start the app,
- Support for both Beginner and Advanced users,
- Simpler UI with four large keys in grey color, (as seen in Figure 1)
- Multi-lingual support in German and French along with English.

The app Eye+ has about **4700+ downloads** [4] **till Oct. 2018**. Related screenshot of world map from Google Play Dashboard depicting number of downloads nation-wise is depicted in Figure 2. One can see that the app has been downloaded across all six main geographical continents of the world. India and United States of America (USA) lead the listing with about 1400+ and 850+ app downloads respectively. Five countries, United Kingdom (UK), France, Germany, Pakistan and Philippines, also have 100+ app downloads. There are another eight countries, Brazil, Indonesia, Canada, South Africa, Bangladesh, Turkey, Morocco and Algeria, completing 50+ app downloads. The average user rating of Eye+ is around 4.6 till Oct. 2018.

The app Eye+ is also useful for normally sighted or regular users who cannot look at the mobile screen due to reasons such as extreme lighting condition (more than 1000 lx) [3, p. 04], protection of private information, constraint of smaller screen, during walking on the street and others [11, p. 292]. This research reported in this paper has discussed the process of usability evaluation of Eye+ using heuristic evaluation method and also, listed the identified usability problems. This evaluation is needed for a rational direction for upgradation of this app to its third version (V3) in near-future.

2. Related Work

The literature work mainly includes the research articles discussing about usability evaluation of mobile apps. These articles focus on expert-based evaluations for identifying usability problems related to mobile apps. There are also articles specifically on guidelines and evaluation of accessibility for visual impaired users [16] [17].

Gomez et al. have proposed a checklist for heuristic evaluation, especially designed for new mobile interfaces. This best-practice checklist has additional heuristics such as skills, pleasurable and respectful interaction with the user and privacy along with more than 150

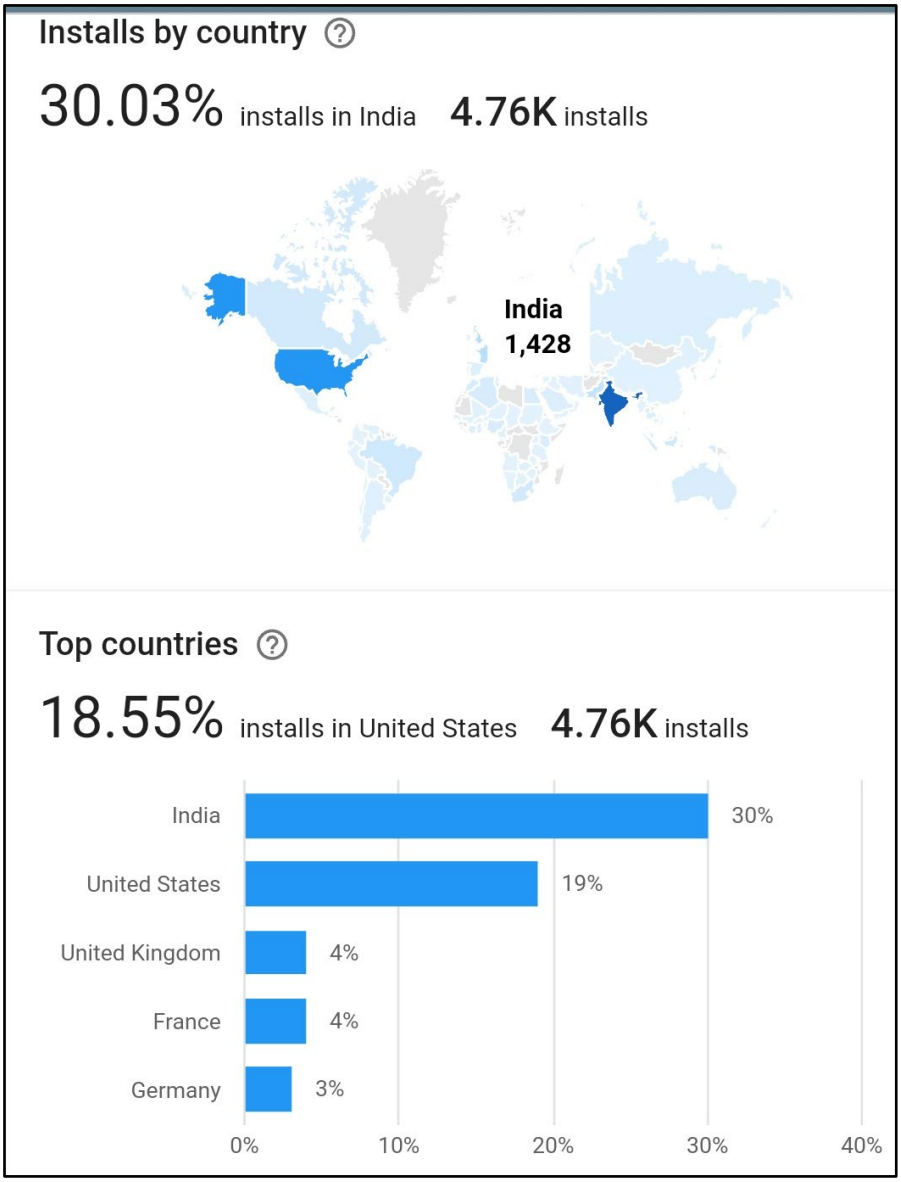

Figure 2: World map from Google Play dashboard depicting number of downloads nation-wise for Eye + along with top 5 countries [4]

related checklist points or sub-heuristics [5]. This is an interesting perspective of heuristic evaluation, but **these additional heuristics have no significant impact in the domain of accessibility computing or on visually impaired users**. Therefore, these heuristics are not considered in usability evaluation of Eye+ along with Nielsen's heuristics.

Watkins et al. have performed heuristic evaluation of Healthy Eating Apps for older adult users. Three experts evaluated five iPad apps related to fruit and vegetable intake using heuristic evaluation method [13, p. 105-127]. Several important problems were identified and they include use of unfamiliar symbols, unnecessary steps required to complete tasks, less accessibility features, small text; insufficient color contrast and unlabeled advertising. This study has approved **the usefulness and applicability of the heuristic evaluation method in identifying design deficiencies and usability problems**.

Georgsson et al. have discussed a study to complete usability evaluation of a mobile health system for diabetes patients using a heuristic evaluation technique of **dual-domain experts i.e. experts from healthcare as well as usability domain** [15]. Major violations are observed with respect to two heuristics – 'Consistency and Standards', and 'Match between System and the Real World'. This study highlights a **need for dual domain experts and for detection of related heuristics with major usability problems**.

Jadhav et al. have performed usability evaluation of messenger applications for Android phones using cognitive walkthrough. These applications include WhatsApp, Skype and GO SMS Pro focusing on primary tasks such as chatting, file transfer, profile viewing and updating contacts [7, p. 9-18]. It has highlighted few usability problems such as lack of provision for multiple smiley selection, no confirmation message for file transfer and ineffective 'Search' functionality. Such **selective task-based evaluation may not be sufficient for summative evaluation targeting design of next version of mobile app.**

These studies of usability evaluations of mobile apps reinforce the applicability of expert-based summative approach of heuristic evaluation in identification of usability problems for app redesign in near-future.

3. Usability Evaluation of Eye+ App

Eye+ V2 app was launched around mid-2017 on Google Play Store. This app had really good response from visually impaired users and other Android users. It had the growth rate of 150+ app downloads per month by late 2017, which has reached to about 500+ downloads per month by Aug. 2018. About 40 users have provided user ratings and reviews on Google Play Store. The user rating stands at 4.6 by Oct. 2018. Though most users have appreciated the app design, few users have raised certain issues related with identification of contacts and voice recognition during making calls through the app. The development team also felt a dire need for usability evaluation and debugging six months after launch of Eye+ V2. Therefore, it was decided that evaluation of app should be done for identification of usability problems and also, to provide a direction for redesign of app to launch its next version V3 in near-future.

3.1 – Inclusion of an Expert from Visually Impaired Community

The development team for Eye+ consists of usability expert, but he has limited understanding in domain of accessibility computing as well as that of visually impaired users. Therefore, it was decided to involve an expert from visually impaired community. The expert involved is one of the co-authors and he coordinates the University Centre for Inclusive Education & Accessibility. He is a visually impaired user himself and also has the required expertise in accessibility computing. He has been there also to help the usability evaluators by sharing expectations, priorities and experiences of visually impaired users [8] during app evaluation process. Two more experts from IT industry, supporting app testing and hosting activities were also included in evaluation team.

3.2 – Selection of Usability Evaluation Method

The evaluation team was interested in identification of major usability problems and design deficiencies in the targeted app Eye+ V2. The prevalent usability evaluation methods such as Cognitive Walkthrough, Heuristic Evaluation and User Testing were studied and discussed by the evaluation team including the expert representative from visually impaired community. The

heuristic evaluation method was selected as it is much quicker and simpler method, especially for expert from accessibility computing. It is an expert-based summative evaluation method, which also facilitates app redesigning [10] and versioning. The blind and visually impaired users at University Centre for Inclusive Education and Accessibility, also were not available due to their examinations and other scheduled activities. The ten heuristics proposed by Nielsen were applied [10] along with 5-point Likert Scale to identify the usability problems as well as their extent [9] affecting design and usage of Eye+.

3.3 – Heuristic Evaluation of Eye+ V2 App

Heuristic evaluation is a method for finding usability problems in a user interface design by having a small group of expert evaluators examine the interface and judge its compliance with recognized usability principles – heuristics [10]. There are ten defined heuristics, which are listed in Table 1. These heuristics are applied on the app Eye+ to identify potential usability problems, which are also listed in the Table 1 along with assigned Likert scale values. A 5-point Likert scale is used for judging severity of heuristics and related problems identified. It has a range of values from '-2 to 2' with '0' in the centre. The value '–2' indicates that the problem severity is high and '2' indicates the high level appreciation for related heuristics. This evaluation was carried out by group of experts. It can be observed in Table 1 that more severe usability problems are associated with two heuristics – 'Consistency and standards' and 'User control and freedom'.

Table 1: Heuristic evaluation table along with assigned Likert scale values

Sr. No.	Heuristics	Usability Problems identified	Likert Scale
1	Visibility of system status	• No provision of instruction repetition, mainly for the beginner users, if required • Invisibility of functionalities provided by the app	**1**
2	Match between system & the real world	• Need for language-support in additional regional and international languages, especially for non-English speaking users	**1**
3	User control & freedom	• Unavailability of Internet or Wi-Fi connectivity within the app • Lack of direct navigation facility to a specific screen or functionality	**-1**
4	Consistency & standards	• Non-compliance of app to Android accessibility guidelines • Unavailability of facility for disabling the app as well as its audio	**-2**
5	Error prevention	• No provision of instruction repetition for the beginner users, if required • Inability of user to detect speech recognition dialog screen	**1**
6	Recognition rather than recall	• Need for recalling four buttons on the app screen due to non-repetition of instructions, if required	**1**

7	Flexibility & efficiency of use	• Unavailability of navigation to recent activities • No provision to record user feedback in the app • Unavailability of functionality to block a particular contact	**1**
8	Aesthetic & minimalist design	---	**2**
9	Help users recognize, diagnose & recover from errors	• No extra analysis done if user's speech input does not lead to any available result • Lack of event completion feedback	**0**
10	Help and documentation	---	**2**

4. Usability Problems Identified in Eye+

Several usability problems have been identified by applying heuristic evaluation method on the app Eye+. An ordered list of the major problems identified is displayed in Table 2 with due consideration to their severity. This list is prepared after a couple of rounds of discussion among the evaluation team related with identified problems and their importance for the next version.

Table 2: Ordered list of major usability problems identified using heuristic evaluation

Sr. No.	Usability Problems identified in Eye+ V2
01	Unavailability of facility for disabling the app as well as its audio
02	Non-compliance of app to Android accessibility guidelines
03	Unavailability of Internet or Wi-Fi connectivity within the app
04	No provision of instruction repetition, mainly for the beginner users, if required
05	Lack of event completion feedback
06	Inability of user to detect speech recognition dialog screen
07	No provision to record user feedback in the app
08	Need for language-support in additional regional and international languages

The usability problems listed in Table 2 are discussed ahead. This discussion includes identification and relevance of each of the usability problems with related screenshots in the app. The solutions are also proposed to deal with these problems, whenever possible.

4.1 – Unavailability of Facility for Disabling the App as well as its Audio

The problem of disturbance due to untimely app activation or related instructional audio and voice communication may disturb the users, who are busy in their work. A few users have reported that this trouble leads to deletion of app. This problem was identified during consideration of one heuristic, namely 'Consistency & standards'. Therefore, the expert from the accessibility computing domain in our evaluation team has suggested that the user should

be able to disable the app or its audio as per the need of time. Many Android apps have such disabling facility; but at present, this facility to disable the app or its audio isn't available with Eye+.

4.2 – Non-Compliance of App to Android Accessibility Guidelines

The app Eye+ is not totally compatible with all of the Android Accessibility Guidelines. It does not follow an important accessibility guideline, 'Create easy-to-follow navigation' [1]. The app does not allow direct navigation to a specific screen or functionality. Also, a few of the options / keys in the app as seen in Figure 3, require complex or multiple touches such as press, or press and hold, which are not easy to execute for most of the visually impaired users. These problems are also identified during consideration of a heuristic – 'Consistency & standards'.

Figure 3: App screen showing options / keys requiring complex or multiple touches

4.3 – Unavailability of Internet or Wi-Fi Connectivity within the App

The app Eye+ requires mobile Internet or Wi-Fi connectivity for its working; especially for providing audio support in multiple languages. If such connectivity is not available, the visually impaired user has to exit the app for connectivity and then, get back to the app. That is a really challenging task for any visually impaired user. This problem was identified during consideration of the heuristic 'User control & freedom'. Therefore, the evaluation team has suggested for Internet or Wi-Fi connectivity within the app.

4.4 – No Provision of Audio Instruction Repetition, mainly for the Beginner Users, if required

The app Eye+ supports two types of users – Beginner User and Advanced User as seen in Figure 4. The beginner users need slow audio communication whereas advanced users prefer much faster communication [11]. The beginner users also need instruction repetition frequently for understanding and executing options or functionalities provided in the app. Such provision for instruction repetition is currently absent in Eye+ V2. This problem was identified during consideration of two main heuristics – 'Visibility of system status' and 'Error prevention'.

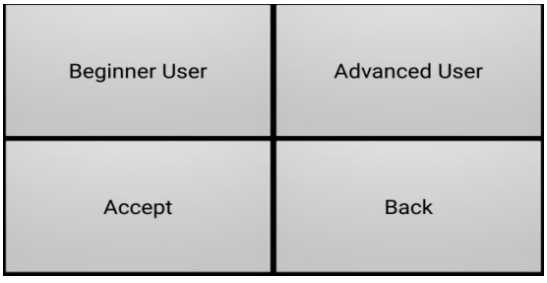

Figure 4: App screen for selection of user type

4.5 – Lack of Event Completion Feedback

The visually impaired users require audio and/or vibratory feedback whenever they take any action. The evaluation team observed that the users occasionally do not get such feedback or acknowledgemnet after an event is completed. This problem was identified during consideration of the heuristic 'Help users recognize, diagnose & recover from errors'. For example, the user fails to get such feedback or acknowledgement during Fast Forward (FF) operation as seen in Figure 3, while using music player.

4.6 – Inability of User to Detect Speech Recognition Dialog Screen

The visually impaired users require to speak up the contact number or message while using Eye+. Once the user selects a particular option for speaking, a speech recognition dialog screen appears as seen in Figure 5 and the app waits expecting the user to speak out contact number or message. The evaluation team observed that users may fail to detect speech recognition dialog screen and wait longer to speak up or get confused as they are not informed to speak up immediately after appearance of dialog screen. This problem was identified during consideration of 'Error prevention'.

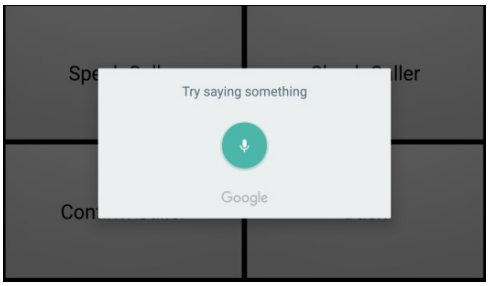

Figure 5: Speech recognition dialog screen in Eye+ V2

4.7 – No Provision to Record User Feedback in the App

The app users can provide user rating (Out of 5.0) along with their feedback on Google Play Store. This feedback may help app developers to improve on app design and its performance. But, it is observed that most visually impaired users rate the app without providing typed-in feedback. Also, some users may come across bugs or usability problems while using the app. The evaluation team felt a need for a facility to record an audio feedback from these users in the app itself. This feedback can be communicated to development team through assigned email account in backend. Lack of such convenient facility for user feedback is seen as notable problem during consideration of one of the heuristics, 'Flexibility & efficiency of use,' by evaluation team.

4.8 – Need for Language-Support in Additional Regional and International Languages

There is a multi-lingual support provided in German and French languages along with English in Eye+ V2 as depicted in Figure 6. It helps the visually impaired users to use the app with audio communication in related foreign languages. So, there are about 150+ app downloads each in Germany and France by Oct. 2018 [4]. The evaluation team has suggested to provide language-support in additional regional and international languages to improve a reach of the app. This suggestion was put forward during consideration of the heuristic 'Match between system & the real world'. There are 80+ app downloads presently from Brazil [4]. To improve on this download count, Portuguese, the national language of Brazil, and Hindi, the national

language of the host country, India, of the app developers, will be added in multi-lingual support for Eye+ V3 in near-future.

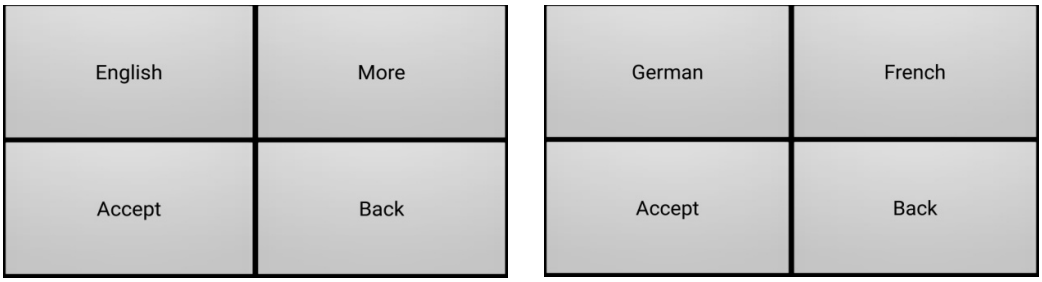

Figure 6: App screens for multi-lingual support in German & French along with English

5. Conclusion and Future Work

The evaluation team observed that the Android app Eye+ V2 needs significant design enhancements in response to major usability problems identified during heuristic evaluation. More severe usability problems are associated with two heuristics – **'Consistency and standards'** and **'User control and freedom'**. There is a need for app / audio disabling facility, compliance to accessibility guidelines, provision of audio instruction repetition, event completion feedback, increased multilingual support, Internet or Wi-Fi connectivity and audio user feedback within the app. The app developers are determined to resolve the identified design deficiencies and usability problems for the next version, Eye+ V3, in the near-future. In future, the findings of this app evaluation could be also used to propose new heuristics for eye-free interfaces.

Acknowledgement

We thank all visually impaired users who have contributed immensely in user studies and testing of the app Eye+. We also thank Mr. Mahadev Karad and Mr. Vijay Wagh for app conceptualization and development during the initial two versions of Eye+.

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Assessment of Network Readiness for Telemedicine Services in Uganda

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ABSTRACT Background: There are not very many telemedicine projects in Uganda and Africa at large that have reached scale. One of the reasons for this has been the failure to have a readiness assessment for different factors like cost, technology take-up, and network performance prior to implementation of the projects. **Objective:** To assess network performance of selected networks in selected areas and relate it to minimum network requirements for different telemedicine services and finally use the assessment to recommend readiness of the selected networks in implementing given services in those areas. **Method:** The assessment was classified into bandwidth and latency assessments. Six networks with RIPE ATLAS probes in different locations were used for latency measurements with latencies for a period of two months used while 3G and 4G networks were considered for bandwidth measurements for a period of 9 hours using speedtest by Okla tool. **Results:** All six networks considered for latency measurements showed support for all selected services but showed performance variations with some networks performing better than the others. Also the individual networks showed variation (jitter) with some having high variations while others indicate a rather close to constant performance. 4G showed support for all selected services and 3G only supported a few services at given hours of the day. **Conclusion:** Different telemedicine services have different network requirements and due to the variable nature of cellular networks being the most used in Uganda, an assessment of network performance is very crucial in informing about the possibility of implementing telemedicine in given areas and thus having successful projects in providing health care remotely.

Keywords: Telemedicine, Health care delivery, Uganda, RIPE ATLAS, Speedtest by Okla.

1. Introduction

Uganda's health care system is faced with many challenges some of which include but are not limited to policy matters, distance and mechanism and limited to access to medical facilities and staff [1]. Uganda's health situation is in a bad shape with a ratio of 1.49 core medical doctors per 1000 population which is way below the minimum ratio of 2.3 doctors per 1000 population set by the World Health Organization WHO for achieving the millennium development goals [2]. In addition 70% of qualified medical doctors are in urban areas however the biggest percentage of the population (84.4%) lives in the rural areas of the country as of

December 2014. This means that the biggest percentage of the population when sick is attended to by nurses, aid workers and others sources of healthcare [3] [4].

Telemedicine is an optimal way to bridge the gap between the qualified medical doctors in the urban areas to the sick people in the rural areas. It allows patients to get medical care remotely from their homes using data communications making it very beneficial to people living in hard to reach areas [5]. However technology innovations like telemedicine especially in low income earning countries like Uganda face challenges of sustainability and most do grow beyond the pilot phase [6]. However the benefits of such innovations in health carry great promise in improving provision and reach of better quality health care to people especially in hard to reach thereby answering the objective of Sustainable Development Goal (SDG) number three [7].

Telemedicine is the remote delivery of healthcare services such as health assessments or consultations over ICT communications infrastructure. It allows healthcare providers to evaluate, diagnose and treat patients without the need for an in person visit [8]. Telemedicine has numerous services classified into; telediagnosis, teleconsultation, telemonitoring and telemanagement. Also a classification of the services based on their Quality of Service (QoS) requirements exists where the services are classified as both real-time and non-real-time. For instance in emergency situations remote specialists' diagnosis may require real-time transmission of patient medical data while in non-emergency (delay tolerant) situations, the data can be transferred to a remote location where specialists can analyze it at later point in time [9]. Typical telemedicine applications may involve for instance transmission of patient physiological parameters, transfer of high resolution medical images and such applications generate traffic with diverse network requirements differing in required bandwidth, real-time and non-real-time interactivity and packet loss tolerance. The diverse network requirements make it crucial to have a tool that can provide an accurate QoS assessment of the network and relate it to the different services diverse network requirements to ascertain the possibility of a given telemedicine service on that network in a given area.

Unlike developed countries with proper broadband infrastructure in form of wide spread and cheaply accessible fiber cable, Uganda's broadband connectivity is largely contributed to by cellular network infrastructure from companies like MTN and Airtel [10]. The national backbone infrastructure fiber network is a promising project with fiber connections across the country but has not effectively provided broadband access to many areas especially to the hard to reach areas [11]. The challenge with cellular network performance arises from the random signal propagation impairments like multipath due to reflections and weather conditions that lead to variable network throughput that can affect provision of some critical telemedicine services. Most telecom companies have started rolling out of 4G coverage to some areas in the country with most of central Uganda covered but most rural areas are still served by 3G and 2G network. The only easily available form of network assessment is by use of network coverage maps provided by the telecom companies but these however do not incorporate factors like the variations in network performance and therefore cannot be used to recommend applications pertaining to human health. A reliable and accurate network assessment tool is therefore crucial in determining the available network performance in a given area and what telemedicine service is best supported. The assessment tool can therefore provide informed decisions to medical practitioners wanting to implement telemedicine in a given place on what service to do or not to do depending on the selected network and therefore improving the possibility of telemedicine in Uganda.

2. Methodology

For the assessment, network bandwidths and latencies were considered. Six internet service provider (ISPs) were considered for latency measurements and RIPE ATLAS tool was used. RIPE ATLAS is a platform that assesses global internet reachability with numerous number of probes installed in different ISP networks across the world. The probes are hardware gadgets that keep measuring and storing network information to different server locations across the world [12]. Part of the information stored in the probes is continuous pings to selected server locations. A ping measurement involves sending a packet from one computer to another and awaiting a response. The time taken by the packet to travel to and fro is called the roundtrip time is an indication of the network latency [13]. Six networks were considered because at the time of the assessment only 6 of the 29 probes connected in the country were fully connected and operational. The network locations were obtained and the measurements were to be done in reference to a server (d root server) location in Kampala as shown in figure 1.

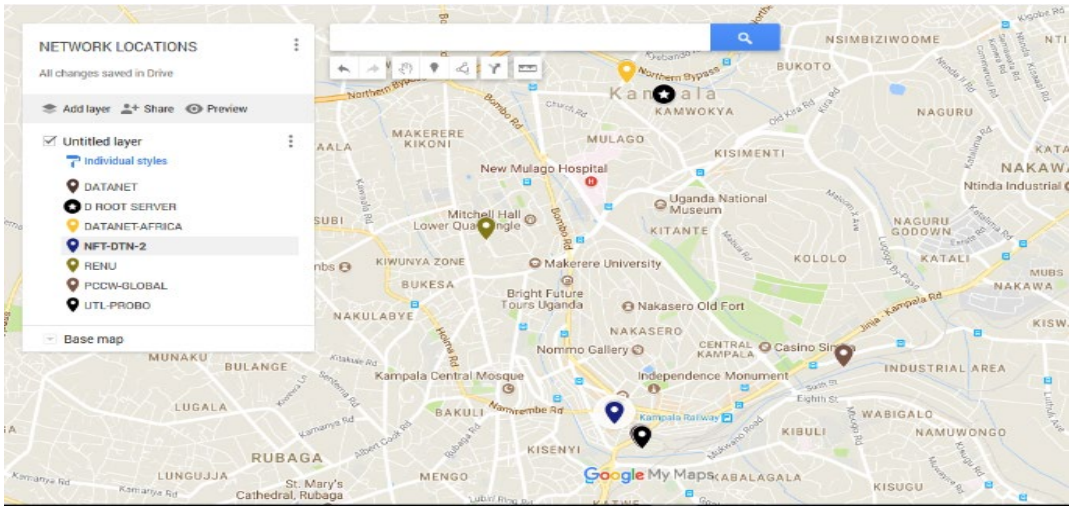

Figure 1: Network locations with RIPE ATLAS probes.

Ping information for a period of 2 months of each of the networks in reference to the d root server was obtained. It was important to have as much data as possible to put into consideration the network variations as highlighted before and this explains the 2 months data used in this work. Data for more than this time would also make the assessment better but the data obtained was already too much for the extraction tools used (python) to handle as the probes do the measurements on a frequency of every after 3 minutes.

For bandwidths, measurements were done using speedtest by okla tool and were done over a period of 9 hours in a one city suburb place called Makerere Kikoni. The choice of place was because it was the author's residence at the time of the assessment and since the measurements were to be done manually, the place would be the most convenient. Measurements were done 4 times each hour and this was done in comparison with a broadband measurement tool used in Italy called "ne.me.sys" that does similar kinds of assessments [14]. 4G and 3G of a selected network were assessed by using a smart phone locked to access either networks for each of the measurements. The phone was used to create a local area network onto which a laptop computer with the tool installed was connected to the measurements.

3. Results and Analysis

The latencies for the six networks were averaged for the two months' time and plotted over a period of 24 hours. Three networks with the highest latencies and lowest latencies were plotted on different axes of different scales because with using the same scale the low latency network plots would not appear at all on the graph. The plots are illustrated in figures 2 and 3.

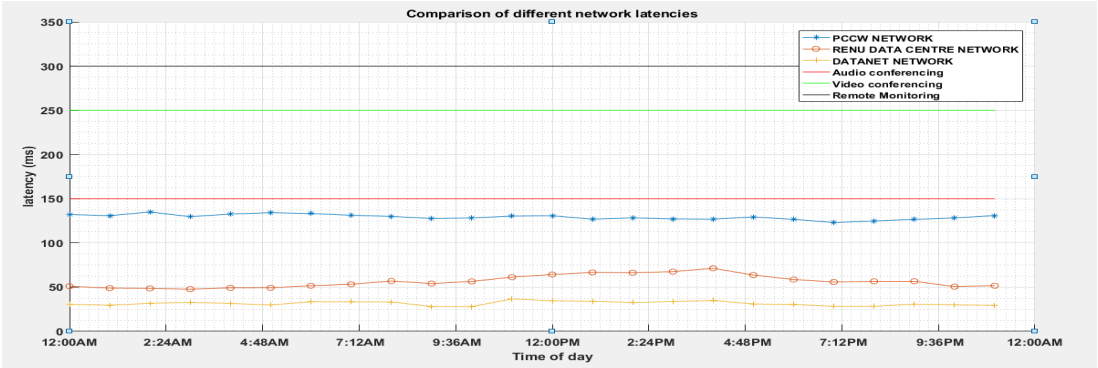

Figure 2: Comparison of latencies for the different networks.

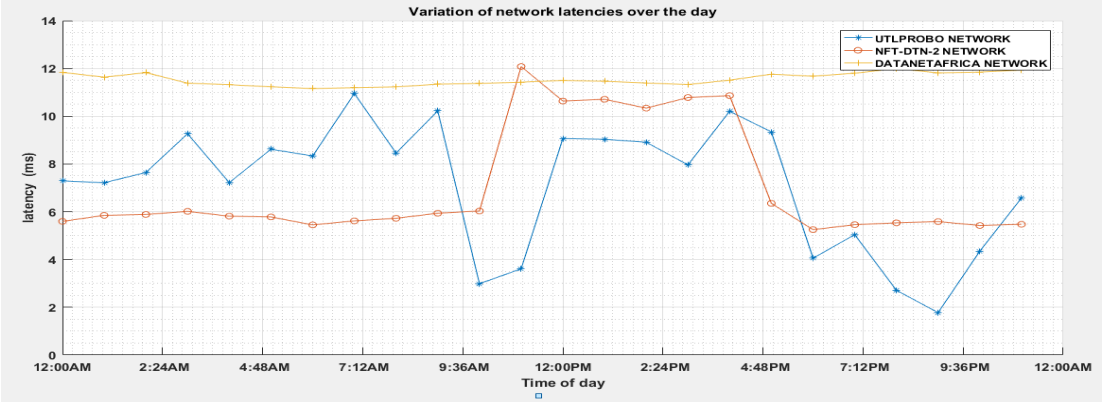

Figure 3: Least network latencies plotted on larger scale.

From figure 2, it can be seen that all three networks support all the selected services and this makes sense because of the close proximity of the network probes and the reference server. However important to note is that all the networks having varying latencies form each other and such variations would not have appeared on the network coverage maps and the maps would indicate all these probes as being in the same place and therefore having the same network performance. This is the reason for the need of such an assessment to give an accurate picture of network performance and before deciding to implement a given telemedicine service in a given region. The networks with least latencies were also plotted on a large scale as in figure 3 and from this it can be seen that the individual network latencies also vary (jitter) over the course of the day. This is very important because with this information sensitive and non-delay tolerant services can be scheduled at times of the day when the latencies are really low and those that are delay tolerant can be scheduled for the times when the latencies are high.

The results from the bandwidth measurements for both 4G and 3G were plotted on same axes plus the minimum bandwidth requirements of selected services as shown in figure 4. The 4G network showed support for all the selected services at all time while the 3G network support of some services varied over the course of the measurements period. The selected services

showed in the graphs i.e. audio conferencing and video conferencing pertain to real telemedicine applications like telesurgery, telediagnosis, telemonitoring etc.

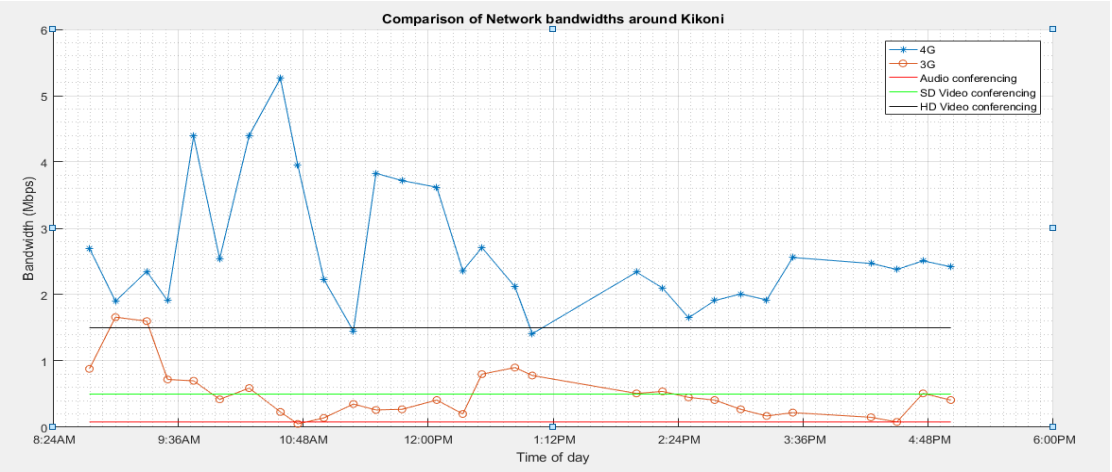

Figure 4: Comparison of bandwidths for the network in Kikoni.

4. Conclusions and Future Work

Network performance is a very crucial factor in any telemedicine solution and therefore a clear idea of the network performance is important in determining the choice of telemedicine service in a given place.

The assessment done in this work gives an idea of the selected networks' performances in the selected regions. Future work will focus on having the assessment packaged in a more user friendly tool like a smart phone application or a computer application that could have the assessment running in the background and after indicating to the user the supported telemedicine services basing on their choice of network the computer would be connected to.

Also focus will be on investigating the possibility of incorporating machine learning in the assessment such that, for instance, the application may only need to extract a few data from the probes but be able to use these data to make predictions of future network performance and also have these predictions included before coming up with a final decision on the best supported service.

Finally, the assessment especially for latencies was done using network probes limited to one location because of the limited number of probes in the other areas of the country. With presence of more probes especially in networks in hard to reach areas, an assessment of the possibility of telemedicine in these area will also be done.

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Towards a maternal and neonatal e-learning mobile aided system for rural health centers in Uganda

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ABSTRACT Knowledge and skills concerning maternal and neonatal healthcare are very vital in preventing and managing complications that may lead to maternal or infant mortality. Currently, there is a scarcity of health workers with adequate expertise to meet maternal and neonatal health care demands in rural Uganda. As part of efforts towards addressing the limitation of maternal and neonatal expertise, this paper proposes a mobile aided e-learning system for providing quick access to maternal and neonatal information or knowledge to expectant mothers and to health workers with limited expertise. An exploratory study was conducted in three sample health centers (Luweero Health Center IV, Lusanja-Kitezi and Nazigo Health Center II) in rural Uganda to establish various issues concerning maternal and neonatal healthcare with regard to the proposed system. The findings from the exploratory study motivated and were the basis for the first prototype of the maternal and neonatal mobile aided e-learning system that is also presented in this paper.

Keywords: maternal health, neonatal health, mobile-aided e-learning

1. Background

Although maternal and infant mortality rates in Uganda have decreased to 43 deaths per 1000 live births and 336 deaths per 100000 live births respectively in 2016 (Uganda Bureau of Statistics, 2016), there is still a need to improve maternal and neonatal services especially in rural Uganda. The Ugandan government has implemented a referral system, but the expertise needed to meet maternal and neonatal healthcare is also limited. While pregnant women can benefit from easily accessible information and knowledge, health workers with limited expertise can also benefit from readily available knowledge and consultation services where critical expertise is needed to make correct preventive or treatment decisions and implement them effectively.

Various forms of Information and Communication Technologies (ICTs) have been proposed and developed for different purposes in resource constrained developing countries (Ariani et al., 2017) including e-learning systems for medical education (Frehywot et al., 2013). As a contribution towards continuous efforts in the application of ICTs in healthcare, this paper proposes a mobile-aided e-learning system for maternal and neonatal healthcare. This proposition is based on the rationale that mobile devices are ubiquitous in developing countries

including Uganda and offer the highest likelihood for adoption of e-learning for maternal and neonatal healthcare. Our proposition also takes into consideration that to increase the validity of the proposed mobile aided e-learning system, it is important to establish the major issues that may affect its adoption and use in rural Uganda. As Frehywot et al. (2013) concluded in their review of e-learning in medical education in Low- and Middle- Income Countries (LMICs), a thorough understanding of appropriate e-learning tools, the practicality and effectiveness of e-learning use, and the feasibility of e-learning is needed to realize the impact of e-learning in improving healthcare. For this paper, an exploratory study was conducted in three sample health centers in rural Uganda to establish various issues concerning the application of the proposed mobile-aided e-learning system for maternal and neonatal healthcare.

1.1 – Key Definitions

Maternal health – is the health of women during pregnancy, childbirth, and the postpartum (postnatal) period.

Neonatal health – is offered to newly born babies until the end of 28 days from birth. During the first 28 days of life, the child is at a high risk of dying and therefore needs appropriate feeding and care.

Mobile aided e-learning system – Is an e-learning system where learners can access learning materials remotely using mobile technologies such as smart phones or tablets (Frehywot et al., 2013).

1.2 – Related work

A number of initiatives concerned with the use of mobile technologies for e-learning in healthcare have been proposed and implemented. For example, Zolfo et al. (2010) presented an innovative approach aimed at enabling healthcare workers involved in HIV/AIDS care in urban and peri urban stations in Peru to access state-of-the-art in HIV treatment and care. In this case, the learning needs for HIV/AIDS healthcare workers are very similar to learning needs for maternal and neonatal healthcare. It is thus plausible to adopt the approach by Zolfo et al. (2010) for maternal healthcare; however, Zolfo et al's (2010) approach was proposed for Peru which differs from Uganda according to several contextual factors.

Apart from e-learning, there are other apps which have been developed in various countries for providing information and facilitating maternal healthcare services and from which we draw inspiration for the work in this paper. The following paragraphs cover some of these apps:

OMama[3] is an app that was developed for families in Ontario, Canada. It connects women and families to trusted, evidence-informed health pregnancy, birth and early parenting information. It is important to note that before this app was developed, over 1,100 women and care providers responded to questions regarding what information the app should contain. Moreover, a follow up on the use of the app was also planned. In this paper, we recognize the necessity to involve pregnant women and healthcare providers in developing and assessing the use of maternal and neonatal healthcare apps.

[3] www.omama.com/en/About-Us.asp

Ada[4] is a health companion app that was developed in the United Kingdom and offers an Artificial Intelligence (AI)-powered health platform that is aimed at helping people to understand their health and navigate to appropriate care. As described in a popular science article by David Nield (2018), AI is used in Ada to spot patterns in a person's symptoms that might otherwise be overlooked. The app feeds a user with simple questions that are personalized to their particular situation; then it lists potential conditions with their symptoms and treatments (Nield, 2018). This app has been adopted by millions of people; this demonstrates the impact AI has in personalizing healthcare services. By the time of writing this article, we could not easily access the details associated with the development of this app. We cannot tell how much the app has for maternal and neonatal healthcare and whether it can meet the e-learning needs for maternal and neonatal healthcare. The main inspiration we draw from this app is the use of AI to personalize healthcare. In a similar manner AI should be suitable for personalizing e-learning for maternal and neonatal healthcare; however, it is not of particular focus in this paper.

GetIN[5] is a mobile app that was developed in Uganda to be used by community health workers and midwives to register and follow up pregnant women so that they can attend antenatal care. The idea behind this app was motivated by the high number of underage pregnancies that for obvious reasons are likely not to be recorded and followed up and in turn are at a danger of maternal mortality. This is a significant innovation towards reducing unattended pregnancies and maternal healthcare complications. Such an app can definitely benefit from additional functionalities including provision of information and knowledge as is the case for the work in this paper.

Beyond the functionalities provided by the systems above, we identify a number of properties that would be associated with an efficient and effective mobile aided e-learning system: provision of timely maternal and neonatal expertise to prevent unnecessary complications and deaths; provision for capabilities for users to access and express their health status; the ability to access as much maternal and neonatal information and knowledge as possible, at any time, and without any limitations; easy localization of the functionality and content of the system to meet information and knowledge needs of users with varying natural language capabilities; the possession of a user friendly interface for effective interaction.

2. Conceptualization of the proposed mobile-aided e-learning system

The proposed system is expected to enable pregnant women, new-born baby mothers, village health teams and health workers in rural areas to access maternal and neonatal information and knowledge. In this paper, we envisage this access to be achieved via a suitable user interface on a mobile device such as a smart phone. The proposed system must also contain appropriate information and knowledge that can be used for maternal and neonatal healthcare. For e-learning purposes, we have identified a number of learning modules that would be essential for maternal and neonatal healthcare. The following is a list of some of these modules from the United Nations Population Fund (UNFPA-UK) that are especially targeted for use by health workers: Pregnancy danger signs; Management of prolonged and obstructed labor; Family

[4] https://ada.com
[5] https://getinmobile.org/

planning; Management of post abortion care; Management of pre-eclampsia and eclampsia; Control of bleeding after birth; and Managing puerperal sepsis. We believe that in addition to an e-learning component, the proposed system can be a more complete healthcare support system with more functionalities including: having the functionality for locating nearest antenatal care services; providing information about birth attendance services and stages and signs of labor; providing information for requirements preparation for labor and delivery; providing information about nutrition and dieting during and after pregnancy; providing information about hypertensive diseases (such as heart diseases, stroke, peripheral arterial disease) in relation to pregnancy; and providing information of approved drugs and immunization for expectant mothers. Based on this conceptualization, we set out to determine the current experiences in accessing maternal and neonatal healthcare information and knowledge in rural areas and perceptions about the proposed system.

3. Exploratory study

In order to inform the requirements of the proposed system from expected users, we conducted an exploratory study from three purposely selected health centers that are located in areas which to a great extent are comparable to rural Uganda. The three health centers are: Luweero Health Center IV, Nazigo Health Center II, and Lusanja-Kiteezi health centers. We use the term comparable because these health centers are not so remotely located but the health facilities can be associated with those found in most of rural Uganda. The choice of these locations was also based on a number of limiting constraints and one of the author's easy access to health workers, pregnant women, and mothers for new born babies. In total, 55 expected users were interviewed (15 healthcare providers from Luweero Health Center IV, 10 healthcare providers from Nazigo Health Center, and 30 pregnant women and mothers from Lusanja-Kiteezi). The interviews aimed at establishing the current status of maternal healthcare and collecting feedback on the proposition for a mobile-aided e-learning system for maternal and neonatal healthcare. From the exploratory study, we found out that many rural based health centers lack supporting technologies that could stimulate quality maternal and neonatal health services. Both midwives and expectant mothers need knowledge so as to enhance the lives of mothers and their newly born babies. It was also discovered that health providers need to expand their knowledge on handling situations around labour and delivery by mothers.

3.1 – Feedback about the proposed mobile-aided e-learning system

- Most of the respondents appreciated the proposed provision of maternal and neonatal healthcare information and knowledge via mobile devices. This can be associated with a willingness to adopt the proposed mobile-aided e-learning system by expected users in rural Uganda.
- Language issues. Most of the respondents indicated to use local languages that they easily understand alongside English. This is true considering that most of the people in rural Uganda are likely not to comprehend the English language which is used in these kinds of apps.
- Most of the respondents also recommended that the proposed system enables access to information about maternal and neonatal healthcare providers including their contacts.
- Most of the pregnant women and new born baby mothers also recommended that the proposed system should provide a component where they can communicate their status and about the kind of treatment and support they receive from their spouses. Here, it was noted that pregnancy complications can also be associated with lack of support from spouses.

3.2 – Feedback about factors that may cause failure of mobile aided applications to improve maternal healthcare services

- Resistance (this includes unwelcoming attitudes of the health workers). They feel these systems would just waste their time and thus rely on personal understanding.
- Inadequate resilient hardware to support the software enabling the functionality and sustainability of the systems
- Lack of appropriate guidelines/regulations on the utilization of these systems.
- Lack of quality evidence on their outcomes and impact. Some health providers may not have faith that the new system will work consistently over the long term and may find ways to avoid switching to using them.
- Financial pressure of running these systems. So, health providers pay ongoing costs of Internet and mobile network access over the years.
- Inadequate training and supportive supervision. Limited training availed to health workers thus poor quality of care in the health units. Thus, need for extensive training. On the side of supportive supervision, limited follow-ups keep midwives from expanding the range of their tasks using these systems.
- Language. Most of the service providers and expectant mothers are not familiar with the language as used by the programmers, so they tend to ignore using the system. They prefer their local languages.

4. Implementation of the mobile aided e-learning prototype

4.1 – Functionalities implemented in the prototype

- SMS texting component for appointment reminder. With relevant information that relates to the phase of their pregnancy. For example, they receive a reminder when it is time to visit the clinic again and to take malaria pills, proper care for their health.
- Training / learning component (mainly for midwives)
- Feedback to allow interaction between the health providers and the expectant mothers as well as amongst midwives themselves.
- Sufficient health related data from prominent sources of expert health workers and organizations worldwide. For example; ministry of health, AMREF, health insurance companies.
- Open data (information/knowledge component)
- Text message component (as an added advantage for expectant mothers with difficulties to directly access the system).
- Live recordings component.
- Site map for easy navigation through the system.

The tools and software used to implement the above functionalities include: presentation tools and validation tools (enabling the back-ground support, color) like PHP and HTML; Swift (for mobile compatibility); Sublime text editor and note pad; Java script; and Bootstrap. Paper sketches were also used to enable capture a broad view of the system before it is put into use.

4.2 – The flow of interaction within the system

Figure 1 summarizes the interaction within the mobile aided e-learning prototype. A user has to sign in to access the different functionalities of the system. Most importantly, users must have already registered necessary details including all their names, usernames and passwords; some details such as email are optional. Registration details enable tracking of the use of the prototype by the different types of users (including patients and health workers). As figure 1 shows, the mobile aided e-learning prototype is expected to provide a number of services

including consultation; access to learning modules, healthcare provider locations; and a feedback interface for comments from users.

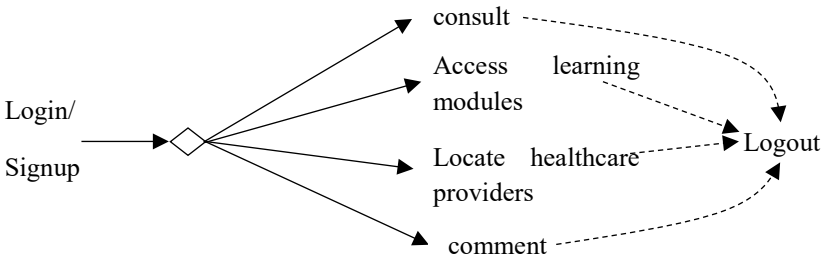
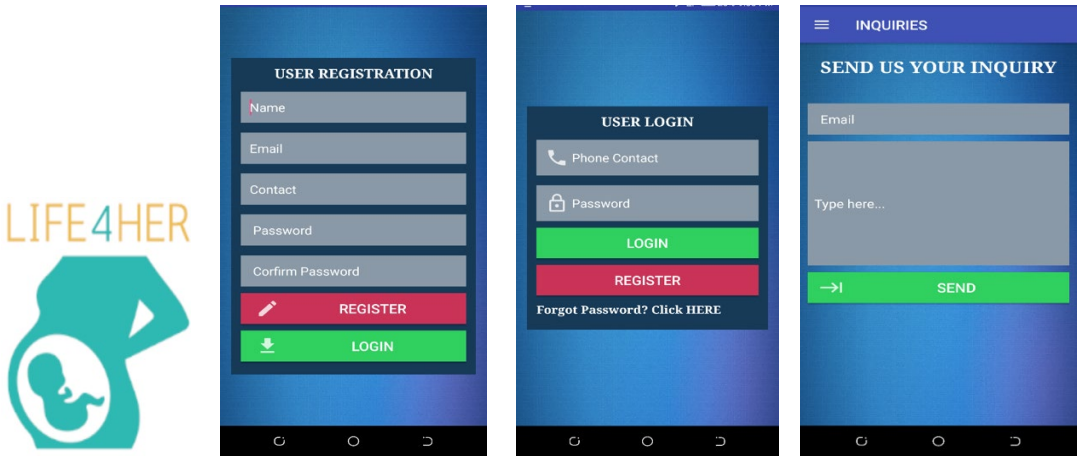


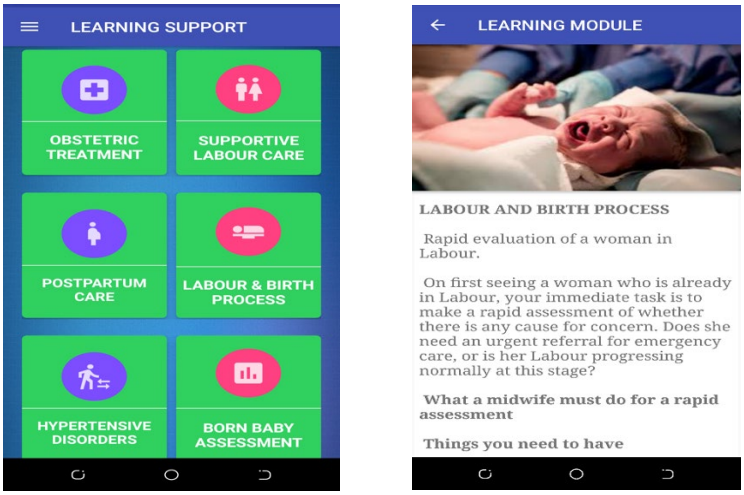
Figure 1. High level summary of interaction with the system

The homepage of the app enables expected users (pregnant women, mothers, and health workers) to access key information about the prototype and links for registration and login. Figure 2 (a) shows the app splash screen on start-up after installation on a mobile device; the user registration interface; the user login interface; and an inquiries interface.



(a) (b) (c) (d)

Figure 2: app splash screen on start-up (a) Registration (b) Login (c) and Inquiry (d) interfaces



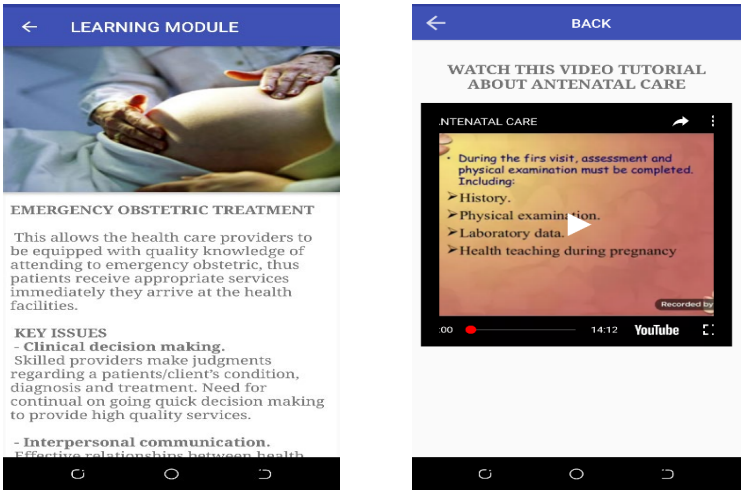


Figure 3: Examples of Learning support interfaces

Figure 3 shows examples of learning support interfaces that enable access to different learning modules including video presentations of learning material.

5. Testing and validation

The prototype was tested to remove different forms of errors. This involved testing the functionalities of the prototype to determine whether the interactivity involved was free of errors.

The prototype was also validated by expected users including twenty pregnant women from Luwero health centre IV and health workers from two health centers. Remarks from expected users included; the mobile app will provide them more understanding on maternal and neonatal health services, thus they highly recommended it. Need for internet to access all sessions when using the app could sometimes be a challenge in remote areas.

Expected users also appreciated the ease of use of the mobile app. However, they suggested integration of local languages where possible.

6. Conclusion and Future work

This paper proposed a maternal and neonatal mobile aided e-learning system to provide expectant mothers and less experienced health workers with easy to access knowledge and guidance. An exploratory study was conducted to establish the perceptions towards the proposed system from expected users including factors that may challenge the use of the system. Based on findings from the exploratory study and literature on similar systems, key requirements for a mobile-based application were identified; a prototype was developed, tested and partly validated. Although the mobile-based prototype covers key functionalities, some concerns from expected users as voiced in the exploratory study are yet to be realized; an example is the need to access maternal and neonatal knowledge in indigenous languages which are the main mode of communication in rural Uganda. Such unaddressed concerns actually require their own committed research; we recommend that this research should be part of future work.

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Bridging the information gap among expectant mothers in Uganda by use of USSD

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ABSTRACT Over the years, mobile phones have developed into one of the best ways of providing reliable access to information to people in low and middle-income countries. With the increase in the number of mobile phones, there has been a corresponding increase in the number of mobile applications which can be used as a new medium for the dissemination of information to people. In this paper, the authors focus on the Unstructured Supplementary Service Data (USSD) application to provide information about and report danger signs during pregnancy to pregnant women and medical practitioners respectively. The USSD application is used in the project since it is a technology that can be used by everyone including the rural population where the prevalence of smartphones is not so high, and many rely on the more cost-effective traditional phones.

Keywords: USSD, SMS, pregnancy, healthcare information system, e-health.

1. Introduction

Maternal death is caused by many and variable factors and the risk rises in the case of risky pregnancy or during a premature birth. According to the World Health Organisation (WHO) [1] about 830 women die from preventable causes related to pregnancy and childbirth and 99% of all maternal deaths occur in developing countries. Uganda, in particular, has a high maternal mortality rate of 368 deaths per 100,000 live births [2]. This is an alarming figure since all of these deaths are preventable. The deaths are mainly caused by the delay in seeking medical care due to inadequate information about danger signs during pregnancy.

The leading cause of death among pregnant mothers is postpartum haemorrhage. Most pregnancy complications for rural mothers are a result of lack of or poor maternity care while in urban centres, mothers are often affected by hypertensive disorders. Bleeding among pregnant women could be due to the womb's failure to contract properly.

Fatality due to loss of blood occurs when an individual loses 40 percent of their blood. The other serious causes of death among pregnant women are represented in Table 1.

Table 1: Fatal medical conditions during pregnancy

Haemorrhagic complications	Hypertensive disorders	Other complications
Postpartum haemorrhage	Acute fatty liver of pregnancy	Urinary infection
Placental Abruption	Severe preeclampsia	Pulmonary oedema
Ectopic pregnancy	Hypertensive encephalopathy	Sepsis
Placenta Previa/accreta	Eclampsia	Seizures
Ruptured uterus	Severe hypertension	Postpartum endometritis
Severe haemorrhage due to abortion	HELLP syndrome	Post-abortion endometritis

Women are not informed about all these conditions including signs and symptoms plus the kind of care needed to treat these medical conditions. This causes a delay in seeking medical care due to ignorance.

Poor infrastructure, inadequate literacy, availability of technology and socio-cultural settings are a few factors in the myriad of challenges facing the development of rural areas in developing countries [3]. Healthcare is one of the most important sectors where governments of developing countries strive to enhance the situation by utilizing affordable ICT solutions. However, unlike developed regions, in rural areas within a developing context, issues are intertwined. This requires truly innovative solutions that are affordable, robust and above all sustainable. The reported work is still a research in progress. Nonetheless, this first fully functioning prototype allows for significant reflection on the research and practical challenges we focused on.

2. Background

This project is aimed at providing information about danger signs during pregnancy to pregnant mothers through the use of USSD for all GSM enabled mobile devices. The absence of accurate and timely patient information at the clinic implies that the patient cannot be monitored on a frequent basis, meaning that the medical practitioner cannot take actions as promptly as desired. Patients cannot assess the severity and criticality of situations and try to postpone transport to a clinic or hospital as long as possible due to high travel costs and efforts. In the eyes of caregivers and sisters, deaths can potentially be prevented when medical practitioners are aware of patients' health conditions at an earlier stage.

UCC mobile subscriber report [4] reported a total of 23,993,111 telephony subscriptions from Uganda. The current population of Uganda [5] is 44,126,577 as of Wednesday, May 30, 2018, based on the latest United Nations (UN) estimates. Assuming a fairly distributed population, it is fair to assume that in every home there is a mobile phone of either Global System for Mobile communication (GSM), 3G Universal Mobile Telecommunications System (UMTS) or 4G Long Term Evolution (LTE).

The solution presented in this paper will also be able to advise these women accordingly in case they encounter problems during pregnancy. The motive of the proposed mobile

application is to connect all expectant mothers and their new-borns under one umbrella by keeping track of their weekly/monthly health records, health issues while also localizing them to make any health- driven actions faster and effective in developing countries.

The solution will also provide awareness to people in developing countries which aims to prevent deaths due to superstitious myths and beliefs that prove unhelpful and can increase the risk during pregnancy both to the mother and her unborn child. There are a number of pregnancies that result in deaths due to lack of awareness of the severity of a given condition. Mobile [6] services have been proven as a reliable means of conveying information, but the question of cost and financial sustainability is one that should be considered. For our solution, we shall start by working with government bodies such as the ministry of health so as to offer this information for free to the citizens especially those in rural areas.

2.1 – Definition of terms

Mobile Application: A mobile application is defined as software designed to take advantage of mobile technology. In this paper, we refer to USSD and smart phone application as mobile applications.

Short Message Service (SMS): SMS is a text messaging service component of phone, web, or mobile communication systems. It uses standardised communications protocols to allow fixed line or mobile phone devices to exchange short text messages. SMS are sent to mobile phones via the SMS Gateway.

Unstructured Supplementary Service Data (USSD): USSD is defined as a communication protocol used to send to send text messages, i.e. SMS messages, between a mobile phone and applications running on the network.

Medical Practitioners: These include doctors, nurses and care givers at the different stations of the health care hierarchy.

Patients: In this paper, this term is used to refer to expecting mothers.

3. Overview of USSD

As Kassinen et al. [18] explain, “The USSD protocol is supported by every GSM or UMTS phone. The USSD version in GSM Phase 1 specifications does not have the “push” mode that enables network-initiated USSD connections; only mobile-device initiated connections are possible in Phase 1, as pointed out in [7] and [8].” They also explain that the pushing of messages from the network-side to the handset was introduced in GSM Phase 2, which is also broadly deployed and has been in use since the 1990s.

“The USSD protocol has no store-and-forward support; the connections are always session oriented. The typical user interface to USSD services is either through dialing commands using the phone’s numeric keys or with a menu-based browser.” [18]

USSD is being used for different information services, telecommunications services like voucher airtime recharge, mobile money cash transfers, mobile banking and so on. [18]

“USSD carries messages of up to 182 characters in length (7-bit characters: 160 bytes). As an additional plus, the load caused by USSD on the operator’s networking resources is very light. USSD operates in the same SDCCH signaling channel as SMS does.” [18]

Finally, Kassinen et al. also point out that USSD is better than SMS for implementing Network-Assisted P2P Invocation (NAPI), because:

- USSD is session-based: the radio channel is reserved until the end of the USSD session which yields shorter delays (in addition, SMS could cause unwanted storing of NAPI messages in the message center when the target device is offline); and
- roaming with USSD is free of charge – even the non-roaming use of USSD is often free, unlike SMS.

4. The Proposed Technical Solution

4.1 – Overview of the proposed system

We follow the assumption that frequently providing health care givers with patient information that is relevant, easily accessible and accurate during the whole pregnancy period will benefit patients in multiple ways. Earlier diagnoses can be made, better treatments can be started, but also travel costs and effort can be reduced for both patients and caregivers.

This will result in better life quality and expectancy for patients, but we also expect that providing such information to the medics has a positive effect on the workload and joy for both doctors and nurses attending to the pregnant women.

Facilitating the transmission of patient information by technology operates in the field of telemonitoring (remote monitoring) which is a branch of e-health. Telemonitoring includes the collection of clinical data and the transmission of such data between a patient at a distant location and a health care provider through electronic information processing technologies [9].

4.2 – Research Approach

In this section, we discuss the starting points for the design process: the social context and the related design challenges, followed by the requirements engineering approach.

Social context and design challenges

Physical, financial and skill accesses [10] are tangible boundary conditions to successful ICT implementations. However, acceptance of communication technologies for health care systems is itself a challenge in developing countries and especially in culturally diverse countries [11]. The high rate of failure in ICT programs is explained by Heeks [12] as a 'mismatch between Information System design and local user actuality.' Some of the social and cultural circumstances specific for our research, which have been embodied in the design process are described below.

Originating from many forms of inequalities and experiences with corruption and political mismanagement, the rural population has a low esteem of government actions. Furthermore, many projects that have taken place, started by the government or non-government organizations have resulted in failures. This has resulted in a certain reserve towards new projects, and it affects caregivers' and pregnant mothers' motivation and willingness to share information with the researchers. Some other aspects make it difficult to gather valid information: informality of business processes, 'yesnodding,' and stigma around some diseases like HIV/AIDS. Burdened with more fundamental problems, caregivers and pregnant mothers are tended to disagree about the proposed problem to be solved (lack of communication) and the proposed solution (ICT). Caregivers have limited professional training and are of semi or low literacy level. This limits the extent to which system requirements can be elicited.

Furthermore, a substantial part of the patients doesn't have faith in western medicine and more traditional medicine is practiced. Also, Uganda being a multi-lingual country, language barriers in certain parts of society leads to reliance on interpreters who don't always convey accurate gestures to verify the quality of the information passed on.

Elicitation of requirements

The system requirements were shaped by the "three phases of delay" model as discussed by Thaddeus and Maine [13]. Phase 1 delay: delay in deciding to seek care on the part of the individual, the family, or both. This phase of delay is the main focus of this solution. Our model seeks to provide patients with an ease of taking western medical solutions rather than traditional medicine which has proven ineffective over the years. This is done by reducing distance barriers, financial costs, and opportunity costs and improving the perceived quality of care.

To develop a sustainable system a key requirement is that the community adopts the system, maintains the system and has a sense of ownership with respect to the system. To achieve this, user involvement in all stages of the development process is considered very important. To develop commitment from stakeholders in using and maintaining the system we can refer to [14] who found that there are three components of commitment; (1) affective or emotional commitment, presented in the patient-caregiver relation, (2) continuance commitment, based on the benefits or utility people obtain from participating, and (3) normative commitment, a felt obligation to continue, strengthen by the sense of community and being needed. Normative commitment has in our context a critical additional factor, the tradition and informal ways of working in the current system are valuable to the community and should not be thwarted.

Given these constraints, we took the following steps to derive the requirements for the system and to develop a prototype that meets these requirements. At the start of the design process, the problem, the solution, and its technology were flexible and depended on stakeholders' input. Informal semi-structured interviews in small groups were held during the first two visits to assess users' needs. A workshop attended by all relevant stakeholders was organized at Resilient African Network (RAN) to define problems they encounter and how they could be solved. A secondary goal was to achieve consensus and build commitment. Also, the first basic requirements were elicited and ranked by importance. During the third visit, more detailed requirements were again discussed in small groups and participants could state their technology preference (call centre, Smart phone app, SMS or USSD) after simulating interaction with these technologies. Here medical doctors and engineers gave their opinions about the simulations. Visits were made to pregnant mothers in remote societies of Kikube (Luweero), Kasebuuti (Masaka), Muyomba (Wakiso) and Kikoni (Kampala). These were intended to get user views of the proposed system and find out if it could fix the problem stated, also for usability and usage observations. Questionnaires were administered during these visits for evaluation purposes.

5. Prototype Design

In the previous section, we elaborated on the design approach, the social context, and its challenges. The goal was to design a robust and affordable ICT enabled system through which patients or family members can submit vital patient information to the medical practitioners through the USSD system. The prototype, which is currently tested, meets its functional and technical requirements for the most part. Therefore, the proposed solution and the prototype are jointly discussed in this section.

5.1 – USSD Code Format

According to Akram, R. [15] USSD communication is initiated by dialing a special code known as USSD code or short code. It usually has an asterisk (*) at the beginning and ends with a hash (#) and has digits 0 to 9. The code for our application is *130*45#.

5.2 – Technical Architecture

USSD stands for Unstructured Supplementary Service Data. USSD allows for the transmission of information via the Global System for Mobile communication (GSM) network. USSD is best explainable as 'interactive SMS.' Text messages are sent to and received from a caregiver's mobile phone through a real-time connection to the GSM network. A wireless service access provider (WASP) routes the messages from the mobile network to a server with the application and database. Medical practitioners and information officers have web-based access to the application and personal health records (PHR) via a 3G modem and a desktop computer. A big advantage of the use of USSD is that it is easily accessible (by simply dialing a number) and easy to use (simple menu structure). USSD works on almost all mobile phones, and it is generally used in Uganda, for example, to load airtime on a mobile phone. A drawback is that the open connection is disabled after three minutes.

To simplify the description, the USSD architecture basically comprises of:

- The network part which includes the Home Location Register (HLR), the Visitor Location Register (VLR), and the Mobile Switching Centre (MSC)
- Simple Messaging Peer-Peer (SMPP) interface for applications to enable services.

5.3 – Designing the client application

The system is designed for use by all GSM phones and subscribers will access information through USSD messages on these phones. The user enters USSD code (*130*45#) to access the information. Accessing the system, the user will be asked to subscribe by sending messages to a special number (registration could be free).

The user can then choose to proceed or quit. Language options are displayed so the user can choose a preferred language. Upon choosing a given language option, the user will be notified in this language, and all message interaction will remain in that language. The application has been developed with the main languages spoken by people across the main regions of Uganda. Figure 1 shows a sandbox simulation of the application being used to subscribe to SMS alerts in the "Luganda" language.

After reaching to the last subcategory, the user will receive a USSD SMS informing him that information will be sent to his phone as an SMS or as an audio message.

5.4 – Patient Interaction with the system.

After a patient subscribes for continual alerts of the danger signs using the code (*130*45#), the user can set their preferred language and means of communication, i.e. either voice or SMS alerts. We discovered from talking to various mothers that while taking the messages to their local languages was engaging, it was not sufficient as many could not read the SMS in their local languages. Even those who could actually read, many could not tell when a new message had arrived on their devices and therefore could not navigate their devices to SMS. Therefore the need for Interactive Voice Response (IVR) which is faster than reading an SMS but requires

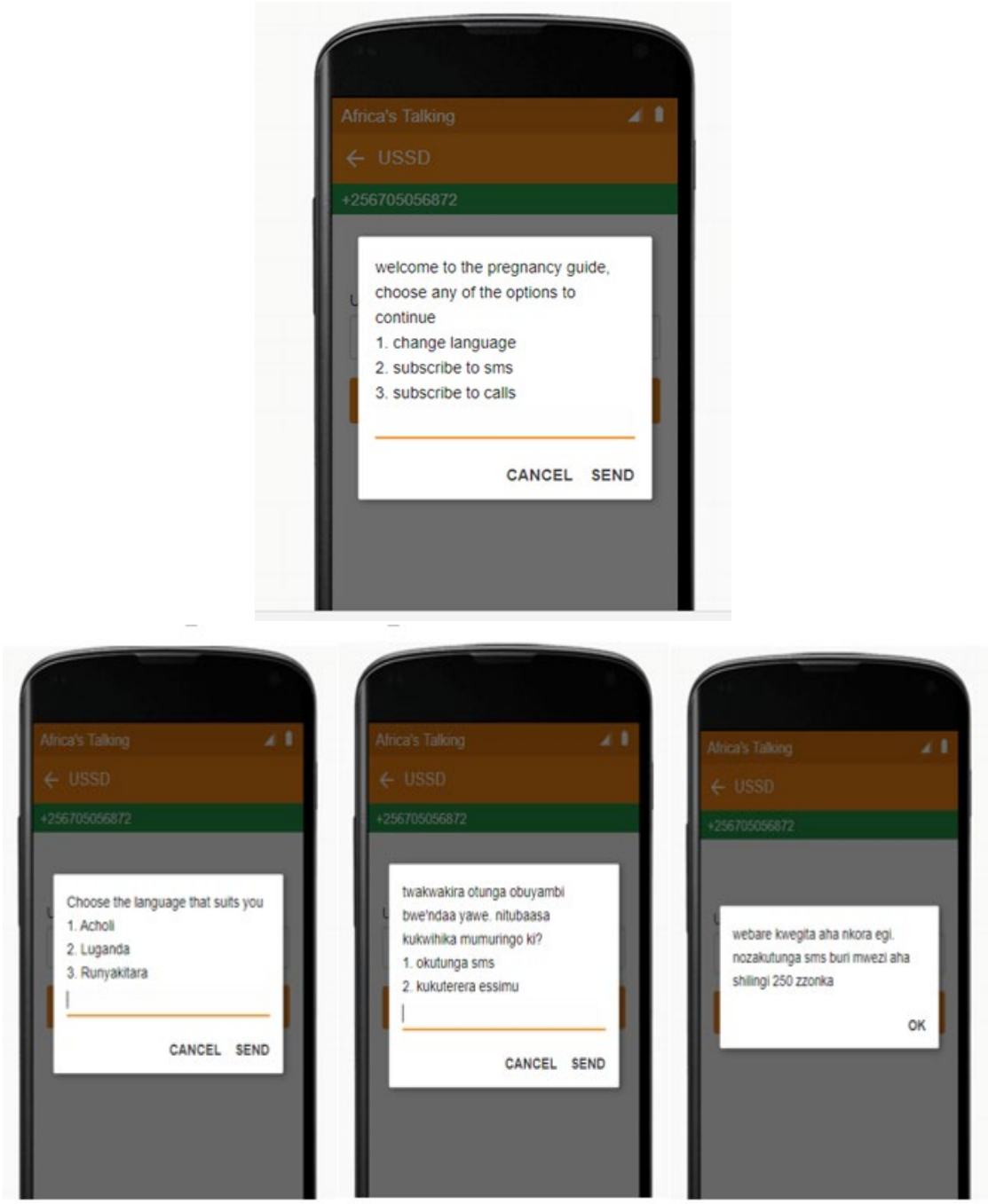

Figure 2: Maternal health USSD application running on the Sandbox Simulator

a specialised team to leverage information to address patient needs, streamline development and control operational costs.

It is normal for a patient to ignore the problem in early stages when they feel fine [16]. The disability arising at the onset of the illness, like extreme fatigue and depression, is managed by the adoption of a healthy lifestyle which includes healthy eating and regular physical activity, oral medication and weight loss.

This is the phase when doctors should care to communicate to patients to avoid long-term complications that could lead to miscarriages or death. The patients can then initiate the USSD

menu to report a danger sign once it is realised to the system which in turn raises a flag to the doctor depending on the danger rate of the sign and the stage of pregnancy. Effective dissemination of health information allows patients to engage with the healthcare system to follow recommended advice, adhere to treatment and cope up with the psychological consequences of their illness.

5.5 – Medical Practitioner interaction with the system

The medical practitioners provide information about the danger signs and health eating habits that is fed in the system's database by the Information officers. This information is relayed to the mobile subscribers depending on their registered stage of pregnancy. The medical practitioners also get a desktop computer interface where they receive alerts of danger signs reported by the pregnant women and can make a judgement on how to respond to these alerts.

6. Evaluation – intermediate results

Evaluation is in progress, but we will briefly discuss our intermediate results.

The goal of testing the prototype is to determine its success and to investigate its potential in comparable areas. Some general preliminary findings are; The stakeholders were all happy and enthusiastic about the solution and the attitude towards it was generally positive. The medical practitioners seemed happier about having the system than using the system. The cases sampled proved that using the system was not as easy as anticipated because users who could not read found it hard to subscribe to the system. However, after a few unsuccessful trials, all users successfully subscribed to the system. Still, some of the users completely failed to report the warning signs and ended up recording false signs to the system.

Submitted patient information (by patients) and login data (from medical practitioners), questionnaires and user observations will be used to disentangle factors that led to high or low user acceptance. Factors that possibly determine user acceptance [3] are for example referent power, years of professional experience, experience with a mobile phone or computer, age, education, learning curve, technology aversion, availability of airtime and network coverage. By investigating these underlying factors and by profiling comparable communities, future behaviour and potential can be assessed.

7. Conclusions

The number of women who die in preventable deaths during pregnancy continues to rise in developing countries. There is a wide gap between what people know and the facts when it comes to pregnancy and hence the requirements to bridge this information divide.

This paper has discussed the design and simulation of USSD applications that can be used as an information tool for disseminating information to pregnant women both in urban and rural settings in developing countries. If this technology is implemented in practice it has the potential to reduce the time delay between an expectant mother having a problem and seeking medical care. This time-reduction can save lives and reduce mortality rates.

Acknowledgements

The authors would like to thank Mr. Gerald Budigiri, Eng. Dr. Dorothy Okello, Eng. Diarmuid Ó Briain, net!LabsUG and Resilient African Network (RAN) for all the support and resources

they have made available to us during the course of this research project. We are also thankful for the feedback from anonymous reviewers working for the M4D 2018 conference.

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MOBICAP – A mobile app prototype for detection of criminals at country borders in low resource contexts. The case of Uganda

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ABSTRACT Uganda is a land locked country bordering Democratic Republic of Congo and South Sudan that are fairly characterized by political and social instability resulting into large numbers of refugees that continue to flock the country for safety. In some instances, criminals take advantage of inadequately manned remote border posts through which they are able to traffic humans and drugs,and move both small and large ammunitions hence contributing to more instability. This paper proposes a mobile-based solution for aiding the detection of criminals at remote border posts. The paper discusses alternative cost affiliated mobile technologies that require affordable resources to capture bio-geographical information of travellers and to ascertain their legibility from forged documents, criminal history and associates, and to monitor continuous movements of travellers and ascertain their motive. The paper then presents a prototype of a mobile application that is designed according to these properties while aimed at providing the necessary aid for criminal detection.

1. Introduction

Uganda has porous borders that are poorly manned by informal (paper based) verification checks of travellers; some criminal elements are taking advantage of failure to track their travel history and criminal record to cross these borders. Ntezza (2015) say that "The Uganda 2012 Overall Crime and Safety Situation (OSAC) report noted that while the country is "generally viewed as a safe, secure and politically stable country within the region, its extensive and porous borders are inadequately policed, allowing for a robust flow of illicit trade and immigration""(Ntezza, 2015). In a report by the USA Bureau of Counterterrorism and Countering Violent Extremism it is said that "Border security remain a persistent concern for the Ugandan government, with especially porous borders between Uganda and both South Sudan and the Democratic Republic of the Congo. Uganda used the U.S.-provided Personal Identification Secure Comparison and Evaluation System (PISCES) to conduct traveller screening at the country's major ports of entry. The use of PISCES led to the late-November 2016 arrest of one individual allegedly linked to the al-Shabaab bombings in Kampala in 2010; the individual was attempting to cross the border from Kenya to Uganda and was flagged by the PISCES system" (Bureau of Counterterrorism and Countering Violent Extremism, 2016).

IFRC say that "Since January 1, 2018, 77,429 people fleeing from interethnic violence that erupted in the Ituri and North Kivu Provinces of the Democratic Republic of Congo (DRC) arrived in Uganda" (International Federation of Red Cross and Red Crescent Societies, 2018).

It is hard to verify whether some of these people are not fleeing from crimes or not involved in rebel activity. In other instances, ADF training camps like Miba in the Mwalika area, 30km south-east of Beni. It is alleged that recruits come from the DRC and neighbouring Rwanda and Uganda. They are either enrolled in ADF by force or attracted by the promise of a better life **(**World Watch Monitor, 2017**)**, these elements bypass porous border points undetected.

On the night of June 9, 1998, the Allied Democratic Front (ADF), a Ugandan rebel force of Islamic extremists based in the Democratic Republic of Congo (DRC), infiltrated Uganda on its western border and attacked students at Kichwamba Technical Institute by setting dormitories ablaze. Between 50 and 80 students were burned to ashes, others where abducted (Human Rights Watch, 1998). The porous, mountainous Uganda-Congo border facilitated the terrorists' ability to infiltrate Uganda, attack the institute, and retreat to their safe havens in the eastern DRC.

On July 11, 2010, during the World Soccer Championship in Kampala, Al Shabaab launched a suicide terrorist attack. During the attack, several people were killed, including 60 Ugandans, 9 Ethiopians, one Irish woman, and one Asian; some 85 were wounded (Al Jazeera, 2010). Investigations revealed that the terrorists exploited the porous Uganda Kenya border to infiltrate items used in the attacks. Recently, a number of Muslim clerics have been assassinated in Kampala; senior security officials have linked these targeted killings to the ADF terrorists, who are still operating across borders **(**Radio One, 2014**).**

However, the threat remains real and constant—in large part because of the situations on Uganda's borders. The Lord's Resistance Army (LRA) makes the South Sudan–DRC–Uganda border insecure (Weber, 2012). While Uganda has pacified the north-eastern region after a successful disarmament exercise, its northeast border remains vulnerable because Kenya has not conducted a similar disarmament exercise.

In this paper we propose the use of mobile technology to aid crime detection at Uganda's border points that have limited capacity. In Uganda, mobile technologies continue to offer commercial solutions to both individual consumers and companies. Uganda also currently lacks the capacity and finances to establish effective infrastructure and surveillance and control mechanisms at all border cross points. The necessary border security infrastructure includes physical barriers (such as fences), roads, lighting, cameras, integrated fixed towers, remote video surveillance systems, mobile surveillance systems, agent portable surveillance systems, thermal imaging devices and unattended ground sensors among others but mobile applications to capture traveller details.

Currently, the country is estimated to have about 22 million mobile phone subscriptions and over 18 million Internet users (Uganda Communications Commission, 2018). Because of the proliferation of mobile technology users in Uganda, we argue that the use of mobile technology is a very suitable alternative for detecting criminals at resource constrained border locations. Mobile technology can be used in areas where there is limited or no grid power supply; instead, solar power can be used for charging purposes. Remote Border Posts can be equipped with a mobile application for accessing traveller history and details, and for exchanging security information with law enforcement agencies. This paper presents MOBICAP, a prototype of a mobile application intended to capture travellers' bio-geographical information, identity, country of origin and destination, dates and occupation / reasons of travel while at the same time offering capabilities for exchanging information with other security agencies. MOBICAP

has been developed for installation on mobile devices that use the Android operating system. It is hoped that such mobile applications are a cheaper and affordable mechanism of identifying criminals who usually exploit remote un-digitized border posts.

Uganda has two main border management systems, Personal Secure Comparison and Evaluation System (PICES) donated by the American government, and Migration Information and Data Analysis (MIDAS) managed by the Uganda Immigration Services (International Organization for Migration, 2016b*).* These systems collect, process and store travellers' information/details however lack country wide coverage, they operate at busy border posts of Malaba and Entebbe International Airport, most remote border posts rely on paper based information capture making the process complex especially tracing false identity and forged papers, international criminals take advantage of these loopholes to cross between countries smuggling weapons and elicit trade activities. These gaps can be reduced by adopting mobile application systems to capture digital information that can be searchable to identify whether the entrant has been recorded in any other border posts for criminal suspicion, also keeping track of the number of entrants visa-vi the reason (Trade, humanitarian, Instability or even disease outbreak). This helps government make policies that can effectively scrutinize trans-border crossings without compromising privacy, controlling the flow of criminal activities while addressing strategies to limit humanitarian instability driving forces.

Mobile applications run on basic phones mostly on android platforms, the economic advantage is their low power consumption, they can be charged on small solar system especially in remote borders where Government power lines have not yet reached, illegal immigrants usually exploit such border posts to cross undetected, mobile application recording bio data details can help in trace backs and investigations.

1.1 – Existing Ugandan immigration systems

Uganda has two main border management systems: Personal Secure Comparison and Evaluation System (PICES) introduced by the American government and Migration Information and Data Analysis System (MIDAS) introduced by the European Union and managed by the Uganda Immigration Services. These systems collect, process and store travellers' information or details. These systems are only used at busy border posts like Malaba, Busia, Katuna and Entebbe International Airport. IOM say that "The PISCES project was initiated by the United States Department of State, Terrorist Interdiction Program (TIP) in 1997, initially as a system for countries to improve their watch list capabilities by providing a mainframe computer system to facilitate immigration processing. It was supplied to a selected group of countries in Africa. Foreign authorities used the technology to monitor the watch list and exchange information with the United States Department of States regarding suspected terrorists appearing at their borders. The information is used to track and apprehend individual terrorists, not for the wide-ranging analysis of terrorist travel methods, according to the Government of the United States report. It matches passengers inbound to the United States against facial images, fingerprints and biographical information as they depart from airports in high-risk countries. A high-speed data network permits US authorities to access advanced information concerning inbound passengers. PISCES workstations installed in participating countries are linked by wide area network to the nation's Immigration, Police or Intelligence headquarters" (International Organization for Migration, 2016b).

Most of the remote border posts rely on manual based information capture and processing which is complex especially when tracing for false identification and forged documents. International criminals take advantage of these loopholes to cross such borders from where they smuggle weapons and conduct illegal trade activities.

1.2 – Possible solution

Empower border staff in remote locations with a mobile application to capture traveller information for possible comparison among other post to assess the truthfulness of the traveller. Mobile application can run on basic phones with android platforms. The economic advantage is their low power consumption and that they can be charged on small solar systems especially where Grid power is non-existent. Mobile technologies are also portable and can easily be connected to post and access information to and from servers via wireless networks.

2. Literature review on border management

Today scholars argue that globalization, which is characterized by internationalization of production, liberalization of trade, and development of communication technology, has led to the erosion of borders**. (**International Organization for Migration, 2016b**).** Andreas (2009) observes that, contrary to conventional wisdom that in the new world of globalization borders have become irrelevant, instead the state intervention through border policing has increased due to the rising risks emanating from clandestine cross-border criminal activities..

In Uganda, while there are systems in place for the identity management of nationals and migrants at a number of BCPs, their use is inconsistent. There is an obvious weakness in Uganda's border control because of the prevalence and acceptance of insecure temporarypasses (not passports) and in some cases allowing travellers to bypass the Border Management System (BMIS) in the name of traditional trans-border movements. There are occasions when no biometric registration or other checks are done on the departing migrants, some of whom might have been on wanted lists. (International Organization for Migration, 2016b, p. 59). "East Africa has been a volatile region, facing numerous challenges from political, military and economic instability. Such conditions have placed great strain on the border management of Uganda, exposing its borders as being vulnerable to irregular movements and mass migrations. The pressures on Uganda's borders are also a major contributing factor to other cross border issues such as trafficking in persons and smuggling of precious materials which fuel conflicts" (International organization for Migration, 2018a).

IOM reports that during the opening of the South Sudanese Government High Level Expert Meeting held in 2018 towards the protocols on free movement of persons and transhumance in the IGAD region, South Sudanese Foreign Affairs Minister Martin Elia Lomuro "urged the experts to tackle various sticking issues, including nomadic pastoralism and belligerent asylum seekers. He said many South Sudanese live in capitals of neighbouring countries, where they own property inappropriately acquired from South Sudan, and reportedly use their wealth to finance instability back home." He urged "these cannot be treated as ordinary asylum seekers". Further IOM say that Mr Ali Abdi, Chief of Mission of IOM Uganda, "urged IGAD member states transition from restrictive to facilitative border management strategies, promote free movement of persons, and unlock the region's intra-regional trade potential" (International Organization for Migration, 2018b).

In a press release from May 2016, IOM claims that "Uganda's porous borders make it extremely challenging to counter transnational organized crime, including terrorism, trafficking in persons and smuggling of migrants. As a country fully engaged in regional integration, Uganda must also ensure the legitimate cross-border flow of people and goods" and that the Japanese Ambassador to Uganda Junzo Fujita is providing funds to IOM to help the Ugandan government improve its border security. According to IMO, "Fujita said that the project will contribute to the security of all Ugandans by enhancing the country's capacity to respond more effectively to various migration and border challenges. 'We cannot allow transnational crime to take hold because of porous borders. Also, we must ensure that Uganda's borders are contributing to enhanced trade, investment and tourism'." (International Organization for Migration, 2016a)

Lack of strong, established and well-facilitated structures along Uganda's borders to effectively conduct surveillance and monitor border activities provides transnational criminals with an opportunity to violate the national borders. However, this situation can only be remedied by a regional effort between Uganda and its neighbours through joint border operations and information sharing. Though some improvements in this regard are underway, the development is ad hoc and needs improvement.

Land border crossings constitute obstacles to regional integration and facilitating the movement of goods and persons across borders ranks high in the priorities of Regional Economic Communities in Sub-Saharan Africa. These obstacles are common to gateway corridors serving the landlocked countries and also hinder regional trade and international transit, thereby adding to the importance of addressing this challenge (Fitzmaurice and Hartmann, 2013).

Papademetriou and Collett states that "Governments are beginning to place greater emphasis on the need to collect data on people who wish to enter their country before their arrival at the border. The data collection ranges from biographical information contained in the passports […] to more detailed information on travel plans (collected through Passenger Name Records [PNR]) and the purpose of an individual's visit […] This information historically collected through visa applications and at ports of entry, is no longer used just for immigration enforcement and the prevention of visa overstay, but also assess potential security risk" (Papademetriou & Collett, 2011).

3. Requirements gathering: method and result

3.1 – Sampling

Through sampling, a number of border posts were reviewed to assess how the immigration information process is handled, it was observed that Entebbe Airport and Malaba Border post with Kenya have the highest number of entrants and the digital approach to digital processing and storage was highly emphasized, Many entrants satisfy requirements like passports and authentic travel documents although depending on the expertize of the illegal entrant, some elements have managed to bypass the virtual fence, for example the 2013 Westgate attackers managed to bypass Entebbe and Malaba check points to Kenya undetected. The Mpondewe – Bwera border post between Uganda and DRC lacks the necessary equipment to control the busy border characterized by individual trans-border crossing basing on same ethnic backgrounds of the indigenous border community, criminals work with these communities to

bypass a poorly managed process to cross elicit weapon accessories and counterfeits between Uganda and Eastern DRC which has recorded a long era of security instability.

3.2 – Interviews

During the Interaction with immigration officials at Malaba border-post they hinted one the system being slow and freezing during peak hours where traffic is at its highest, officials attribute this to limited finances allocated to them especially for IT maintenance and Upgrading, this limits their capacity to add strong and high speed/memory machines that can capture, store and retrieve information faster in real time.

Immigration Officials expressed concern about remote border posts that continue to rely on manual information processes not only because of small budgets but also poor geographical terrain and overall national infrastructure challenges like absence of power lines, roads, water for employee's wellbeing and operational activities. They urged that remote borders are not frequently bypassed with bulk illegal merchandise but small bits of ammunition pass through such borders in parts and soft target for crossing high classified criminals like wanted terrorists and rebel structures.

Immigration officials give credit to the MIDAS system and PICES so far operating on main entry/exit points where individuals with pending court cases have been intercepted trying to escape through use of electronic verification and information exchange, other criminals on the Interpol hit list have also been intercepted, counterfeits and human trafficking offenders have also been intercepted. Officials continue to emphasize on the need to train and recruit IT skilled personnel to learn the proposed system to cover other remote borders, this comes at a dollar cost on top of the limited budget at the moment.

In consultation with security officials, they expressed frustration about lack of prior information about individuals on Interpol's hit list and wanted criminals from neighbouring countries who enter the country from remote borders with fake travel documents that cannot be tracked by the manual processes at these borders hence limiting their efforts in combating international crime. Security personnel further hinted at the laxity of IT equipment personal where international traffickers and wanted criminals have bypassed the digital fence at these major Airports and border posts, they hinted that the PICES system is accurate and so far the best but does not serve the host government it instead benefits the American government more in efforts to track the movement of their political and military rivals from Asia and Middle East who travel to other states less hostile to the West where PICES system has been installed

4. Proposed System Prototype

4.1 – Conceptual Design for the criminal detection prototype

The proposed application is conceptualized to help immigration staff go mobile in their data processing since digital data can be verified and easy comparisons between different border posts done in a minimal time lag. Conversely, the application is also supposed to furnish Headquarters and other stations with information about all travellers who have been registered through that specific border point. Figure 1 illustrates this conceptualization.

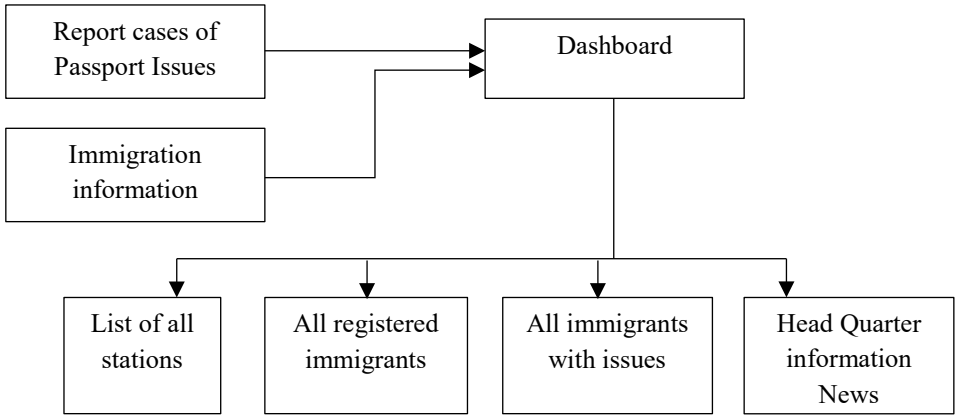


Figure 1. Conceptual design of MOBICAP

4.2 – Use Case Diagram for the criminal detection prototype

To represent the functionalities of the system, a use case model is used. A use case model describes a function provided by the system that yields a visible result to the actors. In the proposed system, the following use cases are identified in Figure 2.

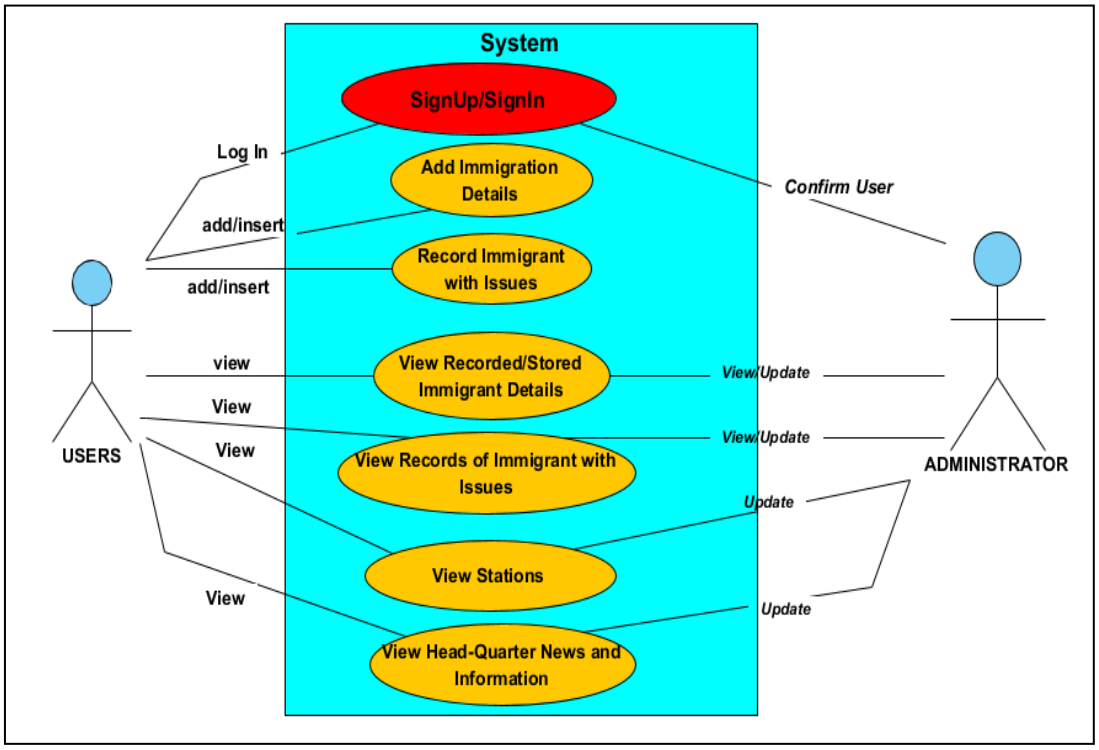


Figure 2. Use case diagram for MOBICAP

User actions and their descriptions

Users are border post officials that capture travellers' information. In the proposed application, the users are required to authenticate themselves before they can use the application. This is

achieved through a Sign up/Sign in functionality where border control officials are capable of logging into the application or creating an account that is used for granting them access to the application.

A traveller's details can be added using the Add immigration details functionality. This ensures that a specific traveller's details are captured and recorded for future reference.

The View Recorded/Stored Immigrant Details functionality enables a border control official to access stored information about a traveller.

The View Stations functionality enables a border official to view details of available border stations in a country.

The View headquarters news and information functionality enables users to view headquarter notice board for information updates.

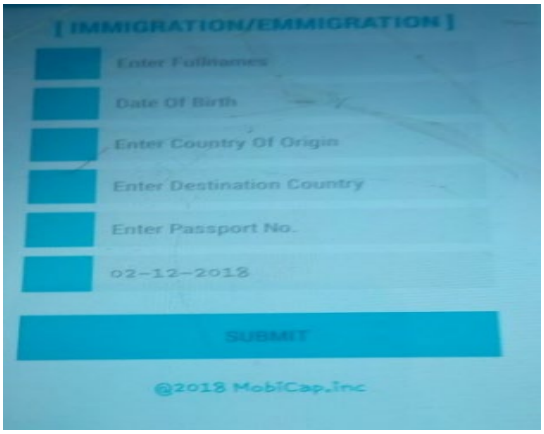
Administrator actions: is a system administrator of the database system, can view, update, edit, insert and delete immigrant information, stations and news depending on the need.

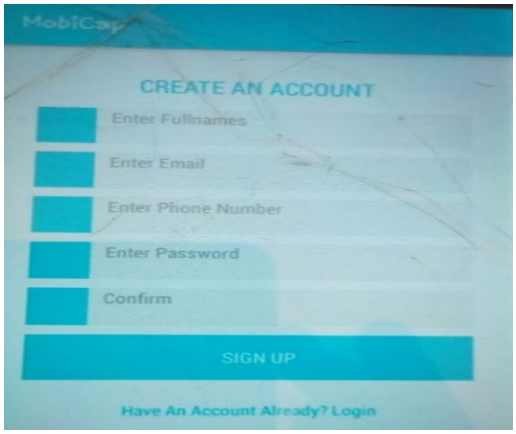
4.3 – Implementation of the criminal detection prototype

MOBICAP is installed on android operated mobile phone devices and can be given to immigration officials in remote border posts. The official can create accounts and log on the application which is backed by an SQL Database store that is accessed by a central administrator who generates comparison reports, monthly assessment summaries, and can also grant privileges, edit and update the database in cases of corrections.

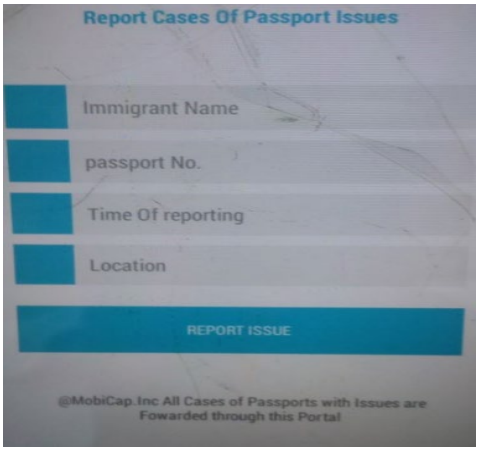
Immigration officials record bio-geographical particulars of a traveller, and also are capable of querying the database and other sources of information to resolve issues surrounding fake / expired travel identities and wanted criminals / smugglers. The officials can view the recorded information on phone screen for reference purposes. The images below are a sample of screen shots of the mobile app.

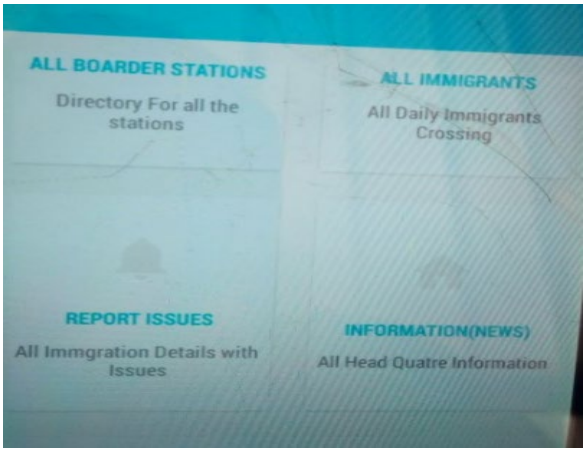
Prototype screen shots[*]





[*] One screen with personal data has been removed by the Editors.





5. A first validation

Port Bell Luzira is one of Uganda's main cargo ports with a sizable number local and regional human traffic connecting Uganda's most industrial town of Jinja, Kisumu in Kenya, Musoma and Mwanza in Tanzania. Port Bell is not as remote as other border ports on the northern and western borders; it was selected as an interview site because of its closeness to the capital city Kampala, assessing the increasing population of business community offloading and loading merchandise not withholding the number of travellers that use the ferry to cross borders. Despite the port being in close proximity to the Capital City with all the infrastructure, it still lacks digital data capture of traveller's details and instead travellers details are recorded in counter books manually. Thus, this could be a site which need an enabling technical solutions like the proposed mobile application.

The following brief is extracted from the Interview Report which was generated after consultations with Immigration staff at Port Bell during the presentation of the MOBICAP mobile application showing the functionality of its information capture and retrieval of traveller bio-geographical Information.

The staff decried instances of forged identities, human trafficking, illegal trade and lack of verification mechanisms to ascertain whether a traveller is avoiding the other digital border posts like Malaba, Entebbe, Katuna for various reasons.

Staff appreciated the mobile application claiming it would revolutionize their information capture process. The European Union and World Bank have offered the government a helping hand to revamp the pier, remodelling the entire port, including design for capacity augmentation of the existing berths, dredging, reclamation of lagoons, and massive expansion which will increase human traffic and as a result the mobile application based information system will be of great importance in capturing traveller details.

The Immigration staff hinted on the need for a full scale development of the Mobile Application with additional automatic analytics in the application for easy and quick generation of reports for daily, weekly and monthly summaries of travellers and their details to enable fast decision making and predict forecasts at the stations

6. Conclusion and Future work

The implementation of MOBICAP fairly fits the financial capacity of Uganda Immigration Services to purchase android phones, wireless adapters and storage facility / servers. This system satisfies the demand for low developed countries to use basic systems to capture, store and retrieve information of both security and intelligence value in the fight against trans-border crime. The prototype presented in this paper is however, still basic as it lacks many functionalities beyond just matching structured database information. Future work on the app includes equipping it with state of the art data mining capabilities to use even unstructured information in detecting criminals.

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Panel Abstract

Panel Abstract

The Impact of Shrinking Civic Space on Technology-Based Initiatives for Democratisation

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As reliance on technology grows, so does the immense opportunity for its use in enabling civic agency, social innovation, financial inclusion and improved governance. Uganda's decision to tax the use of social media applications and mobile money transactions is among the first of its kind. The country's technology market is relatively small and costs of such a taxes on the citizens' political, social and economic rights, therefore seem to outweigh the potential benefits. But other countries, including Tanzania and the Democratic Republic of Congo, have this year introduced regulation on social media / online content creators, which requires payment of annual fees including for licences. Zambia has proposed a daily tax on calls made over the internet.

These developments mirror the overall shrinking civic space in some Africa countries, where governments are getting more hostile to the political opposition as well as to activists, critical media reporting and to criticism by social media users. This session will therefore present different perspectives on the impact of recent developments in the ICT and governance sectors in Kenya, Tanzania, Uganda and Zambia; discuss the implications for the rights of citizens, democratic engagement, women's participation in governance, social accountability and human rights monitoring.

Moderated by Dr. William TAYEBWA, Head of the School of Journalism and Media, Makerere University, Uganda.

Poster and Demo Extended Abstracts

Poster Extended Abstract

Improving information quality in healthcare, the Malawian context

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In sub-Saharan Africa, the management of timely and accurate response to communicable diseases still is an overwhelming burden. In order to correctly assess diseases, decide and act on assessment, healthcare workers need complete, timely, valid, and consistent information – i.e. a need of high information quality.

In the case of Malawi, there are several challenges to improve information quality to and from remote healthcare workers in the field. Most health records are paper-based and manually managed. With paper-based patient registers, incomplete filling of records and illegible handwriting are known problems. Particular problems were identified with laboratory testing and medication supply chain logistics. For example, referral lab samples can take up to 21 days for results to be returned to a clinic (Wu and Mumba 2016). Combined, these challenges inflict information quality. However, mobile technologies have gained momentum in healthcare in both low and middle-income countries and high-income countries thanks to improvements in network coverage, cheaper transmission fees, and widespread penetration of mobile devices. There also evidence that mobile technologies can improve information quality, aspects of pivotal importance in healthcare (Adokiya, Awonoor-Williams et al. 2016, Hardy, O'Connor et al. 2017).

However, established in interviews with local stakeholders regarding the effects of mobile apps for assessment of diseases, such as D-Tree, and SL-CCM App, there are still issues with information silos, insufficient alignment to national health records and lacking accessibility of information for healthcare workers. These issues are mainly caused by autonomous applications, not connected to other systems.

In agreement with stakeholders and authorities in Malawi, there is an evident need and a wish to connect these isolated applications so information can be accessed and shared. Furthermore, an initiative that must be compliant with Malawian healthcare systems. With the modification of existing systems and a middleware, information sharing and sufficient accessibility can be achieved. "A Medic" (amedic.org) is an initiative to study further and develop a sustainable, locally adaptable information system that connects remote healthcare workers in the field, hospital doctors and national health records. Essential components are:

- an assessment tool,
- an on-demand communication channel,
- a generic patient record database.

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Poster Extended Abstract

Supporting Mothers of Premature Infants Using Social Network Sites: Kenya Case Study

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In Kenya, the rate of preterm births is estimated at 12% annually [11]. The preterm infants are admitted to the Neonatal Intensive Care Unit (NICU) where they receive specialized care [12]. Studies show that most mothers of preterm infants suffer from stress due to the uncertainty of the infant's health condition [2,5,12]. Some mothers feel guilty for not carrying the pregnancy to term and in some cases, they are condemned by the society for giving birth prematurely [6]. These mothers are vulnerable to stress during the infant's hospitalization and they need constant support to help them manage the stress related to prematurity.

In this study, we focus on exploring how Social Networking Sites (SNSs) such as Facebook, Twitter, and YouTube can be used to support mothers of premature infants through information sharing [9]. In public health and health promotion, SNSs are increasingly being used to disseminate health information because they remove geographic and physical access barriers [8]. In addition, people facing communication barriers in the health facility—which is common among new mothers, often use the internet to obtain health and psychological support information [1,7]. Choudhury et al. research prove that participation in health-related online communities and support groups have been associated with significant reductions in anxiety and other psychological distress [3].

Building on this premise, we focused on exploring the use and implications of SNSs in spreading health information and educating mothers of preterm mothers on their health rights as they take part in the care of the preterm infants. To explore the feasibility of SNs in supporting mothers of preterm infants, we created Facebook [6] and Twitter [7] groups and used these platforms to share parental support information. On Facebook, we screened members before giving them access to the group. We included health organizations and medics as members of the groups to provide clinical information as well as to authenticate the shared information. We educated mothers on low-cost intervention (such as Kangaroo Mother Care (KMC) and the importance of exclusive breastfeeding for infants' development. Furthermore, we shared encouraging stories of infants who survived after premature birth.

This research is ongoing and preliminary findings show that mothers frequently visit the groups to access psychological support information. They expressed their satisfaction by liking and adding appreciative comments on the motivating and encouraging posts. This resonates with Shin et al. findings that prove users frequently visit SNSs when the information shared is relevant and useful [10]. However, no mother shared their story/queries on the timeline. They preferred using private chats for inquiries

[6] https://www.facebook.com/groups/180103339214809/

[7] https://twitter.com/PreemiesMumKE

and to share their current motherhood ordeals. This echoes Farfan, G result which shows that SNSs users only share information with people they already know rather than with strangers [4]. Nevertheless, Heldman et al. provide a list of key principles that can be used to enhance interactive communication with the audience who access health information on SNSs [6].

These results reveal that SNSs play a critical role in the transmission of health information and can successfully be used to support and educate mothers of premature infants if they are fully engaged in communication. These findings serve as a foundation for more in-depth empirical research on how best to leverage SNSs, specifically the ability to engage with our audiences, to improve premature birth outcomes.

Acknowledgment

We are grateful to the Collaboration on International ICT Policy in East and Southern Africa (CIPESA) for funding this research, as well as the participants who form part of this Project. We would also like to thank Ashnah Kalemera for guidance and insights throughout this research.

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Poster Extended Abstract

Optimising Placement of Baseband Unit Edge Clouds in Cloud Radio Access Network

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Cloud Radio Access Network (CRAN) has been deployed to improve cellular network performance as well as reducing costs which Mobile Network Operators (MNO) face while trying to meet the increasing subscriber demands such as high data rates. The key feature of CRAN is that Base Band Unit (BBU) functions maybe pooled at a location or locations removed from the Remote Radio Head (RRH) functions. They are centralised and virtualised at a BBU pool. The front-haul link between the BBU and RRH maybe long (over 40km) thus high front-haul link latencies which in turn leads to higher overall network latencies. This is a major challenge for technologies such as 5G which aim at providing near zero network and user latencies. The long front-haul link lengths also affect the synchronisation between the RRHs and the BBUs [1].

This project introduces a novel way of addressing this challenge. It considers running the virtualised BBU pool in optimally placed Edge Clouds (ECs) such that virtualised BBU functions are extended closer to the RRHs. This reduces the front haul link length and likewise the front haul link latencies in CRAN. The key feature of CRAN is having several RRHs sharing the same BBU pool. In this proposed idea, at the cell sites still remain only RRHs that will be sharing a BBU pool but located in an EC. *In terms of implementation, an already virtualized BBU pool is considered; therefore, orchestration of all functions in the BBU pool remains as it was at the centralized locations. The virtualized BBU pool can be instantiated at the* EC co-located at the antenna site or at the EC at an aggregation site. Since the aim is to reduce front haul link latency to as low as possible, locations closest to the RRHs are preferred given that the constraints are fulfilled.

Position of the BBU pool in CRAN is crucial as it determines the overall front-haul link latencies. In placement of BBU pools in CRAN, researchers have been focusing on minimising number of BBUs, substrate links, energy, actual Virtual Machines (VM) required and actual network set up costs. To the best of my knowledge, no work has been carried out so far as regards to placing BBUs in optimally placed ECs with an aim of minimising overall front-haul link latencies. In this project, the network model under consideration consists of Voronoi cells with RRH and candidate EC locations placed in it using Poisson point process. The cells are clustered using fuzzy c-means clustering algorithm. General formulation of the problem leads to a constrained nonlinear optimisation problem that is solved by genetic algorithm in MATLAB. Optimal locations for the BBU ECs are determined to further achieve proper resource utilisation, reduce cost of ownership as well improving user quality of experience.

Numerical results demonstrate that the proposed idea greatly reduces the overall front-haul link latency, improves EC and BBU utilisation, front-haul link utilisation improves and user delays are reduced thus improving user Quality of Experience (QoE) as well as reducing CRAN cost of ownership. The

algorithms used are not specific for a given network but can be used for different networks and under changing network conditions.

Keywords: Baseband Unit, Cloud Radio Access Network, Edge Cloud, Latency, Remote Radio Head.

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Poster Extended Abstract

The Anthropology of Smartphones and Smart Ageing

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The Anthropology of Smartphones and Smart Ageing is a multi-sited research project based at UCL Anthropology and funded by the European Research Council. The project employs a team of ten anthropologists, who have been conducting simultaneous 16-month ethnographies in Uganda, Cameroon, Ireland, Italy, Brazil, Chile, Jerusalem, China and Japan since February 2018. Findings will be widely disseminated in open access books, regular blogs, videos and online education materials.

The aim of this collaborative five-year project is to understand the impact of mobile technologies on the experience of mid-life around the world, with the intention of assessing practical implications for the field of mobile health. Despite best intentions, mHealth interventions may often fail to align with existing mobile phone practices and therefore to appeal to users' preferences. We aim to demonstrate how anthropological insight can lead to more culturally appropriate mHealth interventions and more effective improvements in people's lives.

In the case of the Uganda fieldsite, primarily based in a low-income area in Kampala, and secondarily in participant's home villages in rural Northern Uganda, it is evident that people already use mobile health in various informal ways. For example, older adults often use their phones to support elderly relatives' health in the village, giving advice and sending mobile money. This may suggest that the communicative nature of existing popular mHealth usage in Uganda would be the most beneficial approach for a new or existing initiative.

In this way, a holistic ethnographic exploration of the new opportunities or challenges of connectivity afforded by mobile phones can supplement the work of digital and health practitioners in Uganda. We are currently seeking partnerships in order to contribute our contextual insights and help to improve accessibility of health information and services.

Poster Extended Abstract

Deaf in India

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Technological advancements try easing the life of people around the world. People, who are differently-abled, are getting more attention for easing their lives. There is around 2.21% differently-abled population in India, which is the second largest contributor to the world's population [3]. Among various disabilities, deaf is somehow overlooked. This needs attention as around 19% are deaf in the disabled population of India [3].

Deaf in India faces challenges as illiteracy, parent awareness to special education and lack of communication with the world. To address deafness, hearing aids and cochlear implant as shown in e.g. [4] and [2] are promoted in India by giving subsidy.

But these aids contribute little hearing sense to the deaf. Also wearing such aids whole day is a little painful. As a result, the deaf have to rely on a special way of communication - sign language (SL). There are very less Educational organizations in India educating sing language. So, deaf find difficulty communicating with ordinary people around them. This has minimized at very low extent because of the smartphone. In India, smartphone (Android) cost starts from $80, which is an affordable price to have a smartphone. As deaf are also comfortable with the smartphone, many Android apps are developed to address special needs [1, 5, 8], but didn't achieve popularity. This seeks more research in this area.

This motivates to look more into effective use of such a device to ease the life of deaf in India. Children, first educate to speak mother tongue from their parents. Deaf Children are not exception to this. Parents of deaf children find difficulty in teaching mother tongue. But this can be minimized by providing e-learning platform to these parents for enabling effective duplex communication with deaf children. The areas for research can be an effective interpretation of SL to local language and vice-versa, interpretation of digital media to SL and converting a book to SL. There is also a scope for research in sensing non-speech sounds around deaf [6].

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Demo Extended Abstract

Footomo Kit

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Problem. Livestock production has been confronted with several epidemics over the last decades. 25% of Livestock in sub-Saharan Africa die due to contagious diseases like East Coast Fever, Mastitis, and Foot-and-Mouth disease. 65% of livestock in Uganda predominantly cattle are susceptible to Foot and mouth disease leading to huge losses in terms of livestock productivity and trade. [1, 2]

Foot-and-mouth disease (FMD) is one of the highly contagious diseases of domestic animals. Effective control of this disease needs sensitive, specific, and quick diagnostic tools at each tier of control strategy. [2-4]

Outbreaks with devastating economic consequences still occur and remain a terrible threat to countries that have eradicated the disease and to those that never had the disease. [5]

The main concern nowadays is in case of an outbreak how to prevent spread of the virus. [6]

Solution. In recent years, compact wireless sensor network devices have made animal health monitoring, disease detection and diagnosis increasingly smart. However, detection of contagious viral diseases – specifically Foot-and-Mouth disease – is still complicated and inconvenient due to the nature of the virus in an animal's body. But, proper diagnosis and detection of the disease is very important and accurate results need to be displayed. In order to overcome FMD in any animal, we propose a wireless sensor network based model for detecting this disease in livestock.

A complete integrated information and communication technology is desired for FMD disease detection system to identify the animal health during the livestock disease diagnosis [7]. The answer to the new detection model is to use the WSN (Wireless Sensor Network) based technology. The key features of the WSN technology is the low power consumption [8].

The Footmo Kit is a hand-held device that diagnoses FMD in livestock with multiple vital parameters in one test in hard-to-reach and remote areas. The device is put in the mouths of a cattle and it detects the disease against the antigen content in the saliva and body temperature. This is done to assess the specific antibody responses in saliva. The results in real time are then displayed to the farmer on the screen. When the animal is found infected, the farmer reports to the nearest animal scientists or veterinary doctors. The antibodies are detected correlated between the rate of decline of the antibodies titres and the presence of virus in probang samples.

Future outlook. Our technology and approach will allow for scalable, affordable and dynamic growth in the future

Mission. To Power Livestock Production, increase household income and Strengthen food Security by controlling foot and mouths disease in Uganda and entire world.

Vision. To be the most dependable tool for diagnosing Foot-and-Mouth disease.

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Workshops Abstracts

Workshop on 'Mobile Accessibility'

Organizers

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Target Audience

App Developers, Usability Experts, University Teachers, Research Scholars, Engineering / Science Students, Physically Challenged People, and Older People.

Objectives

1. To explain the importance of mobile accessibility for people with disabilities and older people
2. To list common barriers experienced by people with disabilities and older people
3. To apply basic principles of accessibility during the preparation of mobile content
4. To carry out preliminary checks of mobile apps for accessibility and communicate the results
5. To present case study that influences mobile usage by people with disabilities and older people

Workshop Outline

- What is accessible computing?
- How people with disabilities use computational services?
- Difference between Accessible & Inaccessible User Interfaces
- Various accessibility standards & guidelines
- Mobile accessibility standards
- Various Laws, policies, directives
- Accessibility myths
- Approaches for accessibility implementation
- Design considerations
- Development tool accessibility
- Accessibility of rich Internet applications
- PDF accessibility
- Android accessibility
- IOS accessibility.
- Windows mobile accessibility.
- Approach to accessibility testing
- Demonstration of accessibility testing tools
- Testing with screen readers

Duration: 1 Day (5-6 hours) – 3 Sessions on Accessibility, Accessibility Perspectives, and Case Study of Eye+. Held the day before the conference, 14th of November 2018.

Graduate Students Track

Organizers

Edgar Napoleon ASIIMWE
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Target Audience

Master students and PhD candidates.

Objectives

This track is organised as a workshop to provide a forum for PhD students and Master students in the area of mobile communication technology in and for development to present their works and receive feedback. The goal of the workshop is to provide professional development in M4D with critical, but constructive, feedback and advice to graduate students on their ongoing research from senior researchers.

Workshop Outline

Student participants had prior to the workshop submitted their work plans. These had been reviewed and the more mature had been accepted for presentation and discussion at the workshop. The conference fee was waived for accepted students.

- Start: an IPID social event between 9am-12pm
- Arriving from the social event by 12 to have lunch at 12pm-1pm
- Short lecture followed by Q&A: 1:10-2pm (On Academic writing and publishing or something else) by John Sören Pettersson. 40+ students are attending.
- Presentations from the selected 5 Ph.D. students and feedback 2-3pm in 3 groups. Mentors: Asiimwe, Nabende and Pettersson.
- Closing followed by evening tea and cross-group presentation by speed dating after 3.30pm.

Duration: 1 Day (7-8 hours). Held the day before the conference, 14th of November 2018.

Proceedings of the 6th International Conference on M4D Mobile Communication Technology for Development

M4D 2018, 15-16 November 2018
Makerere University, Kampala, Uganda

Information Systems

ISBN 978-91-7063-886-2 (print)

ISBN 978-91-7063-981-4 (pdf)

ISSN 1403-8099

Karlstad University Studies | 2018:47