Research Track – Full Papers

Evaluating the impact of mobile phone based 'health help line' service in rural Bangladesh

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Abstract: Access to basic health service is limited in rural areas of Bangladesh, where 80% of the total population lives. For instance, 35% of doctors and 30% of nurses are located in four metropolitan districts where only 14.5% of the population lives. Most of the rural people are physically remote from the qualified health care providers. Two major mobile phone service providers in Bangladesh have initiated mobile health care help line service s nationwide as a remedy in this case. Since there is much hope of mobile phones to be used for basic health care services for populations living in rural areas, this research aims to evaluate how far such interventions reached for the improvement of health care in those communities. Through an interpretive case-based research strategy, our field studies uncover enthusiasm from the rural people towards availing health help line services and the intervention's contribution to improved health-seeking behavior.

1. Introduction

Information and communication technology (ICT) can be defined as a diverse set of technological tools and resources used to communicate, to create, disseminate, store, and manage information in its various formats (e.g., business data, voice conversations, still images, motion pictures and multimedia presentations). These technologies include computers, the Internet, broadcasting technologies (radio and television), and telephony. Importantly, ICT is also concerned with the way these different uses can work with each other. In recent years, many developed and developing countries have witnessed a phenomenal development in ICT development. While defining development, Economist David Fielding explained development as progress of a nation relating to its material wealth is not independent of progress in other spheres. It's not only the economic growth that is needed for development; a country needs development in other sectors also to be developed. He reasoned that economic growth has a close connection with democratic development and education promotes good health, and good health promotes education (Fielding, 2002). According to the United Nations Development Program, human development contains many aspects and is more appropriate to measure progress. The United

Nations also defines Development more than just financial income. Human development is about having choices so that people can live the lives they value (UNDP, 2006). UNDP introduced the new Human Development Index or HDI in 1990. HDI is used to measure a nation's achievements in terms of longevity (life expectancy at birth), knowledge (literacy and school enrollment ratios) and standard of living (GDP per capita) (UN, 1990). ICT is an emerging trend, which is going through rapid growth. Developed countries are already utilizing the benefits of ICTs towards development. It is being argued that ICT can influence economic growth, health services and many other sectors of a country. Recently, in Bangladesh, ICTs have been remarkably developed. Despite many attempts to deploy ICT in city-urban-rural areas in Bangladesh, what exactly achieved through ICT is little explored in the research area. Hence this research is an attempt to fill this gap by exploring ICT intervention in a particular area in Bangladesh. The objective of this paper is to portray the health sector of Bangladesh in light of the impact of ICT on health. Mobile phones as a part of ICT can greatly affect the health scenario of Bangladesh. Though two major telecommunication service providers, namely Grameen Phone and Banglalink are providing health help line service, we focus on Grameen Phone as it holds the biggest market share. This article is presented in as follows: first, we present a brief description of ICT and its link towards development followed by a description of ICT intervention in Bangladeshi Health context. Finally, we present a 'case study' using an interpretive approach guided by a theoretical framework -"Communication for Development".

2. ICT and Development link

ICT has been regarded as a key component for development. Since the 1990s ICT has been considered as an engine of growth to transform the economic, political, cultural and social conditions of many developing nation states (Deliktas & Kok, 2003; Hicks & Streeten,1979). Generally everyone agrees that ICT can offer opportunities for citizens of developing nations to communicate and collect information. Information then can be utilized for education, increasing productivity, and improving health (Morawczynski & Ngwenyama, 2007). Research has also identified a strong correlation between economic performance, health, education, and political development. From the late 1980s, debate started on monitoring different factors for human well being which includes education, health, political freedom etc as crucial parts of development (Andoh-Baidoo Francis, Bollou & Morawczynski, 2006).

We find that mobile phones (one of the major components of ICT) in less developed economies are playing the same crucial role that fixed telephony played in the richer economies in the 1970s and 1980s. Mobile phones substitute for fixed lines in poor countries, but complement fixed lines in rich countries, implying that they have a stronger growth impact in poor countries. Many countries with under-developed fixed-line networks have achieved rapid mobile telephony growth with much less investment than fixed-line networks would have needed (Waverman, Meschi & Fuss, 1986). In Bangladesh, the major part of teledensity depends on mobile phones. Among the total 38.41% teledensity, 37.23% is due to the mobile sector. PSTN or the fixed telephone line contributes only 1.18% to the total teledensity.

It is found that mobile telephony has a positive and significant impact on economic growth, and this impact may be twice as large in developing countries compared to developed countries. Beside their fully articulated fixed-line network, the addition of mobile networks had significant value-added in the developed world. Through the mobile network, mobility and flexible billing policy have been offered which are unavailable for fixed lines (Waverman, Meschi & Fuss, 1986).

The number of mobile phones subscribers in Bangladesh is rising exponentially. According to the Bangladesh Telecommunication Regulatory Commission (BTRC) the total number of

mobile phone users reached 50.40 million by the end of September 2009. Although at the middle of 2007 the mobile phone penetration was 27 million. Table 1 shows the number of mobile phone users according to the operators. The increase is significant and the trends show that the large numbers of mobile phones subscribers will be boost in the near future.

The Mobile Phone Subscribers (in millions) for different operators are summarized in table 1:

Table 1: The mobile phone subscribers in Bangladesh (BTRC, 2010)

Operators	**May 2007**	**July 2007**	**Dec. 2008**	**March 2009**	**Feb 2010**
Grameen Phone Ltd. (GP)	13.24	15.73	20.99	21.05	23.75
Axiata Bangladesh Ltd	5.55	6.67	8.20	8.76	10.31
Orscom Telecom Bangladesh (Banglalink)	5.53	6.61	10.33	10.83	14.13
PBTL (Citycell)	1.27	1.31	1.81	1.87	1.94
Teletalk Bangladesh Ltd. (Teletalk)	0.87	0.91	0.98	0.98	1.04
Warid Telecom Int. (Warid)	0.20	1.14	2.33	2.26	3.00
T*otal (In Millions)*	26.66	32.37	44.64	45.75	54.15

3. Setting the Context

3.1 Bangladesh's health sector

In Bangladesh, a significant decline in infant and child mortality has been observed over the past decade. This is mainly because of proper control and prevention of diseases, such as measles, poliomyelitis, and diphtheria along with widespread use of ORS for diarrheal diseases. Bangladesh is on the verge of Polio eradication, and has already achieved the elimination goal for leprosy at the national level. People are living longer; the average life expectancy at birth in Bangladesh increased to over 65.1 years in 2004. However the maternal death ratio is still high at over 300 per 100,000 live births.

Although there has been substantial progress in disease prevention and control and a decline in childhood communicable diseases, new and old infectious diseases like malaria, tuberculosis and acquired immunodeficiency syndrome (AIDS) are still considered to be serious threats to health for the years ahead. Projections are uncertain because of the potential of travel and trade, urbanization, migration and microbial evolution to amplify these diseases. The emergence of drug resistant malaria and tuberculosis further increases the risk. Other major causes of death that are on the rise include heart diseases, diabetes, cancer, disability, and mental disorders.

Malnutrition is another major cause of death and debility in children in Bangladesh. Micro-nutrient deficiency is quite common; nearly 75% of children's lives are spent in illness mostly due to malnutrition related debility and infections. Poor nutrition deters physical, cognitive and mental development. Low birth weight and malnourished children are susceptible to infections; roughly two-thirds of under-five deaths are attributed to malnutrition, 75% of it being associated with mild and moderate malnutrition. About 25% of maternal deaths are associated with anemia and haemorrhage. Women and adolescent girls mostly suffer from Anemia from iron deficiency (WHO, 2008).

In Bangladesh, there is an acute shortage of qualified doctors in rural areas. While around 70% of the total population lives in rural areas, 75% of the qualified physicians practice in urban

areas. Even though the population of Bangladesh is concentrated in the villages and small towns, the medical services in those areas are far from sufficient. It is found that most of the health care centers fall within 1 mile from the living place. It is also found that the average waiting time for a doctor is approximately 30 min and in some case it extends to about 57.1 min with an average consultancy period of only 2.5 min, which in some cases lowered to 1.5 minutes (Aldana, Piechulek & Sabir, 2001).

According to the 2007 Global Gender Gap Report, the position of Bangladesh is 126 for average life expectancy, where births attended by skilled health staff (as % of total) is 13 and the ultimate result is high infant mortality rate and high maternal mortality rate. Only 45% of the total population has access to health care facilities (Ashraf, 2009). From another investigation it has found that, about one-fifth of adolescents did not receive any tetanus toxoid (TT) during their last pregnancy. The mother's blood pressure was not taken in four out of five births, nor was urine taken and tested during pregnancy. Antenatal care coverage was only 25 percent. Most important reasons for this poor condition are lack of hospitals, professional doctors, distance barriers and lack of awareness among rural people.

3.2 What can be achieved by using mobile phones in health sector of Bangladesh

Natural disasters leading to disruption in food supplies lowers the nutritional status. A third of all deaths under the age of five are associated with severe malnutrition. Moreover, more than 75% of all illnesses in Bangladesh are ascribed to lack of safe drinking water and adequate sanitation facilities.

Having recognised the potential of ICT to contribute to improvements in health and education, Bangladesh is implementing ICT projects across the country. Their success depends on the capabilities of individuals and organisations.

When the Government declared ICT a 'thrust' sector in the last decade, many young Bangladeshi men and women returned from abroad to apply their skills, but low bandwidth and the high cost of Internet access discouraged them from establishing ICT-enabled businesses there.

Currently mobile phones are one ICT component used in the health sector. Due to availability and connectivity of the technology, there is enormous scope for mobile services in rural health care. M-Health or mobile health is a recent term for medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, PDAs, and other wireless devices. M-Health applications include the use of mobile devices in collecting community and clinical health data, delivery of healthcare information to practitioners, researchers, and patients, real-time monitoring of patient vital signs, and direct provision of care. In general sense, where medical care relies on the face to face session between patients and doctors, in M-health concept physicians treat a patient who is distant physically. The primary purpose of M-health is to reach health care service to a patient who is some way isolated from specialized care. M-health can provide services on 24 hours a day and seven days a week basis.

Also tele-medicine services through internet have been implemented in some countries to provide distance medical help to general people. For example, in India, they are offering tele-medicine services in many regions where they provide computers with webcams, printers, and power backups, local language software and communication equipment. Through this service, people are getting better treatment with a very low cost.

The telecommunication industry in Bangladesh is undergoing rapid development, which has remarkably improved the communication connectivity all over the country. The productivity and usability of tele-medicine data depends on the availability of high bandwidth.

During the last few years Information and communication infrastructure of Bangladesh have experienced a huge boom in development. Bangladesh government has given immense

importance to ICT for development for economic growth and poverty reduction. In April 2007 Bangladesh got connected to the submarine cable network as a member of the SEA-ME- WE-4 Consortium (Nessa et al, 2008). Several private and public telecommunication operators have established their network all over the country. As they are expanding their operation to the most rural areas, they are also dwelling to improve the network performance and inclined to introduce the latest technologies to the people. Internet facility is almost available in every district of Bangladesh. The total Internet density is 4.47% in Bangladesh.

Table 2: Internet density in Bangladesh (BTRC, 2010)

Subscriber	Up to Dec.2008 (Subs. In million)	Up to Dec.2008 Internet density	Up to Feb.2010 (Subs. In million)	Up to Feb.2010 Internet density
Mobile	46.13	3.09%	62.05	4.25%
PSTN	0.54	0.04%	0.54	0.05%
ISP	1.23	0.08%	2.42	0.17%
T*otal*	47.80	3.21%	65.01	4.47%

Table 2 shows that the Internet density in our country is highly dependent on the mobile communication sector. This implies that with more mobile penetration, more Internet access will be created. As mobile health is extremely dependent on telecommunication infrastructure, and Bangladesh is growing in the telecommunication sector very fast, there is much scope of improving overall health sector of rural area, based on mobile phone. Mobile phones can make the remote medical monitoring, consulting, and health care more flexible and convenient. It can increase data accuracy, reduce errors, and result in overall improvement of patient care. Also through the mobile Internet, tele-medicine services can be offered to provide better and cost effective health services.

4. Methodology

The Most Significant Change or MSC technique was invented during a program where a complex, participatory, rural development program in Bangladesh was being evaluated. The MSC technique is used by many international development organizations as it was used by Harris and Tarawe in E-Bario stories highlighting the changes occurred in the said society for using information technology (Harris & Tarawe, 2009). It represents a different method compared to the conventional monitoring system where quantitative indicators are used (Dart & Davies, 2003). Although quantitative indicators are used widely in this sector, MSC technique is more appropriate as it involves regular collection and participatory interpretation of "stories" about change. MSC has also been referred to as the "Evolutionary Approach to Organisational Learning", the "Story Approach" by Dart (1999) and "Monitoring without indicators" by Guijt, Arevalo and Salsdores (1998). Dart and Davies (2003) prescribed seven key steps:(1) the selection of domains of change to be monitored, (2) the reporting period, (3) the participants, (4) phrasing the question, (5) the structure of participation, (6) feedback, and (7) verification.

First, the people using/managing the MSC process identify the domains of change they want to evaluate. The stakeholders identify broad domains, like "changes in people lives". The broad domains are not usually precisely defined as it would have been in case of performance indicators. Instead, the domains are left loose deliberately. The stories are collected with the help

of a simple question like, "During the last month, in your opinion, what was the most significant change that took place in the program?" It is then up to the respondents to give out stories that they think is most appropriate to the domain category. In addition, respondents are encouraged to report *why* they consider a particular change to be the most significant one. The stories are analyzed and filtered up through different levels within the program later on.

As Shaw, Brown and Bromiley (1998) emphasize that stories are central to human intelligence and memory. A good story defines relationships, cause and effect, a sequence of events, and a priority among items and the elements in the story remain to be a complex whole. Stories can share the impact of interventions where program staff can contribute to a deeply shared understanding of what is being achieved. From this common base the dialogue starts about what is desirable as expected and unexpected outcomes. Boje points out that in complex organizations, the reason for storytelling relies in working out of value differences at the interface of individual and collective memory (Dart & Davies, 2003).

In this paper, we report the attitudes and experiences such as how the villagers have been benefited through mobile health help line services, socio-economic barriers to adopt new technology based services despite illiteracy and so on, of four (4) beneficiaries and one (1) doctor who obtained health help line service via their mobile phone from the three villages. Five stories have been presented to represent the scenario of change in Chittagong Hill Tracts using mobile phones. The participants shared stories from their lives.

The profiles of the participants are summarized in table 3.

Table 3: Profile of interviewees

Name	Age	Occupation
Aungshain	45	Farmer
Mongsingprue	30	Tea-seller
Amity Chakma	22	Student
Mei Ho	28	Health-worker
Dr. Rashed Khan	35	Doctor

The interviewees were asked questions about health help line and the structured questions, eventually generated the stories they experienced in real life. In the interviews they shared their problems and feelings and experiences related to the Grameen Phone Health Help line. How their life has been affected and what they experienced by taking the service was the main theme of the interview. The interview was audio recorded and later on, transcripts were written. The stories were later on written from the transcripts. To maintain the right of privacy of the respondents, they were given a brief on the research purpose and asked whether they want to participate in the study as well use their names and other information in the paper.

The background of Chittagong hill tracts (CHT) where the participants belong at and Grameen Phone Health Help line ICT projects providing service at that area are discussed as follows:

4.1 CHT

CHT or Chittagong Hill Tracts is comprised of Rangamati, Khagrachari and Bandarban districts. CHT is located in the south-east of Bangladesh, near the Myanmar and Indian border. Approximately 1.3 million people, only 1 percent of total population, inhabit in CHT. But CHT makes up 10% of the total land area of the country. 90% of CHT population lives in the rural areas. In CHT there are at least 11 different endemic ethnic groups with their unique landscape and people. Bengalis have also settled in the CHT districts over the last 30 years from other parts of Bangladesh. Currently around 50% of the CHT population is Bengali. In past decades, the CHT districts have been disadvantaged by civil unrest. After 25 years, these conflicts officially ended with the signing of the Peace Accord in 1997. Recognizing the rights of indigenous communities to land and other sovereign issues is one of the goals of the Peace Accord but still people in the CHT have not achieved their full rights to these issues (Unicef, n.d.). Health condition in CHT is not satisfactory because of low level of awareness, lack of knowledge about the adequate facilities and difficulty getting access to available health care facilities. Most of the people get traditional and indigenous health treatment from quacks and village doctors. The survey shows that around 96% people avail allopathic treatment, 37% indigenous or traditional treatment, 20% village quacks, and 5% homeopath. The study conducted by CARE, Bangladesh found the similar statistics that about 86% people go to allopathic, 38% indigenous doctors/quacks and 23% people are faith-healers.

Although survey indicates many public sector health facilities, but people rarely benefited from them because of bad communication, lack of medical services and medicines. There are wide variation in health status among different tribes and people living in the semi-urban and rural areas and in remote areas. Tribes like Bengalis, Chakma, Marma, and Tripura have better access to health facilities while other tribes especially the Chak, Khumi, Lushei, and Rakhain are deprived of such health facilities. The health condition of the tribes living in remote area is the worst. Because of unsafe water and mosquitoes the occurrence of diarrhea, discentry, malaria, dengue fever, measles, etc. is very frequent in these areas.

Most of the people of the remote areas fail to get access to the health facilities located at Thana or district that are far from the communities. The survey shows presence of modern medical facilities as well as indigenous system and also indicates the major constraints towards getting access to health services like inability to afford cost of treatment (68%), problems of transportation and communication (68 per cent), scarcity of physicians (57%), and scarcity of health centers (35%). It was also studied that people are conscious of their health conditions while only 4% ignorance was found (Asian Development Bank, 2009).

Mobile networks are already available in most of the CHT areas. For better health care for poor people remote medical monitoring can be offered with very low cost through mobile health services.

4.2 Grameen phone 786 project

The GrameenPhone Ltd., a leading private cell phone operator in the country has been actively working to make mobile communication and technology solutions available to the wider community. GrameenPhone has launched a Health information and service titled ‘Health Line’. The GrameenPhone and Telemedicine Reference Center Limited have jointly introduced the Health Line. The Health Line service is a 24-hour Medical Call Center manned by licensed physicians and accessible to all GrameenPhone subscribers. It can be reached by dialing 789 from any GP mobile phone. This service is an interactive teleconference between a GP caller seeking health-related advice or consultation and a licensed physician who would be available on

a 24-hour a day and 7-day a week basis, to receive such calls. Moreover, a registered caller for the service would get consultation and treatment advice over telephone from a licensed physician for both emergency and non-emergency situations. Registration is not mandatory for other services.

Some of the Health Line services given are:

- Doctor and medical facility information
- Drug or pharmacy information
- Laboratory test report information (interpretation)
- Medical advice from doctor
- Medical Emergency

In addition to the above, a subscriber would be able to request his or her pathology/radiology test reports, from designated Diagnostic Centers, to be sent via SMS to his or her phone. The SMS would be followed next day by the delivery of the report at the consumer's mailing address. An SMS report would be charged Tk.10 only. A regular SMS sent will charge Tk. 2.30.

5. Findings

The scenario of mobile based health service can be best described with the stories from real life as these persons are somehow influenced by the service or had beneficial service from the health line. In some cases there are obstacles to avail the service. In this section, the finding of our research is presented in a story like manner as follows:

5.1 Stories about Grameen Health Line

Story-1

Name: Aungshaing
Age: 45
Occupation: Farmer

My village is in the remote area of Bandarban. Doctors are not available readily and we have to travel quite a distance to consult a doctor. A few days ago, my only child, suffered from high fever and we were all tensed about what to do. To consult a doctor, we had to go to the town, and it would have taken a lot of time. Then we thought of calling the health helpline to get some immediate consultation. The doctor from Grameen Phone asked many questions about the symptoms and prescribed some medicines. He also persisted if the fever stays longer than 5 days, we must take our child to be diagnosed by a doctor. After following his instructions for a day or two, we could see improvement in his health. My wife and I were happy to see our son get cured. I really appreciate the service as it provides valuable medical consultation within our reach.

Story-2

Name: Mongsingprue
Age: 30
Occupation: Tea-seller

Our village in Bandarban has only one doctor, but he is normally unavailable. It is really hard and costly to get treatment from the doctor. So, we normally do not look for doctors or seek

professional treatment. We just sit back at home and wait for the disease to be healed naturally. But last time, when my father got upset stomach, we were not very anxious about it. We thought he would be fine in a few days. But it turned out to be diarrhea and it got severe with days. My father is an old man; he could not fight back the disease and grew weaker with time. We got worried. Then my son told me, there is a health service in the phone. I grew curious and asked what it was. Then I learned that there are doctors in the phone, I mean, you could call the doctors for consultation. I thought something must be done. So I called the helpline, and asked the doctor what to do. The doctor advised me to give my father oral saline to drink immediately. Then there was another problem. The pharmacy was too far away, it would take 7-8 hours to reach the pharmacy. I told my problem to the doctor, and he gave me instructions to make saline at home. He also advised what type of foods should be eaten and a lot of liquid drinks, especially water should be drunk in this type of situation. The simple knowledge of making oral saline saved my father's life. It would have been devastating if anything happened to my father for the cause that we didn't know how to make oral saline.

Story-3

Name: Amity Chakma
Age: 22
Occupation: Student

I don't live with my parents in village as I am seeking higher education in a university; I live in Dhaka most of the times. Last time during the holidays, when I went back at home to visit my parents in Khagrachori, one of my neighbors came to me for help. They lived just next door to us. The guy was middle aged with a wife and two children. The wife came to our house one afternoon, seeking my help. Her husband had high fever and he was shivering with fever. She was afraid that something bad might happen to him, so she wanted to call a doctor. As the hospital is vacant of doctors normally, she took her mobile phone out of urgency. But when she called, she couldn't understand the language and could not make the person on the other side of the phone understand what she was saying. She was typical tribal villager who grew up in her own village speaking her tribal language. She could not speak Bangla and so she could not communicate. She burst into our house crying for help. She said, "I know you live in the town where Bangali stay. So you must know how to speak their tongue. Please help me to understand them, call the helpline for me and ask them what is happening to him." Of course I accepted her request as I knew Bangla. I called the helpline and then they gave some instructions on how to treat the patient and also suggested to do a blood test as they strongly believed the case to be malaria. I just realized, though helpline is a very useful service but there stays a language barrier. I was wondering what she would have done in case I wasn't around. It might be hard to provide tribal language options in the helpline, but it would be really useful for the people.

Story-4

Name: Dr. Rashed Khan
Age: 35
Occupation: Doctor

Grameen Phone Health Helpline has been very helpful for general people. I have been working in the Health Helpline service for a year. So far I have been giving people medical help and have received cordial attention and gratitude. It's amazing that I am living in the capital and people from distant areas are getting my advice using mobile phones. The most frequent callers are rural people from remote areas, where doctors are not easily available and health centers in Thanas are

quite far away. Next group is the lower income groups living in urban areas who have difficulty to bear doctor's fees. Sometimes students also call. But middle income group don't usually call unless there's a big emergency or a crisis situation, when they are totally confused on what action to take. It is rare for the big earners to call. I think it helps for the underprivileged to have a scope to seek for medical advices. I know from personal experience that unavailability of doctors for cost, transportation etc has seriously affected the people living in the lower level of social hierarchy. I am happy to lend a helpful hand for them. But it would be better for them if medicines can be availed for low cost for them. Sometimes it is hard for them to buy the prescribed medicines. As technology is thriving in Bangladesh, I hope that soon there would be better network stability and my personal opinion is to establishing telemedicine centers using internet would be another good service for the people.

Story-5

Name: Mei Ho
Age: 28
Occupation: Health-worker

Rangamati is more developed than the other districts of Chittagong Hill Tracts. I am a health-worker, but I wasn't before a year or so. I used to do farming with my father. Last year, I got to know about some training courses about general health. I attended the course for six months. As I have completed my education up to Higher Secondary level, I wanted to do something better with my education. I completed my course for being a health worker. There is a scarcity of doctors in our villages. So I had a lot of patients coming with different problems. It was not possible for me to deal with some problems as I am not a trained doctor. I needed to consult a doctor for prescribing medicines. I didn't want to kill people by applying wrong medication like the so-called village doctors. Then I found a way to deal with my problem using Grameen Phone Health Helpline. There are doctors available for 24 hours and I could call them to get medical advice and then give the same advice to the people seeking advice. Now, I have a very good reputation and people at my place call me the "mobile doctor". It is nice to help people and earn a respectful living at the same time. The health helpline has helped me to reach a better position in my life.

5.2 Analyzing the stories through the lens of a theoretical framework

The Communications for studies framework has been widely used to study ICT4D value chain. It provides some variant on ICT4D value chain and that makes the model "Communications-for-Development" (adapted from Bertrand et al 2006) and this framework is used to describe the impact of any intervention made to create a change. The framework is outlined in figure 1.

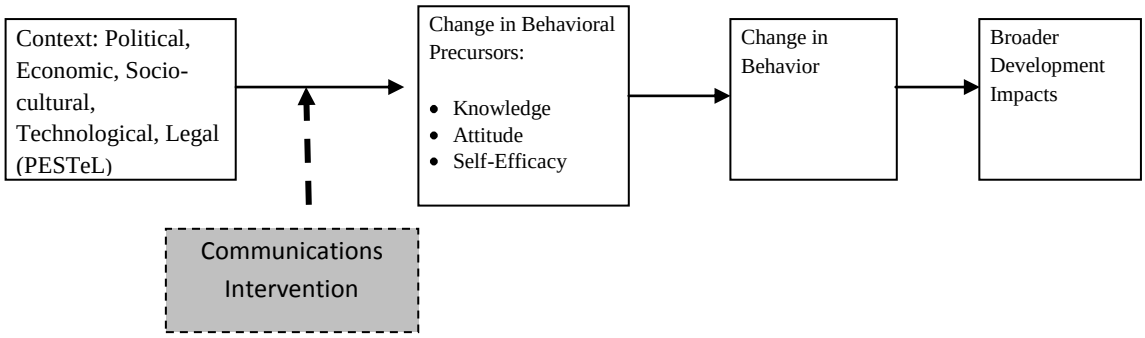

Figure 1: Communications for Development

The stories collected to analyze the mobile health intervention have been analyzed using figure 1 "Communications-for-Development" model and we derived outcome as in figure 2.

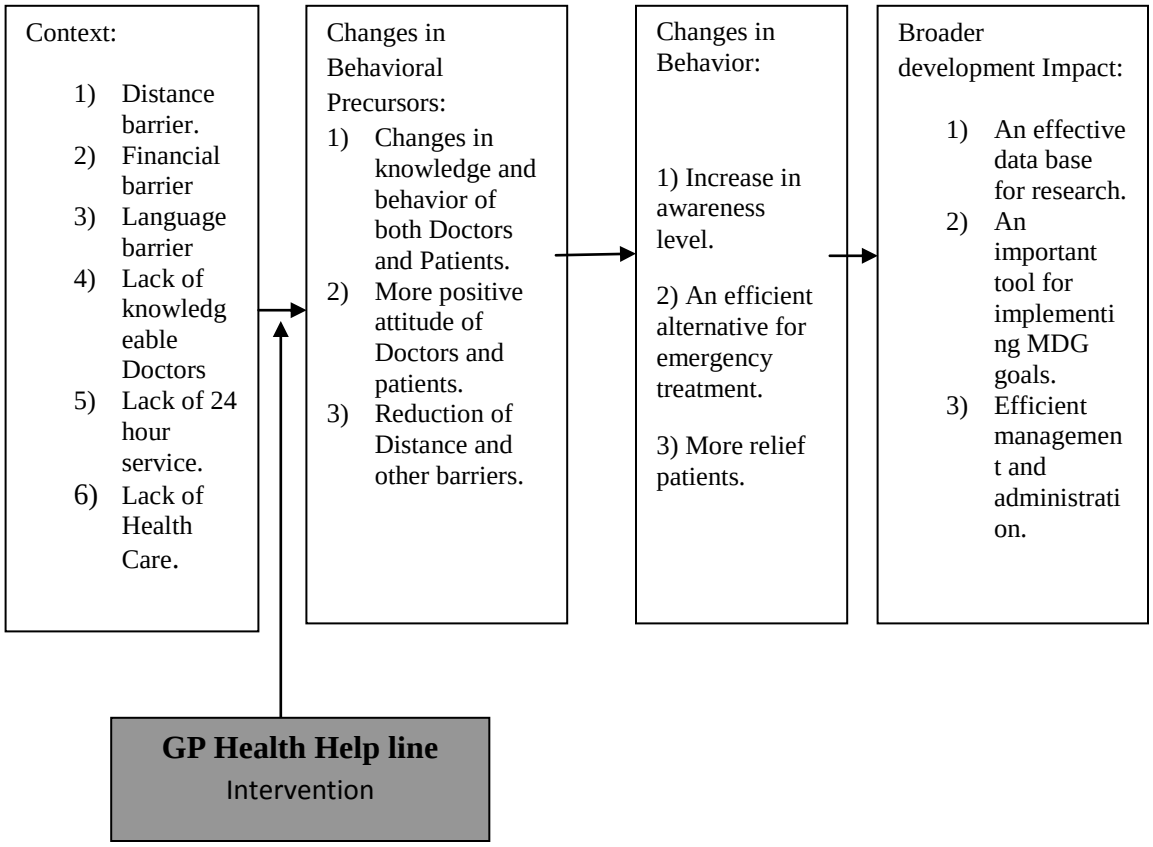

Figure 2: Implication of Communication for Development model in this research

The stories can be summarized and portrayed using the communication for development model as in table 5.

Table 5: Stories compared with indicators from communication for development model

Story	Context	Changes in Behavioral Precursors	Changes In Behavior	Broader development Impact
Story - 1	Distance barrier is present as well as lack of proper medical facility.	As the father of the child said, "After following his instructions for a day or two, we could see improvement in his health."	Used the helpline as an effective alternative way of treatment.	*An effective data base for research.*
Story-2	Unavailability of doctors and financial barriers are present.	Learning how to make oral saline by making a call to the helpline and gaining information as the interviewee said, "The simple knowledge of making oral saline saved my father's life."	A feeling of gratitude that his father was saved.	*An important tool for implementing MDG goals.*

Story-3	Language barrier is present as tribal people in the hilly areas speak their own language rather than Bangla. “But when she called, she couldn’t understand the language and could not make the person on the other side of the phone understand what she was saying,” she said.	An emergency situation handled through an available interpreter; in this case, the interviewee is herself an interpreter.	Emergency consultancy was availed.	*Efficient management and administration*
Story-4	Financial and distance barrier.	Financial and distance barrier has been dissolved using the helpline.	Patients are relieved to get some professional advice.	
Story-5	Lack of knowledgeable Doctors, lack of health care is present in the said village.	Change in behavior towards the health worker. As the healthworker said himself, “I have a very good reputation and people at my place call me the *mobile doctor*”	An efficient alternative for effective treatment.	

6. Summary, limitations and research directions

Bangladesh suffers from many laggings in the health sector including lack of medical facilities like equipment, hospitals, proper management, ample number of doctors and nurses. As a big portion of the population lives under the poverty line, it is hard for them to avail costly treatment. People from remote areas suffer from distance barrier and in the case of CHT, language barrier. The case study of GP HealthLine has introduced some hopeful scenario where callers have sought medical advice and they have been given so. Another interesting aspect is using the helpline to gather information by a health worker. It is therefore, evident that callers are getting benefits out of the service to some extent disregarding the usual barriers. Further studies could help to enlighten the whole service scenario with more information. A major limitation of this study is the small sample and its unrepresentative nature. All respondents were from hilly areas of Chittagong, from tribal groups and a doctor serving in the GP HealthLine in Dhaka, Bangladesh. It would be important to expand the research to incorporate representatives from all sectors of the Bangladeshi society who are likely to use mobile phones, and including users from other parts of Bangladesh. In rural Bangladesh, where 80% of the total population lives, the majority lives and work under high risk of infectious diseases, such as diarrhea, typhoid and etc. Another limitation is the lack of relevant data, as the Health Helpline service is not very old and not much research has been done in this field. This field of mobile based health service in Bangladesh is a recent topic, so there are many areas within this field for further research. It would be useful to expand the research to include larger sample size and within wider areas to incorporate a better view of the sector. Government policies and programs related to promote ICT Bangladesh are other research areas that would contribute to knowledge in this critical area. With the Government of Bangladesh working on a new ICT policy, this would be a good time to introduce the pros and cons of ICT based health service. The insights reported in this paper could provide useful input from a user perspective to do further quantitative research in the domain using the indicators reported in this paper.

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Epidemic and Communicable Disease Surveillance Data Reporting and Medical Cases Communication System

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Abstract: In the current system of epidemic and communicable disease cases reporting, it is observed that data reporting and analysis: takes a long time, is error prone and is vulnerable to data loss. Some experiences have shown that with the help of Short Messaging Services (SMS), text can be exchanged between mobile subscribers or other third party applications. Thus, SMS can be applicable for formal data collection, remote patient monitoring and telemedicine services. In this work, the requirements of the epidemic and communicable disease cases reporting and communication system of the Ministry of Health of the Federal Government of Ethiopia is identified. Systems analysis and design was conducted to come up with a viable SMS-based medical data collection and communication system using the existing mobile network. Our proposed system can overcome the current limitations and can permit instant access to reported medical cases by concerned health professionals and decision makers.

Keyword: mobile medical record reporting, mobile epidemic disease surveillance, SMS for medical case communication.

1. Introduction

In the many of the current practices, health extension workers collect data using paper or pre-designed forms and report the same to a near-by health center or Health post. This has usually created delay to respond to critical issues on time. The collected data from the field can also be lost or damaged in the way of the process. Moreover, since the data collection is paper-based, it becomes difficult to analyze the data or to retrieve required information from the collection. One of the emerging applications of mobile phones is collection and delivery of information from remote sites.

Currently there are efforts to use SMS-based applications for data collection. What makes the services such as SMS based applications more interesting is that: mobile networks are mostly well established systems and even the most remote locations are having access to mobile phone services. Thus, it can be used by field workers and health assistants from sites where there is limited infrastructure such as road and internet access. These systems are widely used in health care programs in different countries. For instance, mobile phone based data monitoring and

disease management applications were developed in Latin America and Africa [1, 5]. Similarly, an SMS-based system called RapidSMS was used by UNICEF in different countries to supply the high-protein food Plumpy'nut to under-nourished children [4, 6].

The main objective of this work is to design and implement a mobile e-health system for epidemic and communicable disease surveillance cases reporting and communication system using SMS based service in a mobile network. The proposed system also supports the reporting of health cases and the request for medical professionals' assistance at remote locations. As a result, medical data collection can be done easily, within seconds and with minimum data loss directly from the site of the incidence to a central location where data interpretation, analysis or decisions can be made. The developed system is based on the requirement analysis for early detection and timely response of the epidemic and communicable diseases surveillance of the Federal Ministry of Health (FMOH), Ethiopia.

The remaining part of the paper is arranged as follows. Section 2 presents the current system of medical cases reporting and communication under the Federal Ministry of Health. In Section 3 review of related work is presented. Section 4 presents analysis of the requirements of the current system. Section 5 presents the design of the proposed system. Section 6 described the implementation of the system. Conclusions are given in Section 7.

2. The Current System

The health care system in Ethiopia is organized based on the country's administrative structure under the Federal Ministry of Health, the Regional health bureaus (RHB), and the Woreda Health Offices (WHO). The FMoH and RHB functions more on policy related issues. The Woreda health office on the other hand is responsible to manage and coordinate the operations of the primary health care service [10, 2]. In each primary health post, health workers are assigned to give service to the community [3, 11].

Health Extension Workers (HEW) are responsible to conduct house to house visit, educate families, monitor health conditions of families, and report cases such as disease outbreaks which is seen in the village. In this case, data collection is the major task which is done regularly so as to track the health status of the community. Currently data collection is done using paper-based forms. The collected data is then reported to the hierarchal higher level offices of the Woreda health office, the regional health bureau and the FMoH depending on the case.

Analysis on the collected data can then be done either manually or with the help of a computer. Due to the bulk of data, manual data analysis may be error prone and a time consuming task. To minimize this problem, application software like MS-Excel is used. However, this approach also requires entering the collected hardcopy data into the Excel tables and data entry errors are not escapable. Furthermore, since data collection is paper based, data reporting and analysis takes much time. As a result, health programs with sensitive cases such as disease surveillance and reporting face big challenges.

The disease surveillance and reporting program, which is organized for early detection and timely response of epidemic and communicable diseases requires a more efficient data collection and analysis approach. Currently in this program, about nineteen communicable diseases were identified and are under close surveillance. These diseases are kept in two categories. The first category contains communicable diseases that need to be reported immediately when their symptom is seen. In this case, health workers who noticed the symptoms should report to the nearest health facility or to the surveillance focal person. The report should then be delivered at federal level within 24 hours. However, mostly available means of reporting does not permit this requirement to be fulfilled. The other category contains list of diseases which are under routine surveillance. This category includes all diseases which are in the first category and also other

communicable diseases. In this category, the existence of these diseases will be surveyed and reported weekly. In this case, paper based reports may take days before they reach the concerned surveillance officer. And in worst case, disease cases may be left unreported at all. Another problem in the current system is that even though the report reaches on time, analysis may take time since it requires data entry of all forms received.

After observing the problems of reporting in the current system and considering the available technologies, in this work, we propose a mobile e-health system for reporting and communication of medical cases in general and epidemic and communicable diseases surveillance data in particular.

3. Related Work

In public health monitoring programs, health record collection and reporting is one of the main tasks. Health centers, hospitals, and other parties in the health sector need accurate data for making better decision and for designing policies and programs for better health services. In different countries such as South Africa, Uganda, Kenya, SMS based data collection applications are tested and implemented [13]. In these cases SMS based messaging service are used to collect relevant health data and to send it directly to a database system.

3.1. Mobile Messaging Applications in Health Care

Currently mobile technology is used for better health service provision. A range of mobile based applications are being developed and used. These applications are categorized based on their purpose. These include mobile phone based applications for health education and awareness, applications for remote data collection and monitoring, applications for communication and training, applications for remote diagnostic and treatment support and applications for disease and epidemic outbreak tracking. The applications were used for gathering data from remote areas. Such applications have been deployed in many developing countries mainly as a pilot projects [13]. Some of these applications are discussed below.

3.1.1 Medical In-Field Diagnostic Assistant (MIDA). MIDA aims to help isolated rural health workers with a free, interactive diagnostic support tool to enhance their work and also to compile health information to assist government and NGO workers. MIDA uses mobile technology to minimize system running cost and to realize mobility. With the help of this system, rural health workers can get assistance from the server by sending free text message with their mobile phone. Reported cases can also be accessed by health professionals in the health center through web interface [12].

3.1.2 Click Diagnostic. Click diagnostic is a system developed to transform healthcare delivery through mobile telemedicine. It is piloted and deployed in developing countries such as Botswana, Malawi, Egypt, Ghana, and Bangladesh. University of Pennsylvania's Global Health Program and MIT's Innovations in International Health were involved in this project. Click Diagnostic system enables health-workers to provide advanced medical consultation and to gather health data by connecting to global health servers via mobile phones. It is designed to provide different services such as remote consultations and diagnosis, early diseases detection and warning and public health data-gathering [8].

3.1.3 Cell-Preven. Cell-Preven is a system that combines the phone and internet to create a real-time surveillance system of adverse events. It is tested in Peru as a pilot project. The overall goal of this application was to develop an interactive-computer system using cell phones for real-time data collection and transmission of adverse events. With the help of this application, data can be collected by interviewers from field and the collected data can be sent to an online

database where it could be accessed immediately. In addition, selected symptoms can be reported to key personnel via e-mail and SMS messages to act on it on time.

This pilot project has demonstrated that it is feasible to develop a public-health surveillance system based on cell phones to collect data in real-time in Peru. Cell-preven enabled on time delivery and analysis of health related data [14].

3.1.4 The Dokoza System. The Dokoza System is an SMS based mobile system designed to fast-track and improved critical services to patients. Initially it was developed for HIV/AIDS and TB patients but extended to include other diseases patients. The project is implemented in South Africa to mainly solve the problem of data-sharing in health sector. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication. The cell phone makes use of an existing mobile technology and normal SMS text message and does not require special additional software for interacting [13].

3.1.5 Mobile Phone for Tele-dermatology. Tele-dermatology is a subset of telemedicine that incorporates telecommunications technology to deliver dermatology service at a distance. In dermatology, examination is primarily based on visual inspection. Because of this, visual information can be passed as digital image for tele-consultation and tele-diagnosis. For this application, images are transmitted electronically using the Multi-Media Messaging Service (MMS). Currently new generation cellular phones allow taking good quality images and transmitting them directly to other cellular phones via MMS services. Several experiments were conducted to test the applicability and quality of mobile-phone-captured images for tele-dermatology application. And the result of this pilot study showed that transmitting images via MMS for tele-dermatology is applicable under certain specified conditions [7].

3.2. Review of the Systems

All the above reviewed systems deal with mobile based data collection. However, most of the systems do not use forms for data entry. Rather free text messaging with the built in SMS interface of mobile phones are used. As a result of this, data entry could be error prone and guiding information or manual is required to help the data collector on how to collect and report the data.

The way the reported data is managed by these systems at the server side differ. Some of the systems do not treat the collected data directly in a full-fledged database system that can also be used to make it instantly accessible for designated or responsible medical professionals and also to analyze the collected data and generate reports in a required format.

As requirements for different applications differ, none of the systems reviewed can be used for the case of the application that we considered. It is therefore necessary to design and implement a system that fits to the case identified.

4. Analysis of the Requirements

Health extension workers are responsible to conduct house to house visit, educate families, monitor health condition of families and report cases such as disease outbreaks which is seen in villages [3, 9, and 11]. The current practice is that data is collected using paper-based forms. The collected data can then be reported to health centers, district health offices, regional health bureau, etc. depending on the type of the case.

Taking into account the functioning and the drawbacks of the current health data collection system, the requirements, the actors and the operations of the system are identified and appropriate tools are used to analyze the system. Some of the main analysis results are presented

below. Table 4.1 identifies the actors in the system and Figure 4.1 is used to present the interaction of the actors with the different operations.

Use Case Model

Actors

An actor describes any entity that interacts with the system. In this case, the interaction of actors with the system is through either the mobile application which runs in the mobile device or through the web-based database interface which is accessible to authorized health professionals or to the system administrator.

Table 4.1 Actors of the system

Actor	Description
Health worker	is a personnel who is assigned at Kebele or village level health posts to provide health service to the community.
Health Professional	refers to professionals who give service at the Health center. This includes medical doctors and senior staffs in the health centers.
Surveillance Focal Person	is an individual who is in charge of monitoring the disease surveillance activity at a selected health center.
System Administrator	is a person who maintains and administers the system.

Use cases

To represent the functional requirement of the system, use case model is used. It 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 (Figure 4.1).

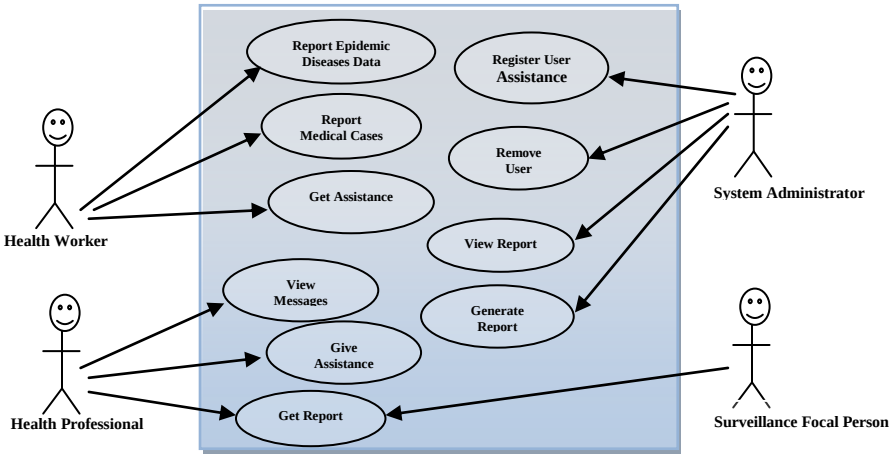

Figure 4.1 Use Case Diagrams

Table 4.2 presents a summary of the use cases. The flow events, the preconditions, and post conditions of the use cases are not included in this report.

Table 4.2: Description of the use cases

Use Case Name	Actor	Description
ReportMedicalCase	Health worker	The health worker reports Medical disease cases
Report Epidemic Diseases Data	Health worker	The health worker reports epidemic and communicable disease cases based on the given formats for early warning and prevention
getAssistance	Health worker	getAssistance enable the health worker to get assistance from the health professional on how to treat a particular case.
generateReport	System Administrator	Used to generate weekly report based on the collected record. This use case allows the System Administrator to generate reports.
registerUser	System Administrator	Enable the system administrator to add new user to the system.
removeUser	System Administrator	Enable the system administrator to remove an existing user.
Viewreport	System Administrator	The system administrator views the reports sent by the health workers
ViewreceivedMessage	Health Professional	It is used to access received case or epidemic reports
GiveAssistance	Health Professional	Enable the health profession to give assistance to the requested assistance by the health worker
getReport	Health Professional and Surveillance Focal Person	It allows the health professional (surveillance focal person) to get report.

5. System Design

5.1. System Architecture

The general architecture of the system is as described on Figure 5.1.

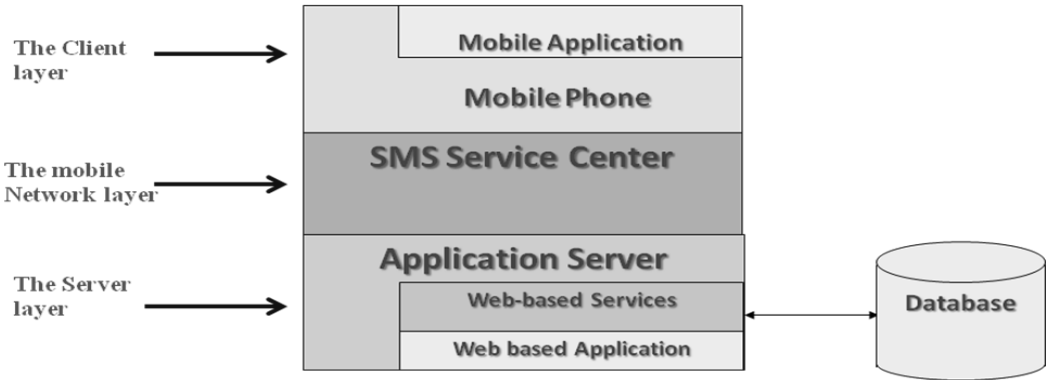

Figure 5.1: General Architecture of the System

At the upper layer of the architecture is the Mobile Phone Devices. This layer defines any mobile device with SMS functionality that can support the client-side application of the system.

Within the Mobile Phone Devices layer is the Mobile Application which is designed and developed as a package for our application and can be installed on the mobile phones. Using the mobile application the health workers will be able to first fill-in the forms provided with the application and send the data. The application extracts the filled data and sends it as SMS messages to the central server.

At the next layer, we have the SMS service center which is provided by the SMS service of the mobile network. When the SMS is sent from the client it passes through this layer. This layer stores the message and forwards it to the recipient phone or GSM modem. If the receiver's phone or the GSM modem is not reached, out of service or switched off, the stored message waits until the receiving cell phone or GSM modem is switched on or moves into range of the network coverage. This process guarantees the submission of messages.

The next layer, the Application Server, accepts the SMS message from the SMS service center either through the use of the wireless GSM modem or through an appropriate GSM mobile device with a serial port cable to be connected to the application server. The web based application automatically receives the message and stores it to the pre-designed Database. The received message can then be made accessible through the web based application by anyone with access privilege.

5.2. Persistent Data Management

To store collected data for later analysis and reporting, persistent data management is required. We thus used a relational database system at the server side. In addition, for temporary data storage, the SQL light record management system of the mobile phone is used. The client-side record management system is an application programming interface that is used to store and manipulate data in small computing devices using a J2ME application. It can be used to store collected data in the mobile phone. This enables the data collector to collect and store data in the mobile phone when there is no network connectivity and then send it when network is available. In the client system, records including collected data about medical cases, epidemic diseases, assistance requests of health workers are stored are stored temporarily on the mobile phone.

The server side relational database includes the tables for storing reported case based diseases, reported epidemic diseases, patient related information, assistance request made by the field worker and its corresponding reply made by the health professional in the health center and a table to store system user's personal data.

6. The Implementation

The following tools and development environments were used to implement the system. Java wireless toolkit in the Android development environment is used to develop the client-side applications such as case and epidemic reporting forms, assistance request form and the local record store which is stored in the mobile phone. Mysql Database Management System; Mysql server is used to store collected data persistently in the server-side of the system. Mysql server is selected because it is a free and open source database management system and it is capable of working with server-side scripting language, php. Thus, php is used to develop the web interface back ended with Mysql DBMS to store and retrieve data. Apache Web Server is used to develop dynamic web applications together with the scripting language php.

The system implementation includes development of user side application which runs on the user's mobile phone. In this case, an HTC mobile phone with Android Operating System version 1.6 is used. An Android phone is selected because it is an open source operating system with very good functionalities and with its own convenient and rich development environment.

To implement and test the designed system, the actual SMS service of the Ethiopian Telecommunication Corporation Mobile Telephone Network (ETC-MTN) was used. With the developed application, using the imitated health data of the actual cases sending an SMS based message from the phone to the web server was tested. During this time, text message consisting of the medical cases to be reported was created in the phone and the message is sent to the web server successfully. Message sending from the server application to the client devices was also tested successfully.

When the user starts the application, a login form is displayed to authenticate him/her to the system. Then after the main menu with the four options: the Case Reporting Form, the Assistance Request Form, the Get Assistance Form and the Settings will be displayed. Some screen shots of the client side mobile application system are shown on Figures 6.1 to 6.4. Each of the options provides forms to be filled. The case reporting form is used to report case based reports. This form is used while reporting case-based reports and epidemic and communicable reports.

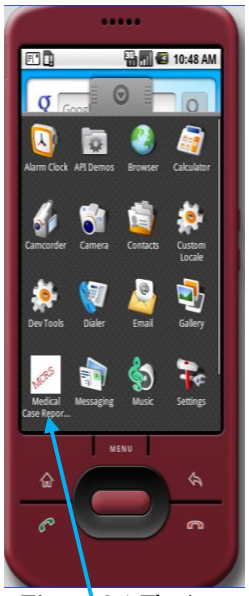

Figure 6.1 The icon of the application Installed on the phone

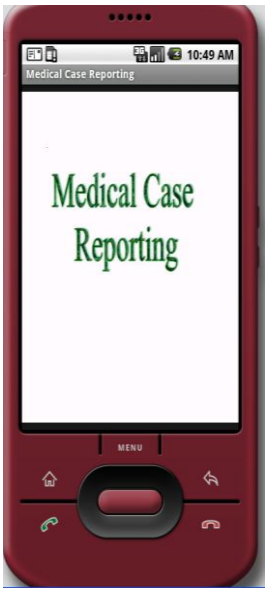

Figure 6.2 The first Screen of the Application

Figure 6.3 List of functionalities of the application on the mobile phone side

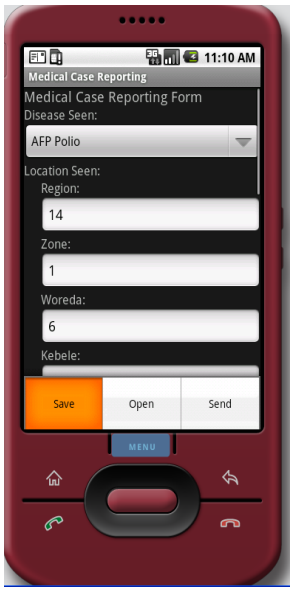

Figure 6.4 Case Reporting form with save and send options

Under the case reporting form option, list of features related to case reporting is displayed. This includes the actual case reporting form, the local store to keep list of sent messages and list of saved messages. The case reporting form includes fields to fill the information about disease type, location and time it is seen, reporting option, and address of the reporting facility. Information related to the patient is filled in a separate form. This form can be accessed through 'Add Patient Record' button. The other functionality that can be accessed from the mobile application is a form to request for assistance. Using this assistance request form, health workers can send request in the form of textual description. A screen form that supports such request is designed in the system.

At the server-side of the system, the web-based interface is developed to allow concerned actors to get access to the reported cases. With the help of this web-based interface, the system administrator, the health professionals and the surveillance focal persons can see the reported cases based on their access privileges. The screen shot of the server-side web-based interface to send messages to health workers is shown on Figure 6.5.

To generate report for the reported cases, there is a generate report functionality that can be accessed by the system administrator. The system Administrator can select a particular case and generate the report for it (See Figure 6.6). In addition, the system administrator can also view registered users and can register new users.

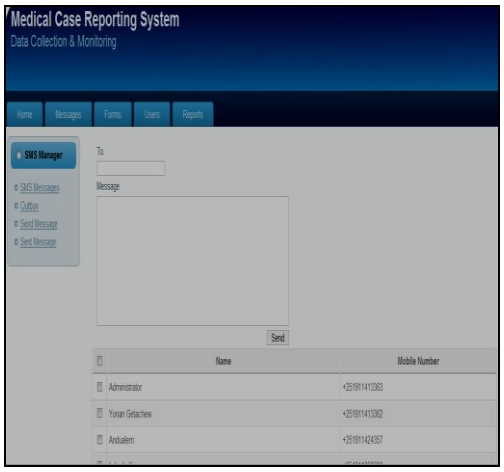

Figure 6.5 Interface for Message Sending from Server to client phones of health workers

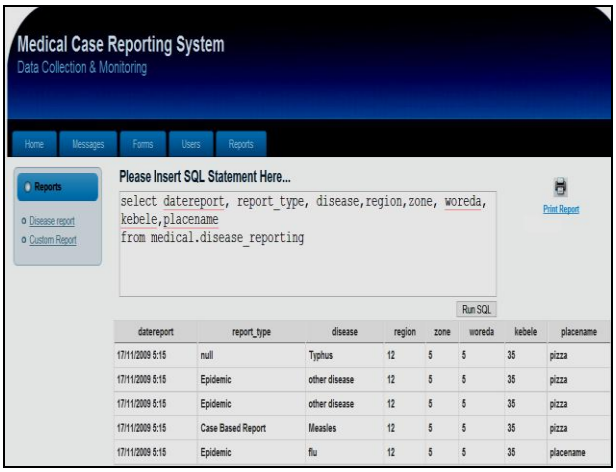

Figure 6.6 Custom Report Generation from the Collected Medical Cases

7. Conclusions

The current manual epidemic and communicable dieses surveillance data collection that uses paper forms has many drawbacks such as its inability to report cases on time and the possibility of errors that can be committed during the intermediate data entry. Mobile messaging services like SMS are used to report health record from remote sites instantly. This method has many advantages to conduct data collection from the areas where there is limited resources, since mobile networks are more widely available than the other infrastructures.

Considering the requirements identified, an SMS-based medical case reporting and communication system was designed and implemented to demonstrate the applicability of the SMS based mobile Information System for epidemic and communicable disease surveillance data reporting needs of the FMOH of Ethiopia. The system development includes developing applications on the mobile phone and the deqq 1sign of a web-based database which runs on the server side to permit relevant offices and health professionals' instant access to the collected records.

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Using SMS for HIV/AIDS education and to expand the use of HIV testing and counselling services at the AIDS Information Centre (AIC) Uganda

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Abstract: Mobile phone users are adopting text messaging (SMS) to completely new ends never envisaged before. The SMS now constitute a feasible tool that connects users, allowing for the exchange of vital information and expert opinions in near real-time. The SMS provides a trusted resource for asking time-sensitive questions, while providing an anonymous forum for gaining insights on potentially sensitive subjects. In this article, we present an innovative approach aimed at scaling up HIV/AIDS awareness via mobile phone SMS desired at encouraging participants to access HIV Counselling and Testing (HCT). Our study, which was deemed 'an enormous success story', reached over 7,000 people in the Lira district for HIV/AIDS education via SMS, the outcome of which saw a high acceptance rate of the SMS survey and increase in the number of people accessing HCT.
Key words: Mobile phone, Text Messages (SMS), HIV/AIDS, Counselling and Testing

1. Background

1.1 Current HIV/AIDS situation in Uganda

The current HIV prevalence in Uganda is estimated at 5.4% amongst adults [1]. According to the Uganda HIV and AIDS Sero-Behavioural Survey, the number of people living with HIV is higher in urban areas (10.1% prevalence) than rural areas (5.7%); it is also higher among women (7.5%) than men (5.0%). It is feared that HIV prevalence in Uganda may be rising again; at best it has reached a plateau where the number of new HIV infections matches the number of AIDS-related deaths. There are many theories as to why this may be happening, including the government's shift towards abstinence-based prevention programmes, and a general complacency or 'AIDS-fatigue'. It has been suggested that antiretroviral drugs have changed the perception of AIDS from a death sentence to a treatable, manageable disease; this may have reduced the fear surrounding HIV, and in turn have led to an increase in risky behaviour [2].

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It is important to increase awareness of HIV/AIDS. Only 28% of Ugandan women and 36% of men aged 15-49 years have comprehensive knowledge about HIV & AIDS according to the results of the Uganda Demographic and Health Survey of 2006 (DHS) [3]. In particular knowledge levels are lower in rural areas compared to urban areas. Furthermore, the uptake of HIV testing needs to be enhanced since knowledge of ones HIV status is key to reduce new HIV infections. Persons living with undiagnosed HIV infection contribute to sustaining the epidemic as they unknowingly transmit the infection to their sexual partners [4].

In addition, they are likely to miss opportunities for timely access to treatment and support, therefore suffering greater morbidity and mortality than those diagnosed and treated early [5, 6]. HIV testing rates remain low in Uganda, one-quarter of women and one-fifth of men aged 15-49 years have ever been tested for HIV and received their results. An additional 5% of women and 3% of men have ever been tested but never received their test results. Seventy-one percent of women and 77% of men have never been tested at all, implying that they are very unlikely to know their HIV status. In addition, 41 percent of currently married women have an unmet need for family planning services [3].

1.2 Introduction

To increase HIV awareness and to enhance HIV testing in Lira District, the Deutscher Entwicklungsdienst (DED) carried out a survey in collaboration with Text to Change (TTC), using SMS messages. Mobile phones are one of the fastest spreading technologies in the world, and they are now being used for more than just their traditional functions. Uganda has over 9 million mobile phone subscribers and throughout Africa as a whole it is estimated that more than a million phone users are being added every week. Phone company research in Uganda estimates that approximately 85% of the population has “access” to a mobile phone through relatives, friends, acquaintances and mobile phone kiosks or itinerant mobile service providers [7].

1.3 Deutscher Entwicklungsdienst (DED) and Text to Change (TTC)

The Deutscher Entwicklungsdienst (DED; German Development Service) is one of the leading European development services for personnel cooperation. It was founded in 1963: since then more than 15 000 development workers have committed themselves to improve the living conditions of people in Africa, Asia and Latin America. Their aims are to fight poverty, promote a self-determined, sustainable development and to preserve natural resources [8].

DED places development workers at the request of governmental and nongovernmental organizations in its partner countries and on the basis of framework agreements with the respective governments. Amongst other activities, DED supports local civil organizations and municipal structures by providing specialist advice, if required supplemented by financial support. One of the areas of work is health: support for rural health systems, promotion of reproductive health, HIV/AIDS intervention. The German Development Service (DED) has been working in Uganda since the beginning of the 70’s in order to contribute to sustainable development and to achieve improved living conditions for the people. Currently more than 30 development workers, 15 volunteers and another 30 national experts commit themselves in our programmes. With regards to HIV prevention DED Lira offers a moonlight HIV testing programme. People can come for a free HIV testing at night in all anonymity. The service starts at 6.00 p.m. and end at 11.00 p.m.

1.4 Text to Change

Text To Change (TTC) is a non profit organization, founded in 2006. It uses state of the art mobile phone technology to collect and disseminate health information. TTC works demand driven and sets up complete programs with local and international partners. Together with its partners, TTC aims to support change by increasing awareness and enabling citizens to make

informed choices. TTCs mission is to empower citizens by unleashing the potential of mobile telephony to provide and collect information, increase awareness and knowledge levels, enhance transparency and strengthen advocacy [9].

Text to Change is specialized in interactive and incentive based SMS programs addressing a wide range of health issues such as HIV/AIDS, malaria and reproductive health. TTC has been one of the pioneers in using mobile phones for health monitoring and advocacy in Africa reaching out to the general public at a large scale. Besides Uganda TTC is currently present in Kenya, Tanzania, Namibia and Madagascar and will be expanding to West Africa and South America in 2011.

1.5 Program objectives

The overall objective of this study was to improve HIV/AIDS knowledge levels and contribute to an increase in the number of people going for HCT services in Lira district with a view to decrease HIV transmission.

2. Methodology

2.1 Study population

The study population consisted of people living in the Lira and its surrounding communities who use a mobile phone on one of the 4 major networks in Uganda (MTN, UTL, ZAIN, and WARID). The program also targeted family and friends of the mobile phone users. Lira-town has an estimated 80,000 inhabitants according to Ugandan Population census 2002 and approximately 145,000 people live in Lira-district. To initialise the survey, we utilized radio and flyers to boost participation.

2.2 Mobile messages

In total, seven question messages were sent on HIV knowledge and three questions on family planning (Table 1). After receiving the response from the participants, the TTC platform automatically replied if the answer was correct or incorrect and additional information was provided. In this way participants were educated on the issues. In addition, demographic questions concerned gender, age and place of residence. Participants were asked about their HIV testing history. Finally, three general messages about the contents and set up of the survey were sent.

Table 1: SMS questions on HIV knowledge and family planning Lira survey

HIV knowledge	A woman can transmit HIV to her baby during pregnancy or breastfeeding. The HIV virus can be cleared from your body by taking Antiretroviral drugs (ARVs). HIV is NOT present in: 1). Semen; 2). Sweat; 3). Blood; 4). Breast milk You can easier get the HIV virus if you have an STI (Sexual Transmitted Infection) HIV weakens the immune system of an infected person by killing: 1). White blood cells; 2). Red blood cells; 3). Antibodies against HIV Women are infected more easily with the HIV virus than men. ARVs need to be taken as prescribed under medical supervision, for the rest of your life.
Family planning	Only women are responsible for family planning, not men. Is withdrawal or pulling out a safe method of family planning? Family planning methods can make a woman infertile.

2.3 Study procedure

The survey was conducted in February 2010 in Lira Uganda. The participants were informed about the survey through a one hour radio talk show broadcasted on two radio stations in which it was explained how people could subscribe to the survey. Participants could opt in by sending an SMS to a toll free short code. After the shows, radio spots were broadcast 5 times a day in local language (Luo) and English during two days to further encourage people to participate. In addition, 10.000 flyers were distributed in Lira town (with a description how to opt in) and some telephone numbers were collected face to face by community health workers.

People who subscribed to the survey were automatically added to the survey database and received text messages. The SMS questions were sent daily from the Text to Change SMS platform for 3 weeks and targeted an audience of approximately 8000 mobile phone users across all networks. Respondents were asked to send back there answers via SMS (free of charge). The responses of the survey participants were captured in the TTC system. All responders received automatic replies from the TTC platform with additional information regarding the question. Participants in the survey could win prizes such as airtime, mosquito nets, mobile phones, football jerseys, and radios. Participation in the survey was confidential. The questions were sent in English. Announcements were also sent out to encourage people to go for free HIV/AIDS testing offered by AIC via the program until February 12, 2010.

3. Related Studies

Numerous applications have explored the possibility of addressing health challenges using mobile phones and other mobile devices in Africa and other regions of the developing world. These applications, referred to as mobile health ("mHealth"), are critical in places where existing health infrastructure cannot meet demand. MHealth applications fall into five broad categories: remote data collection, remote monitoring, communication and training for healthcare workers, diagnostic treatment support, and education and awareness similar to our current study.

Cell phones have been recognized by scholars for their potential in eHealth. Kaplan describes its promise as tremendous, but not yet fully realized due to technical, financial and regulatory barriers [12]. Much of the researches are pilot or feasibility studies with anecdotal reports. These types of research are limited in providing rigorous and grounded evidence for effectiveness (Kaplan, 2006). That notwithstanding, there is a strong drive towards cell phone eHealth. The cell phone and the SMS particularly is an information and communication technology that is widespread and seemingly ubiquitous with high rates of consumer penetration.

In the sexual health context, texting services(SMS) were seen as effective in encouraging enquiries among youths about sexually transmitted infections and related issues to access relevant information (Levine, McCright, Dobkin, Woodruff, & Klausner) [13]. It was revealed that the nature of the platform attracted the audience's attention; in addition, the increase in awareness level of the health issue was the highest among individuals who signed up with the least expensive cell phone providers. This suggests that the accessibility and the convenience that a medium provides play a crucial role in determining the success of an intervention program.

3.1 Relevance of the Study

Through this survey, we sought to contribute to research in the following ways; first TTC addresses logistical gaps in implementing SMS projects identified by previous research. The investment costs are kept low since the survey was based on an existing mobile network, and short-messaging-service (SMS) is cost-effective. In addition, it is non-intrusive, which eliminates potential barriers caused by stereotypes toward HIV/AIDS. On the second level, TTC aims to achieve multiple objectives for public health, namely data collection, increase of awareness for HIV/AIDS, advocacy of behaviours pertaining to HIV/AIDS, and determine the efficacy of presenting incentives to participate.

4. Results

In total, 8,272 unique phone owners subscribed for participation in the survey, of which 1,222 did not respond to any SMS message. They were discarded from further analyses, leaving 7,050 participants. The majority of the responders were male (81%). The mean age of participants was 28 years with a range of 12 to 79 years. In total, 19% lived in Lira town, 50% in the Lira region outside the town and 31% lived outside the targeted region (Table 2).

Table 2: Characteristics of participants

	N	%
Gender		
- male	3685	81%
- female	871	19%
Mean age in years (range)	28 (12-79)	
Age category		
- under 18 years	200	5%
- 19-30 years	2944	67%
- 31-40 years	856	19%
- 41-50 years	313	7%
- over 51 years	91	2%
Place of residence		
- Lira Town	874	19%
- Lira District, outside town	2326	50%
- Elsewhere	1463	31%

4.1 Knowledge on HIV and family planning

Questions concerning HIV knowledge and family planning were answered by 53% of the participants (Table 3). The majority of responders answered correctly, on average 74%. Women were significantly more likely to provide the correct answer to the proposition that women have a higher chance than men to become infected with HIV and that a woman may transmit HIV to their baby during pregnancy or breastfeeding. Furthermore they responded

more often correctly to the question of the presence of HIV in body fluids, and they had a better knowledge about the risks of withdrawal as a family planning method.

Table 3: Percentage correct answers on items by gender

Knowledge Item	Correct answer	Response*	Male	Female	Total
A woman can transmit HIV to her baby during pregnancy or breastfeeding.	Yes	48%	84%	88%**	85%
The HIV virus can be cleared from your body by taking Antiretroviral drugs (ARVs).	No	47%	86%	85%	85%
HIV is NOT present in: 1). Semen; 2). Sweat; 3). Blood; 4). Breast milk	2). Sweat	45%	60%	66%**	61%
You can easier get the HIV virus if you have an STI (Sexual Transmitted Infection)	Yes	51%	91%	91%	91%
HIV weakens the immune system of an infected person by killing: 1). White blood cells; 2). Red blood cells; 3). Antibodies against HIV	1). White blood cells	54%	81%	80%	81%
Women are infected more easily with the HIV virus than men.	Yes	58%	65%	73%**	66%
ARVs need to be taken as prescribed under medical supervision, for the rest of your life.	Yes	59%	96%	95%	95%
Only women are responsible for family planning, not men.	Disagree	55%	88%	86%	88%
Is withdrawal or pulling out a safe method of family planning?	No	54%	81%	87%**	82%
Family planning methods can make a woman infertile.	No	56%	81%	79%	80%

* Proportion of unique responders that replied to the SMS question

** Statistically significant higher proportion of women than men answer correctly ($p<0.001$)

4.2 HIV testing history

In total 86% reported to be ever tested for HIV, of whom 44% was tested in the last year. Women were statistically significant more often ever tested for HIV than men (91% versus 86%). Of all participants tested, 98% obtained their test results. Of those who were never tested for HIV, 97% stated that they would consider going for testing.

4.3 HIV test uptake in AIC Lira

The AIDS Information Centre offered free HIV testing during the survey. Figure 1 shows the distribution of the number of HIV tests in the centre preceding and during the survey. A remarkable increase in test uptake was noticed after the announcements for free testing were sent out. In the second week of February 398 HIV tests were carried out, a double number compared to the 185 in the first week of February.

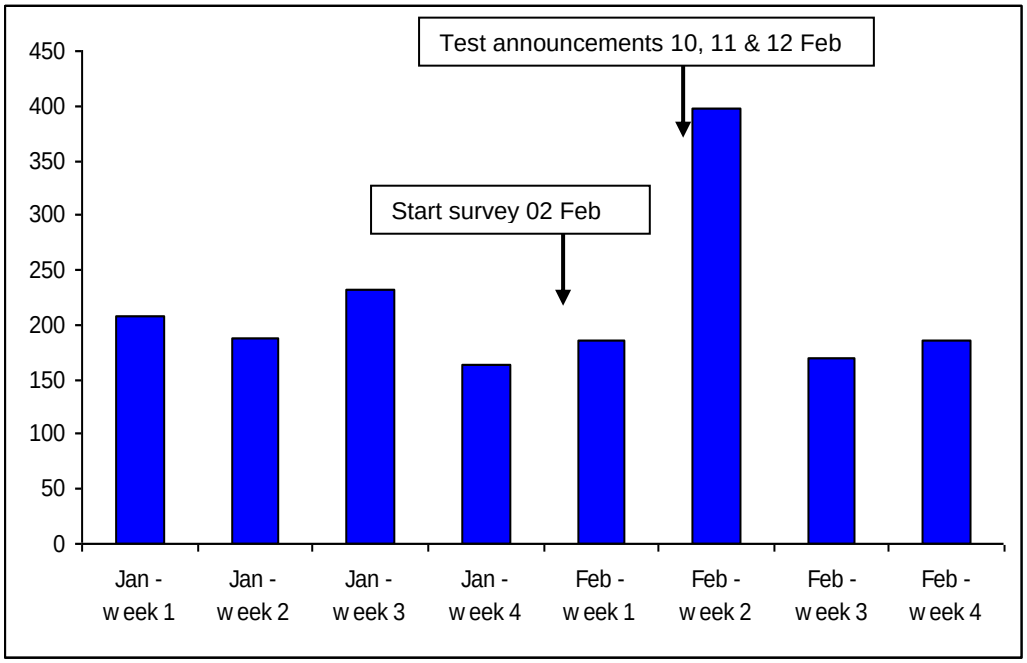

Figure 1: HIV test uptake in numbers in AIDS Information Centre in Lira

4.4 Acceptability of the SMS program

Of all responders, 80% first heard about the SMS survey by radio, 7% through flyers and 13% by family or other relatives. Men reported more often than women that they heard about the survey through the radio (82% versus 73%) while women were more likely than men to hear about the survey from relatives (19% versus 11%). Ninety six percent of participants stated that the survey helped them to gain knowledge on HIV, 4% said they did not gain any knowledge. See annex 2 for testimonials of the participants.

5. Conclusions

The DED-TTC survey reached over 7,000 people in the Lira district for health education by SMS. The acceptability of the SMS survey was high. Far more men than women participated in the survey; the median age of responders was 28 years. In general, participants had good knowledge of HIV and family planning issues. On average, 74% of all questions were answered correctly. Women had better knowledge than men on several issues. The majority of participants was ever tested for HIV, however only 44% of them was tested recently. HIV testing at the Lira AIDS information centre increased considerably after sending out the SMS reminder of the free service; test uptake doubled.

The level of knowledge in our survey is high compared data from the Domestic Household survey of 2006 where only 28% of women and 36% of men had comprehensive knowledge about HIV/AIDS [3]. This may be due to local prevention activities taking place in the Lira district although 96% of participants stated that the survey helped them to gain knowledge. In addition, the number of questions in our survey was limited compared to the DHS survey and this may have impacted the overall outcomes on knowledge. In contrast with the results of the DHS, women were better informed about family planning issues than men. The majority of people in our survey reported previous HIV testing. The test uptake is much higher than the test rates of the whole country shown in the DHS report [3]. However; the proportion that is tested recently (in the last year) is low. Knowledge of one's HIV status is important to reduce the transmission of HIV since persons living with undiagnosed HIV infection unknowingly transmit the infection to their sexual partners [4]. In addition, it is important to timely access treatment and care once diagnosed [4, 5]. Results of this survey

show that more needs to be done to get people tested regularly. One way of encouraging HIV testing is offering testing free of charge. During the survey, free testing was offered at the AIDS Information Centre in Lira. This way of testing reached many people; test uptake almost doubled after the SMS reminder. This is an important way to enhance (timely) HIV testing by reducing (financial) barriers.

Radio appeared to be a good medium to inform a large audience of people about the survey. Eighty percent of participants had first heard about the survey by radio. Consistent with much of Africa, radio ownership in Uganda is high: 78% nationwide, 84% in the Western and Northern regions.

Radio is the preferred media-access choice for most Ugandans for several reasons: language, affordability, broad coverage and diversity of programming. This project takes advantage of the medium of radio to lay the groundwork for the campaign, by producing and broadcasting radio messages and explaining the rules how to subscribe to the survey. If the survey would not have been announced on the radio, the number of people reached in Lira region would have been much lower. However, 31% of all respondents reported a place of residence outside Lira district. Although information on health will also benefit this population, this area was not initially targeted for this project. The radio shows reached mainly men. Women were more likely to subscribe to the survey when they were informed by family or other relatives. This demonstrates that radio needs to be complemented with other media to reach both men and women.

The SMS survey was highly valued by the participants; almost all stated that they gained knowledge. SMS constitutes a new and exciting approach to disseminate information that can be widely dispersed directly into people's hands whenever, wherever. Mobile phones are one of the fastest spreading technologies in the world, and they are now being used for more than just making calls. Like SMS, or text, messaging, users are adopting the devices – and the technology – to completely new ends never envisaged when mobile phones first began to be adopted widely in the late 1990s [10].

Text To Change has a strong history of behaviour change communication interventions (www.texttochange.com). The collaboration with DED and the Lira Municipal Council worked out very well in this project and the combination of an SMS reminder for HIV testing was very successful. Testimonials of participants (Annex 2) show that the SMS messages were highly valued and the information was shared with family and friends. Hence, this TTC-DED survey effectively reached even more than 7,000 people in Lira district.

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Mobiles for Development Research: Quality and Impact

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Abstract: The paper assesses what has been achieved in academic-orientated research directed at Mobiles for Development (M4D) to date, in terms of quality and impact, and assesses some of the challenges at the interface between research, practice and policy. The first section defines the scope of M4D research, and suggests that the bulk of studies have focussed on assessing readiness, uptake and immediate outputs associated with mobile phones, with only few studies providing evidence of outcomes and broader societal impact. The second section points towards variable quality of M4D research and highlights the need for greater conceptual and methodological rigor in the conduct of research. The third section emphasises the importance of effective dissemination of research for informing policy and practice, and the paper concludes by summarising research challenges, suggesting two emerging research trends encompassing bottom-up and productive models of innovation.

1. Introduction – the Scope of M4D Research

Mobile cellular technologies have enabled even the poorest countries to extend telecommunication network coverage to the mass of their populations including the rural poor.[i] This had led to rapid expansion of M4D – particularly in the low income countries (LICs) in recent years. Literature reviews of M4D applications in the field have identified mobile phones making important contributions in key areas (Gakuru et al, 2009; Donner, 2009; De Silva, 2008; Munyua, 2008). These include using mobile phone applications for information, communication and transactional processes in support of agricultural development, micro-financial service provision, micro-enterprise, and data gathering and dissemination for projects concerned with social development sectors covering health, education, the environment and humanitarian relief in response to disasters and emergencies.[ii] Mobile phones are also being used extensively for advocacy and campaigning on a wide range of development issues (Hellstrom, 2010; Kinclade & Verclas, 2008).

Thus, M4D is the primary technological response to the current phase for applying information and communication technology for international development (ICT4D) suggesting a phase shift from ICT4D1.0 to ICT4D2.0 bringing forth new technologies and new innovation models (Fig 1) (Heeks, 2008).

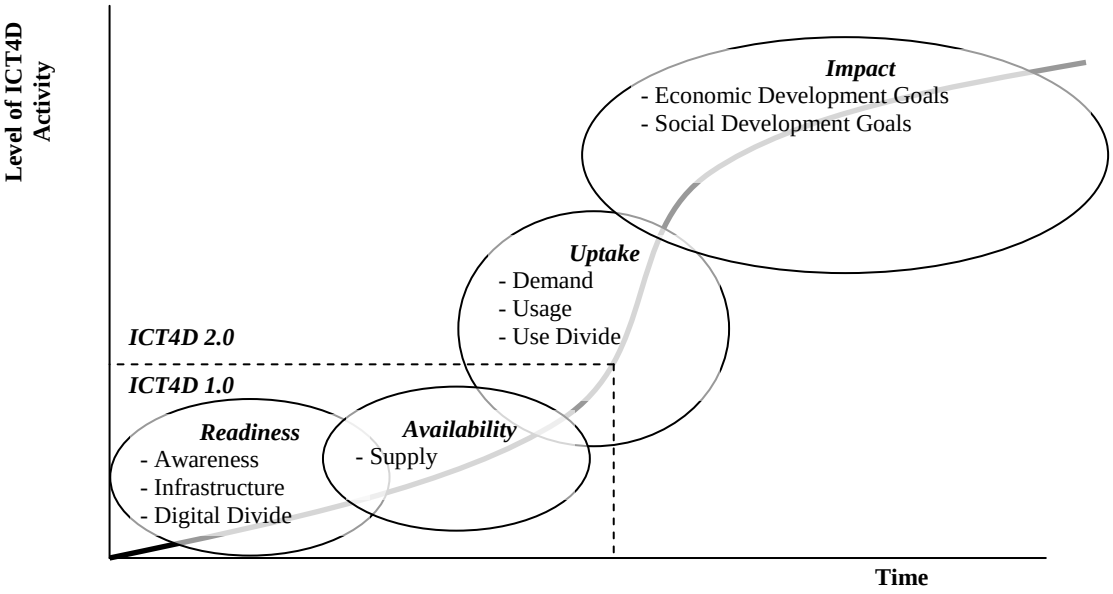


Figure 1: Changing Scope of M4D

Source: Heeks (2008)

Two broad models of innovation have been defined. In the first case, adoption of mobile phones is due to 'passive diffusion' driven by "a combination of a private firms' search for profits plus the poor's search for value" (Heeks, 2008:29). The most successful mobile phone applications – that have been scaled – have tended to be market-driven in this way. The most widely cited example is the M-PESA mobile payments service operated by Safaricom in Kenya, which since its inception in 2007 (as a donor-driven financial services development project)[iii] has achieved significant penetration into segments of the population previously excluded from any form of financial service provision, attracting a customer base of approximately 9 million users and 17,000 service delivery agents over a three year period (Safaricom, 2010).

Most M4D innovation, however, has not achieved scale – it is localised or at the pilot or proof of concept stage (Donner, 2009). This requires 'active innovation' – actively pursued by non-government organisations (NGOs) with donor support and in partnership with the private sector and/or local or national government. An example is 'Text to Change', an East African initiative that brings together technical, health project and funding partners to collect and disseminate health-related information concerning malaria, HIV/Aids and reproductive health. In this case, the use of SMS prompts and mobile-based incentivised quizzes have been effective to raise AIDS awareness, and facilitate testing, resulting in a 35 percent increase in the number of project participants that took HIV tests in the Arua District in North West Uganda.[iv]

M4D research focuses on both *passive diffusion* and *active innovation* and can be modelled as a value chain of activities that incorporates: a) readiness; b) availability and uptake; and c) impact (Fig.2). Readiness, availability (or access) and uptake & use (or adoption) are necessary precursors, but impact is of most interest in terms of the positive benefits that can arise for development. Impact can be differentiated as follows: First, the immediate *outputs* associated with an intervention, defined as micro-level changes (in behaviour or practices) that are associated with use of mobile phones; second, the resultant and more immediate *outcomes*, defined as measurable differences in cost and benefit associated with an intervention involving mobile phones; and third, broader and longer term *impacts*, defined as the contribution of the mobile phone intervention to broader development

goals defined according to changes (+ve or –ve) in socio-economic indicators (e.g., income or equity).

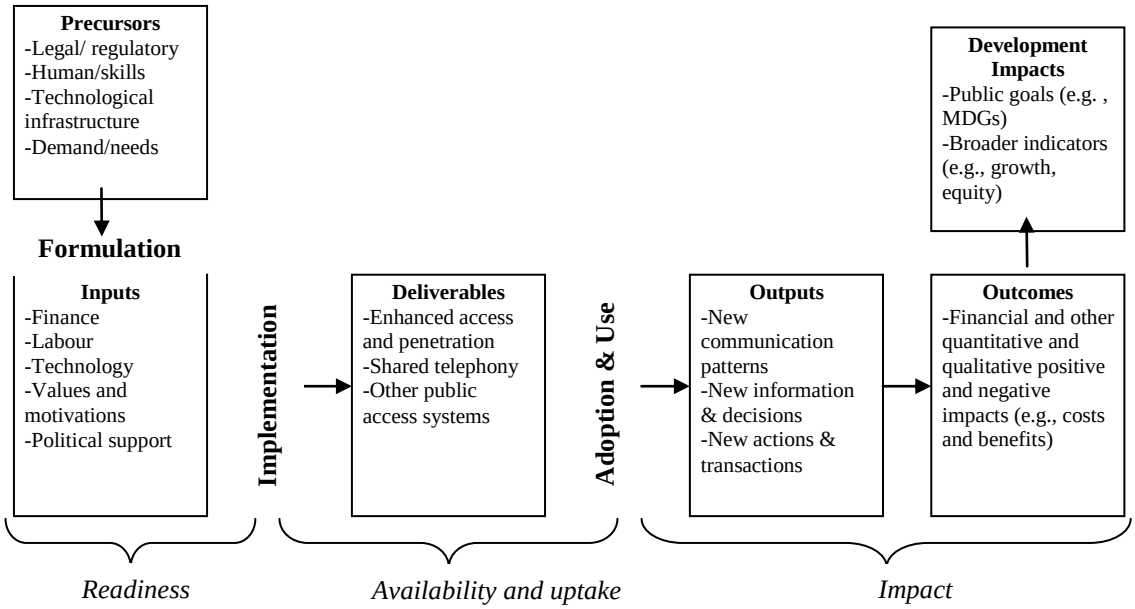
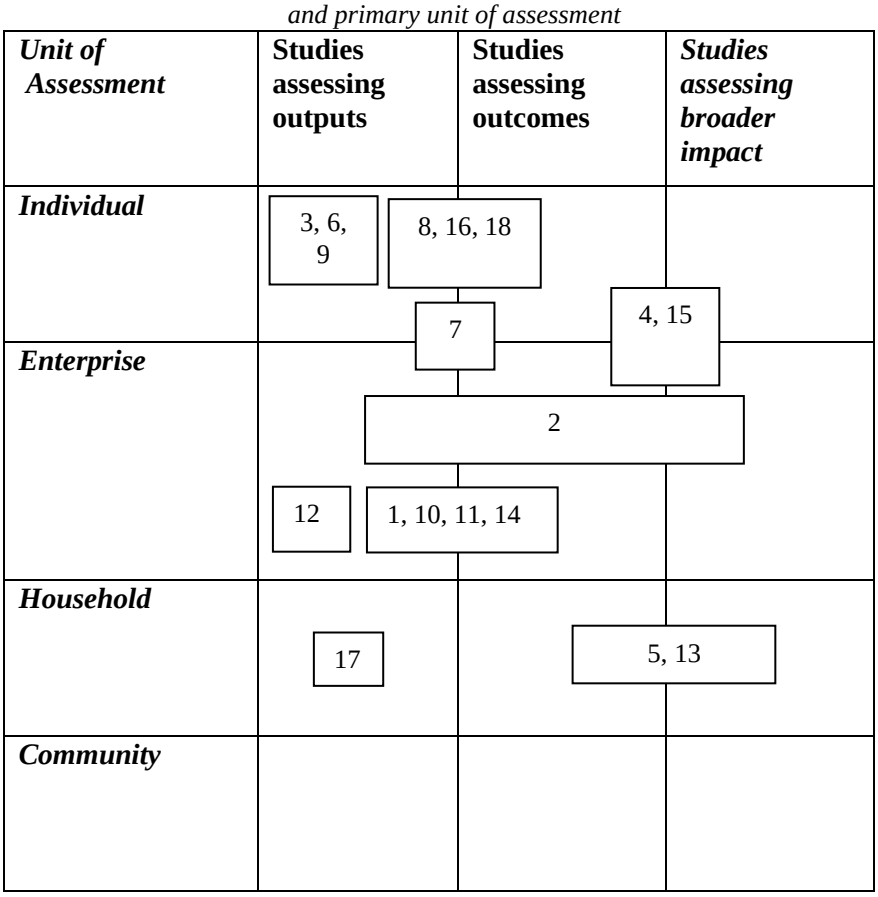


Figure 2: The M4D Value Chain - Adapted from Heeks & Molla (2009)

A review of 18 key M4D studies (Duncombe, 2009) suggests that research to date has focused on assessing output and outcome rather than broader impact (Table 1). M4D is a nascent cross-disciplinary area of the research and it may be too soon to expect a large number of studies that can assess social and economic impact. It is also the case that research complexity increases as we move from assessing outputs to outcomes and finally impact. Thus, identifying and measuring immediate changes in behaviour and practices due to use of mobile phones (e.g., the ability to open up a new channel of communication or access new information) will be relatively straightforward compared with the task of identifying how that information is used, and the costs and benefits associated with its use. Consider a situation where use of a mobile phone stimulates communication between a cattle farmer and a veterinary service.[v] This gives rise to the exchange of text-based information concerning communicable diseases, further stimulating the gathering of useful information (a measurable output). This changes behaviour and encourages new ways of tending to cattle during calving which results in a reduction in stillborn calves (a measurable outcome). In the longer term this increases the income and welfare of the farmer (a measurable impact). What is not clear is the extent to which the use of a mobile phone has been responsible for changing behaviour, and what role other mediating factors may have played. Neither is it clear whether the positive impacts are wholly the result of the actions taken by the farmer on the basis of the information received (if at all). Such issues of attribution become ever more challenging as we move from assessing outcomes to broader impact, due to the difficulty of disentangling the effects of an M4D intervention from a myriad of other possible intervening or exogenous factors.

Table 1: Scoping M4D research according to value chain positioning and primary unit of assessment



Source: Duncombe (2009)

In most of the studies surveyed – largely for reasons of practicality and simplicity – the chosen unit of assessment is either the individual or the enterprise (Table 1). The primacy of the individual as a unit of assessment may not be surprising given that the mobile phone, by its very nature, is a personal communication device, and its utility is normally expressed through individual use. For example, a number of studies (Donner, 2006; Horst & Miller, 2005) track the call-logs of individual phone owners which provide detailed data on usage and networking behaviour. However, the individualisation of mobile phone use is challenged by the extent and complexity of mobile phone sharing in developing countries (James & Versteeg, 2007) and this is likely to present difficulties for creating clear distinctions between units of analysis in the way in which mobile phones are used in practice. A deeper understanding of mobile phone sharing would require the mapping of the social relationships of the individual mobile phone owner, and the way in which they cross over between household, enterprise and community, adding significantly to the complexity and the costs of research design. Ethnographic approaches of Ureta (2008) and Horst & Miller (2005) have gone some way to understanding these complex interactions.

2. The Quality of M4D Research

Weber (2009) suggests that, overall, there is lack of good quality research to inform ICT4D policy and practice and he suggests this as a major obstacle to effective decision making and implementation of ICT4D (and by implication M4D) initiatives on the ground. He states…

"I have argued that we need to eschew rhetoric as the basis for decisions we make about how to use ICT to improve the human condition. Instead, we need to improve the level of rigor of the research undertaken in the ICT4D field. Only through rigorous research can we formulate models of reality that provide the basis for a discourse where we are able to pinpoint matters of agreement and disagreement, frame effective policies and actions, and potentially resolve matters of disagreement" (Weber, 2009, 22)

Rigor is the key indicator of good quality research and it is made up of two key components:

a) *A sound conceptual foundation:* good M4D research should be built upon accepted and proven theories, conceptual frameworks or models. In this way research becomes more coherent and consistent with what is accepted within a research discipline, and it is more likely to make a longer-term contribution.
b) *The use of rigorous methods:* good quality research should have a defined and appropriate methodology which is rigorously applied. It is also important that the methodology is explained to the readership so that the research can be replicated, and thus, either questioned or corroborated.

A key research area for M4D is m-Finance. A recent literature review of 43 m-Finance for development research articles (Duncombe & Boateng, 2009) highlighted the concerns of Weber. From the 17 studies that collected and analysed new primary data, more that 50 percent made no recourse to theory or definable conceptual ideas (Table 2).

Table 2: M-Finance and development research: mapping 43 articles surveyed according to conceptual and methodological approach

	Approaches inspired by social theories	Approaches inspired by socio-technical theories (inc business models)	Approaches inspired by technical theories	No defined theoretical approach evident
Quantitative	37	**11**, 34, 33, 32		
Mixed methods	**1, 4, 18**	**7**		**5, 21**
Qualitative	2, **17, 28**	35, 43	38	3, 36
Descriptive: No defined methodological approach evident	6, **25**, 26	8, 9, 16, **29**, 42	13, 23, 31	10, **12, 14**, 15, **19, 20, 22**, 24, 27, 30, 39, **40,** 41

Bold: Studies analysing primary data (17 articles)
Source: Duncombe & Boateng (2009)

Studies drawing upon deeper theoretically-based approaches tended to be located in the field of economics (Au et al, 2008; Knight-John, et al, 2005) whilst Donner (2007) and Benamati & Serva (2007) drew upon an economically inspired understanding of social capital to show how trust in financial relationships is impacted upon by the advent of mobile phones, and how underlying cultural and social norms condition adoption and usage patterns. Much more prevalent was shallow theory which took the form of framework or model based

approaches. These included, for example, the technology acceptance model (TAM)[vi] or business and banking models such as the access frontier model for financial services (Porteous, 2007; Williams & Torma, 2007). Overall, the sample of 43 articles contained 17 peer reviewed research studies and 26 non-peer reviewed. 24 studies (six of which were peer reviewed) were purely descriptive accounts in which no approach to methodology was discernable.

Thus, the number of studies employing a rigorous approach to both conceptualisation and methodology were a small proportion of the reviewed articles as a whole. Other features of the research area were: a) the lack of availability of time series data or before and after studies embodying quantitative approaches; b) the prevalence of mixed method approaches using survey techniques based on small samples. Another issue concerned the impartiality of the studies that were non-peer reviewed. Many of the key studies had been funded by industry research bodies and the affiliation of the authors was often to agencies or to consultant organisations that were partially funded by the mobile phone industry. There are no reviews that indicate whether these findings are replicated in other avenues of M4D research.

A key indicator of overall quality of research would be to gauge the quality of the journals where M4D research articles tend to be published. Most M4D research is published in journals that specialise in ICT4D. These have been rated by Heeks (2010).[vii] The following table indicates the number of articles (with M4D as a central theme) published in the top-rated ICT4D journal (*Information Technologies and International Development*) since 2004.

Table 3. M4D research articles published in top-rated ICT4D journal

Year	Total No of Research articles (General)	Articles with M4D as central theme	Country focus
2010 (Issues 1-3)	16	2	India; Liberia
2009 (Issues 1-4)	17	3	India, Mexico, Rwanda
2008 (Issues 3-4)	8	1	Nigeria;
2007 (Issues 1-2)	11	2	India; India
2006 (Issues 1-4)	15	4	Tanzania; Rwanda; Mexico; Asia Pacific
2005 (Issues 3-4)	4	0	
2004 (Issues 1-2)	6	1	Rwanda
Total	77 (100%)	13 (17%)	

Source: author

Encouragingly, further analysis of the articles according to the Google Scholar Citation Index shows that M4D research make up the top three highly cited articles (Donner, 2006, 2004; Abraham, 2007) and 6 M4D research articles are in the top ten (with the top three recording 60-70 citations each). This suggests that M4D research is the most widely read in the top ICT4D journal. However, that is the good news. It should be borne in mind that no ICT4D journals are highly rated overall, with none appearing in the ISI Web of Knowledge (WoK).[viii] Higher rated journals from other mainstream disciplines have published M4D research. These include *World Development*, the *Information Systems Journal*, and the *Quarterly Journal of Economics*. The latter journal published Jensen's (2007) study of Kerala fishermen which has been acknowledged as an example of top quality research in M4D. Interestingly the article has recorded 168 citations – well in advance of those recorded for the top-rated research in ITID. This brings us to the question of dissemination and impact of research.

3. The Impact of M4D Research

Creating impact requires good quality research, but it also requires effective dissemination. Research can only have an effect on policy and practice if it is widely disseminated or well targeted. Good quality M4D research identifies and targets a particular audience. The work of Jensen (2007) provides a good example of work with a deep conceptual base (welfare economics and information asymmetries – drawing upon the Nobel prize winning work of Stiglitz) that was methodologically rigorous (longitudinal data with reasonably large representative samples) targeted at an influential audience of economists. The work also received attention from a wider audience of policy-makers and practitioners through a summary article published in the Economist. Thus, research does not end when you finish writing. Importantly it is necessary to get people to read and use what you have written. This process should start at the beginning of the research process by asking "Who is the audience for my research?"

This involves understanding why M4D is a necessary and useful. We can identify three sets of objectives of research: a) for accountability – so that sponsors and funders can be held accountable for the development resources that are expended on M4D initiatives, by measuring the achievement and efficiency and effectiveness in the allocation of those resources; b) for improving organisational effectiveness by providing lessons for the improvement (in best practice) for M4D interventions, including recommendations for comparable or planned projects; c) to contribute to the broadening and deepening of academic knowledge that can contribute to public and private policy concerning M4D, and inform donors, government and the private sector. Thus the potential audiences for M4D research include:

- Those who make decisions about intervention-related investments or the policy and regulatory environment within which M4D operates.
- Those who are responsible for the management of M4D interventions.
- Those who are the beneficiaries of M4D interventions or the users of the services provided.
- Other local or community stakeholders who may have some influence over M4D interventions – particularly their scalability and sustainability.

For most researchers there are tensions in satisfying different audiences. In this respect the question researchers often ask themselves is… is the audience for my research M4D practitioners, or academics? The chosen audience will affect the choice of conceptual frameworks, and present difficulties in satisfying different audiences within a single methodological approach. Public policy makers or donors may be more interested in hard evidence of broader socio-economic impact and justification for further expenditure on infrastructure or subsidy of access; whilst service providers or individual project managers may find client and project level output data more useful.

Thus, for many researchers in the field there will be a tension between *proving* or *improving* impact. Proving impact requires the demonstration of causal relationships (more commonly demonstrated at least partially thorough quantitative means) with the intention of measuring as precisely as possible the broader impacts of the intervention. Improving impact, on the other hand, requires a deeper understanding of the underlying processes associated with an intervention with the intention of improving those processes. Proving impact is likely to be more expensive and consuming of resources, requiring rigorous analysis of reasonably large representative samples, and use of control groups, whereas improving impact can be focused on producing credible and comparable findings by means of smaller samples of project beneficiaries, and making greater use of qualitative data sources accessed within the boundaries of the intervention.

4. Research Challenges

Linking mobiles to development policy and practice – three mobile-related articles were published in the top rated development journal – *World Development* in 2009 (Howard & Mazaheri, 2009; Muto & Yamano, 2009; Buys et al, 2009) – only Muto & Yamano (2009) dealt with impact. All followed an exclusively quantitative methodology. In contrast there are regular research articles that deal with other areas of resource management and infrastructure development such as water, mining or forestry. It would seem that M4D is not linking into the academic debates concerning development (although the recent articles in *World Development* are welcome). This is also in contrast to the growing connections forged on the ground between development and ICT practitioners (as demonstrated through the project level surveys of Gakuru et al (2009), Donner (2009), De Silva (2008) and Munyua (2008).

Thus M4D research is making an impact within the confines of ICT4D, but is largely failing to influence the broader development debate. This means there is lack of conversation between M4D and development studies academics, which has a negative knock on effect given that many donor agencies are staffed by people trained in development studies and who look to development studies for an intellectual lead. This also has practical implications for conducting M4D research. Mobile projects on the ground are predominantly in a pilot or proof of concept stage. They depend upon getting feedback from participants. Projects that fail often get no feedback, or the wrong feedback, or feedback from the wrong people. For example, M4D lacks reporting of participatory or action research methods (Duncombe, 2009). This is surprising given the ground level nature of much m-development activity and the high degree of involvement of practitioners within m-development initiatives. The lessons learned from this activity have not yet been translated into definable and publishable approaches to impact research involving participatory methods. In this respect, M4D can be considered to be lagging behind development studies where participatory methods have been developed as a critique of positivist (both quantitative and mixed method) approaches (Mayoux & Chambers, 2005). This may also lead to a greater level of conceptualisation – actually working on exposing, applying and developing theoretical frameworks that are appropriate for M4D research. This includes conceptualisation of the political and systemic reasons (that go beyond lists of best practice points) and which analyse why it is so hard to scale and sustain M4D projects beyond the pilot stage.

The future direction of M4D research will be largely determined by the availability of resources to conduct detailed studies. Should those resources be forthcoming, then one fundamental issue will be whether future research should be radically different from other forms of impact research. Does the pervasiveness, and perceived importance, of mobile phones for development demand new methods and new theories? Thus far research has been developed from within a broad range of well established and proven theoretical and methodological traditions. Research such as Jensen's has benefited from this secure grounding. However, there may be a number of new and unexplored areas of impact that remain untouched and which are specifically linked to the particular patterns of mobile phone adoption and use that are evident in developing countries.

Two key emerging areas of research can be emphasised:

Understanding new models of innovation: Innovation can embody:

- Hardware, software, network communication innovations that are tailored to the needs of low income users (e.g., user interfaces).
- Application innovations directed at meeting identified needs (e.g., text to change in Uganda).
- Organisational, market and business model innovations (such as were required to scale M-PESA successfully).
- Socio-cultural innovations (i.e., how mobile phones are adapted to local information and communication practices).

Historically, many technical hardware and software M4D innovations have taken place externally in university departments or R&D labs of mobile companies and then introduced into developing country environments (a top-down model). Increasingly, innovation is taking place in developing countries (particularly directed at new applications, forms of organisation and socio-cultural adaptation). This requires partnership models emphasising participative user-engagement (a bottom up model). Greater in country innovation is also expanding due to the fact that developing country populations (including the poor) have potential for mass ownership of technologies – and they themselves can become innovators – in the way that the technologies and applications are adapted to new forms of use (e.g., beeping; airtime as currency; backstreet re-chipping of phones). Here, the research task is to identify technology-in-use, understanding its context and assessing its efficacy, with the objective of seeking to scale or replicate best practice (focussed predominantly on improving impact).

Understanding M4D as a tool of production: the focus of M4D research thus far has been on viewing mobile phones as tools of consumption. That is, to consume information (e.g., to provide advice; to support teachers or health workers) or to consume other goods and services (e.g., to support micro-finance or m-payments). There is less emphasis on mobile phones as a tool of production. For example, as a means to create a new livelihood that generates income by selling new goods or services. There are many and increasing examples of people finding ways to create and to make money via mobiles; for example by producing local content. These are laid out in detail in this years 'Information Economy Report' (UNCTAD, 2010). We have researched this area very little so far, yet this is the way that mobiles have a direct impact on poverty and growth.

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[i] In the case of the poorest continent – Africa – mobile penetration for individual countries increased from an average of 2% of total population in the year 2000 to an average of 33% in 2008. This impressive growth masks extreme variations between countries, but overall, mobile cellular networks have extended coverage to 58.5% of the total African population during this period creating potential for network access for previously un-served communities in some of the poorest countries. African countries with the highest mobile cellular growth rates between 2003 and 2008 are dominanted by those that are least developed. Ethiopia with a compound annual growth rate (CAGR) of 128%; Chad with 94%; Guinea with 88%; and, Niger with 83% occupied the top four places (ITU, 2009).

[ii] Details of a wide range of text based m-development projects can be found at Kiwanja.net. http://www.kiwanja.net/database/kiwanja_search.php. Lists of projects can also be accessed via MobileActive.org. http://mobileactive.org/directory

[iii] Refer to: Hughes & Lonie (2007)

[iv] Make reference to a project evaluation report compiled by the Aids Information Centre and Text to Change in Uganda. Available at http://www.texttochange.com/AIC-TTC%20Arua.pdf

[v] This example is drawn from a case study of m-development application for the cattle farming sector in Kenya. Full details are available from: Kithuka, J., Mutemi, J. & Mohamed, A.H. (2007) Keeping up with technology: the use of mobile telephony in delivering community-based decentralised animal health services in Mwingi and Kitui Districts, Kenya, *Farm Africa Working Paper No.10*. http://www.farmafrica.org.uk/view_publications.cfm?DocTypeID=11

[vi] Refer to: Pousttchi & Wiedemann (2007)

[vii] Refer to: http://ict4dblog.wordpress.com/ Blog entry 17th June 2010

[viii] Refer to: http://wok.mimas.ac.uk/

Household access to mobile telephony in Latin America

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Abstract: By analyzing available data on household access to mobile telephony gathered through household surveys we are able to enrich the information given by the most usual indicator on mobile diffusion, mobile subscriptions per 100 inhabitants. Household data should contribute to a better understanding and contextualization of the current research on the field. The description is centered in Latin America and the Caribbean, where data confirm that (1) mobile telephony is the most usual bidirectional communication tool at a household level, and (2) it is better distributed among income levels than fixed phones and Internet. Finally, it seems that mobile subscriptions per 100 inhabitants cannot be used as a unique tool for estimating household mobile access.
Keywords: mobile telephony; household access; Latin America.

1. Introduction

The fast popularization of mobile phones is intertwined with communication, a specific and basic element of human societies. It has brought new ways of interaction; for instance, while fixed telephony allows for the coordination of activities, mobile telephony favors micro-coordination (Ling and Haddon, 2001; Ling, 2004). Being or not a complementary layer of the former, wireless telephony allows greater flexibility, accelerating those processes that depend on communication. Thus, the structure of the network society (Castells, 2000, 2004; Monge and Contractor, 2003) is enhanced by new, wireless communication technologies (Castells *et al*., 2006).[2]

Whereas Information and Communication Technologies (ICT) have "demonstrable effects on individual and group behaviors and on social institutions, […] they affect distinct groups and subgroups within society in various ways" (Wilson, 2004: p. 22). Therefore, a strand of the literature is devoted to the analysis of the contribution of ICT to social and economic development (see among others, Saunders, 1994; Grace *et al*., 2004; Wilson, ibid; Castells *et al*., ibid: chapter 8; Hudson, 2006; Donner, 2008; HMS Wireless, 2008; Katz, 2008: first section of the book; Servaes, 2008; Straub, 2008). Within this framework, our focus of analysis is set in mobile communication and, specifically, in available statistical data for Latin America at the country level.

Currently, "despite the recent economic downturn, the use of ICT services […] continues to grow worldwide." (ITU, 2010a: ix). Particularly, at the end of 2009, there were 4.7 billion mobile cellular subscriptions in the world, corresponding to 68 mobile subscriptions per each

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[2] For earlier comprehensive analysis of the influence of mobile communication, see Brown *et al.* (2002), Katz and Aakhus (2002) and Ling (2004).

100 inhabitant, a penetration rate that rises to 89 in Latin America and the Caribbean region, 90 in Japan, 95 in the US and 125 in the European Union EU27 (ITU, 2010b).

These figures are very dynamic statistics that allow for an updated general overview of the diffusion of mobile telephony in the world. Published by the International Telecommunication Union (ITU), the data is provided by the industry, thus we can consider that penetration rates constitute a supply-side indicator of mobile diffusion.

These statistics bring one observation per country each year, with the last update being June 2010. Therefore, their level of detail is not enough for an analysis of the effective reach of mobile telephony within a country, or a given set of countries. They do not allow us to answer questions like, for instance: Are there differences in the diffusion of mobile telephony in rural and urban areas within a country? Are there differences among different income segments of the population? Is it possible to determine the importance of mobile phones at a household level, compared with other communication technologies?

Household surveys on ICT access allow us to answer these questions and to better contextualize penetration rates. These data, indeed, can be considered demand-side indicators of mobile diffusion, as they are collected through questionnaires answered by final consumers. Demand-side data do not gather all the active mobile subscriptions in the country. They study household access; that is, household availability of at least one mobile subscription. Therefore, second or subsequent mobile subscriptions are not of interest here. This is also valid for any other ICT at a household level, as the survey's interest in centered on access. Despite the fact that they are scarcer than supply-side data; statistics on household access to mobile telephony constitute a very rich data set in which several household characteristics are included. The best source to be used when studying Latin America is the "ICT Statistical Information System". OSILAC, the Observatory for the Information Society in Latin America and the Caribbean built and manages this system which allows the comparison of ICT data gathered in seventeen countries throughout Latin America and the Caribbean.[3]

Our expectation is that demand-side data on mobile diffusion will contribute to better understand the available evidence on the bottom of the pyramid in Latin America: for instance, it will be of most interest to validate, from a macroeconomic point of view, the magnitude of the gap between mobile and fixed telephony in each country or, on the other hand, to explore what is the exact reach of mobile telephony among the poorest households, as it is usually the only affordable telephony for them (see Galperin and Mariscal, 2009; Ureta, 2008).

2. Overview of mobile diffusion in Latin America: supply-side and demand-side indicators

Data on mobile diffusion in Latin America is gathered in Table 1. It includes information since 2003 on the two indicators already mentioned: the supply-side and the demand-side indicator. Both of them show a fast path of growth in mobile diffusion, when data is available. Indeed, demand-side data are not as complete as ITU data. The main reason is because the production of household surveys is slower and more complex than the collection of industry data on subscriptions and, therefore, there is a higher delay in the publication of these data; and secondly, because a number of countries do not produce this information in their household surveys or do not carry out household surveys.

[3] OSILAC is part of the Economic Commission for Latin America and the Caribbean (ECLAC). For detailed information: http://www.eclac.org/socinfo/osilac/default.asp?idioma=IN (last accessed: June, 2010).

Table 1: Mobile telephony diffusion in Latin America (18 countries). Supply-side indicator[1] and Demand-side indicator[2].

		2003	2004	2005	2006	2007	2008	2009
Argentina	Subs. per 100 hab.	20.6	35.2	57.2	80.6	102.3	116.6	128.8
	Households (%)	-	-	-	-	-	-	-
Bolivia	Subs. per 100 hab.	14.5	20.0	26.4	30.7	34.2	49.8	72.5
	Households (%)	-	-	**39.2**	-	**57.0**	-	-
Brazil	Subs. per 100 hab.	25.5	35.7	46.3	53.1	63.6	78.5	89.8
	Households (%)	**38.6**	**48.3**	**59.9**	**64.2**	**67.5**	**75.7**	-
Chile	Subs. per 100 hab.	45.6	57.4	64.9	75.6	83.9	88.1	96.9
	Households (%)	**46.6**	-	-	**83.8**	-	-	-
Colombia	Subs. per 100 hab.	14.8	24.5	50.8	68.1	76.5	91.9	92.3
	Households (%)	**17.6**	-	-	**64.7**	**71.5**	-	-
Costa Rica	Subs. per 100 hab.	18.6	21.7	25.4	32.8	33.8	41.7	42.6
	Households (%)	**37.6**	**43.1**	**49.8**	**56.4**	**60.4**	**68.1**	-
Ecuador	Subs. per 100 hab.	18.8	27.4	47.8	64.3	74.5	86.7	100.1
	Households (%)	**33.6**	-	-	**63.8**	-	**69.9**	-
El Salvador	Subs. per 100 hab.	19.1	30.4	39.8	63.3	100.5	113.3	122.8
	Households (%)	**13.5**	**24.4**	**34.8**	**45.5**	**65.0**	-	-
Guatemala	Subs. per 100 hab.	16.8	25.6	35.5	55.1	89.1	109.2	123.4
	Households (%)	-	-	-	**54.8**	-	-	-
Honduras	Subs. per 100 hab.	5.7	10.5	18.6	31.9	58.3	84.9	103.3
	Households (%)	**13.0**	**14.8**	**21.6**	**41.4**	**58.4**	-	-
Mexico	Subs. per 100 hab.	29.2	36.9	44.7	52.1	61.9	69.4	76.2
	Households (%)	-	**35.3**	**42.3**	**47.1**	**55.2**	-	-
Nicaragua	Subs. per 100 hab.	8.8	13.7	20.5	33.1	44.7	54.8	55.8
	Households (%)	-	-	**23.1**	**61.7**	-	-	-
Panama	Subs. per 100 hab.	22.2	39.7	54.1	66.1	90.0	115.2	164.4
	Households (%)	-	-	-	**64.2**	**69.0**	-	-
Paraguay	Subs. per 100 hab.	31.2	30.2	32.0	53.7	76.6	95.5	88.5
	Households (%)	**31.2**	**36.0**	**49.0**	**64.4**	**75.0**	-	-
Peru	Subs. per 100 hab.	10.8	14.9	20.1	31.1	54.1	72.7	84.7
	Households (%)	**11.5**	**15.6**	**20.0**	**28.1**	**42.4**	**56.7**	-
Rep. Dom.	Subs. per 100 hab.	22.6	27.0	38.0	47.6	56.2	72.5	85.5
	Households (%)	-	-	**44.3**	-	-	-	-
Uruguay	Subs. per 100 hab.	15.0	18.0	34.7	70.0	90.0	104.7	113.1
	Households (%)	-	-	-	**48.9**	**70.8**	-	-
Venezuela	Subs. per 100 hab.	27.2	32.1	46.8	69.1	86.1	97.5	98.4
	Households (%)	**30.2**	**29.2**	**25.7**	-	**43.4**	-	-

[1] Supply-side indicator: mobile subscriptions per 100 hab. (ITU, 2010b).
[2] Demand-side indicator: households that have at least one mobile phone (%) (OSILAC, http://www.eclac.org/tic/flash/, last accessed: June, 2010).
- Not available.

From the supply-side, it can be seen that, in 2009, there are seven Latin American countries with more than one mobile subscription per inhabitant (penetration rate above 100%): Argentina, Ecuador, El Salvador, Guatemala, Honduras, Panama and Uruguay. On the other end of the spectrum, Costa Rica is the only country with a penetration rate under 50%, which is a consequence of the specificity of the regulatory framework of the country.[4] Regarding the demand-side indicator, household access to mobile phones ranges from 43% (Venezuela, 2007) to 84% (Chile, 2006). It can be seen that there is information on 2008 for only four countries while there is not yet any observation for 2009.

[4] There is one public firm that controls telecommunication market and energy market. Modernization of the sector started in 2007 following the election of Oscar Arias to the country's presidency in 2006.

Are these figures pointing high or low within the world landscape? From the supply side, it seems plausible to say that Latin America is ranging very well, with a mobile penetration clearly higher than the world average and showing values that are close to significant developed economies, such as Japan or the US (see Introduction). Another supply-side indicator, however, brings a contrasting picture: that is, mobile subscriptions with access to data at broadband speed per 100 inhabitants. In 2009, this indicator ranks high in Japan (84), followed by European countries (for instance: Spain, 52; Italy, 54; France, 41; Finland, 40; or Germany, 32). In the US, the indicator reached a value of 8 in 2008; which, in any case, is greater than in any of the Latin American countries under consideration. Indeed, Argentina (6) and Brazil (5) are the leaders, while the rest of the countries fall below 3 (data referred to 2009, ITU, 2010b).

The distance is clear from the demand side as well, with more developed countries showing an almost universal presence of mobile telephony in households: 95% of Japanese households had a cellular phone or a personal handy phone device in 2006 (Statistics Bureau Japan, 2010); as did 94% of Spanish households in 2009 (INE, 2010).[5] In the US, the estimated share of households with a wireless telephone was 83% in the second half of 2009, with only 2% of households having no telephone service at all (Blumberg and Luke, 2010).

From the available information it is easy to notice that it is not possible to forecast one indicator by using the other indicator as a unique source of data. For instance, there is one country in Table 1 than has no information on household access to mobile telephony: Argentina. It is one of the main economies in the region representing 10% of the mobile market in Latin America and the Caribbean region. As ICT related information is not gathered in Argentinean household national surveys, we could think about the possibility of estimating demand-side data based on available mobile penetration rates. However, the evidence we have from the rest of the countries in the table suggests that this is not an easy task since as there is not a unique path in the relationship among demand-side and supply-side data. For instance, in some countries penetration rates are higher than household rates (Chile, Colombia or Uruguay, among others), while in other countries, as diffusion grows penetration rates surpass household possession of mobile phones (i.e. Brazil).

Indeed, what must be expected is that offer-side data reach and surpass the 100% penetration rate in the medium-term in almost all Latin American countries, as the indicator itself does not have an upper bound. On the other hand, the percentage of households having at least one mobile phone has a clear upper bound: 100%. Therefore, as long as the technology diffuses, we will expect the first indicator to be higher than the second, which is the case of Argentina, where there are more mobile subscriptions than inhabitants since 2007. We are not able, therefore, to consistently estimate household mobile access: is Argentina like Uruguay, where penetration is clearly higher than household access; or is it like Brazil, where only recently penetration surpassed household access? Thus, other indicators should be taken into account to get an accurate estimation of this figure.

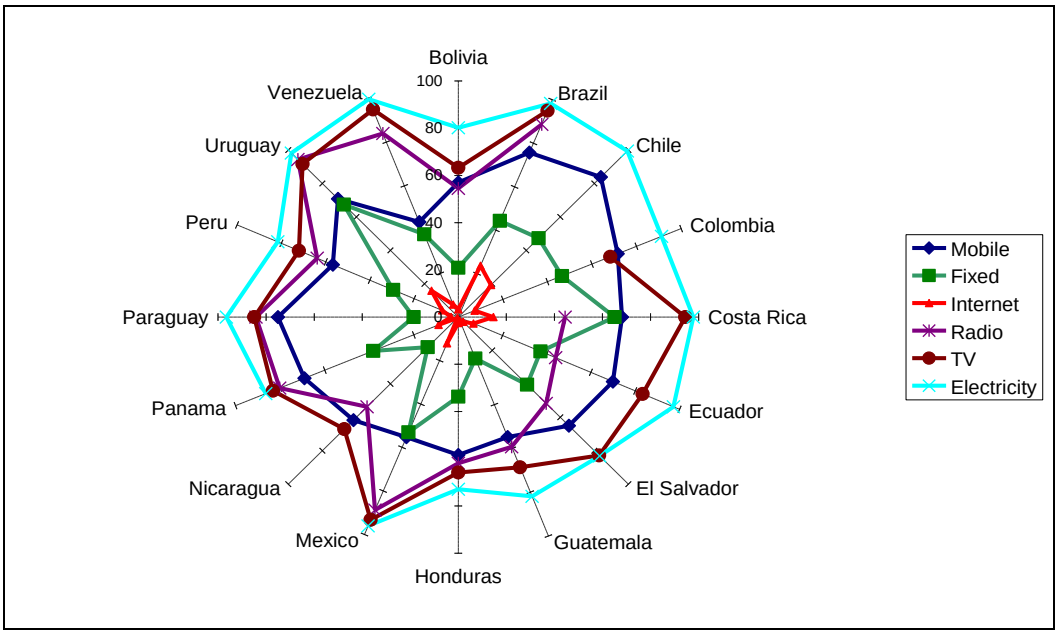
2.1 – Comparison with other selected household technologies

We select a set of household technologies to analyze the significance of mobile telephony at a household level. We consider two mass media, TV and radio, which nowadays are very popular technologies. On the other hand, interpersonal communication technologies are the Internet, as well as mobile and fixed telephony. Finally, we also consider a general purpose technology, electricity which, as expected, is the most common technology (see Figure 1).

Available data for 2007 (or circa) corroborate the importance of mobile telephony in the region: on average, it is the first bidirectional communication technology in households; and

[5] Eurostat does not gather information on standard mobile telephony possession at a household level, as statistics on Information Society are mainly focused on Internet access and use (http://epp.eurostat.ec.europa.eu/portal/page/portal/information_society/data/database, last accessed: September, 2010).

the third communication technology at home. Mass media technologies, in general, are more common (with few exceptions, as in some countries mobile phones are even more popular than radio sets). On the other hand, mobile phones are significantly more common than fixed phones, with the exception of Costa Rica, Mexico, Uruguay and Venezuela. Internet connections lag significantly behind either type of telephone, with only around a 20% of Chilean and Brazilian households accessing this technology.



Source: OSILAC (http://www.eclac.org/tic/flash/, last accessed: June, 2010).

Figure 1: Households with the indicated technology (%). Latin American countries, year 2007 (circa).

3. Mobile telephony distribution

It is possible to break down mobile access by different household characteristics. From Table 2 it can be seen that there is a clear difference in access between rural and urban households. When there is more than one observation per country, a reduction of the existing gap can be observed. The two countries showing the most polarized situation are Bolivia, where urban mobile access is more than four times higher in urban areas than in rural ones (ratio equals 4.15, in 2007); and Peru, where urban household are three times more likely to access mobile telephony than rural ones (ratio equals 2.87, in 2008). The remaining countries show a ratio of polarization below 2, with Chile (1.08) and Uruguay (1.11) having the most egalitarian distribution.

The geographic gap can be explained in terms of the different socioeconomic levels of the average population in each area and also in terms of the different deployment of telecommunication infrastructures (which is always better in urban areas). This gap, conversely, is not reproduced in terms of the gender of the household's head (Table 2). Socioeconomic level tends to be lower when the household chief is a woman. Therefore, their access to different technologies and devices might be lower as well. But this is not the case regarding mobile telephony, which presents a polarization ratio that takes on values close to 1 in all countries.

Table 2. Household with mobile phone (%), broken down by household characteristics.

Selected Latin American countries.

		Geographic area			Gender of household head		
		Urban	Rural		Male	Female	
		(1)	(2)	(1) / (2)	(3)	(4)	(3) / (4)
Bolivia	**2005**	55.8	9.1	6.13	38.9	40.5	0.96
	2007	77.6	18.7	4.15	57.0	56.9	1.002
Brazil	**2005**	64.7	28.8	2.25	59.7	57.9	1.03
	2007	72.6	38.9	1.87	68.0	66.3	1.03
	2008	80.5	48.7	1.65	75.6	76.0	0.99
Chile	**2006**	84.7	78.2	1.08	85.7	79.3	1.08
Colombia	**2007**	77.0	54.0	1.43	72.6	69.1	1.05
Costa Rica	**2005**	59.5	34.3	1.73	50.9	45.2	1.13
	2008	75.6	57.0	1.33	70.9	61.3	1.16
Ecuador	**2005**	73.5	45.0	1.63	65.1	58.8	1.11
	2008	78.6	51.4	1.53	71.5	65.0	1.10
El Salvador	**2006**	49.3	39.0	1.26	47.0	42.5	1.11
	2007	67.7	59.5	1.14	66.9	61.4	1.09
Guatemala	**2006**	66.8	40.9	1.63	53.4	59.4	0.90
Honduras	**2005**	41.1	14.6	2.82	25.7	33.4	0.77
	2007	71.6	45.5	1.57	57.6	60.2	0.96
Mexico	**2005**	-	-	-	41.4	40.1	1.03
	2007	66.6	45.0	1.48	54.6	56.3	0.97
Nicaragua	**2006**	76.5	39.4	1.94	59.8	65.3	0.92
Panama	**2005**	80.7	46.6	1.73	68.1	71.3	0.96
	2007	80.7	46.6	1.73	68.1	71.3	0.96
Paraguay	**2005**	58.4	34.6	1.69	49.6	47.3	1.05
	2006	73.0	51.6	1.41	65.6	61.2	1.07
	2007	81.6	64.7	1.26	76.1	72.1	1.06
Peru	**2007**	58.2	12.0	4.85	42.8	40.8	1.05
	2008	72.7	25.3	2.87	57.2	54.9	1.04
Dominican Rep.	**2005**	49.4	34.8	1.42	43.5	44.8	0.97
Uruguay	**2005**	-	-	-	52.5	41.6	1.26
	2007	71.3	64.1	1.11	74.8	62.6	1.19
Venezuela	**2005**	-	-	-	26.7	23.5	1.14
	2007	-	-	-	43.8	42.8	1.02

Source: OSILAC (http://www.eclac.org/tic/flash/, last accessed: June, 2010)

It is even more interesting to analyze mobile phone access regarding the incoming level of the household. Table 3 gathers the available data, which is broken down by income quintile. The first quintile corresponds to the poorest 20% of the population, while the fifth quintile corresponds to the richest 20% of the population. First evidence, not surprisingly, shows that the higher the income level, the higher the ratio of households accessing mobile telephony. Secondly, the polarization index, calculated as the ratio between the fifth and the first quintile, drops when mobile telephony becomes more popular at a household level. Regarding this indicator, the most unequal country is Bolivia (ratio equal to 4.4, in 2007) while Chile and Uruguay are the most balanced (1.1, in 2006 and 2007 respectively).

Thirdly, fixed telephones and Internet connections are more unevenly distributed, showing a higher degree of polarization (see the four last columns in Table 3). We understand that this is a clear consequence of their lower diffusion. In this sense, for all those countries for which Internet connection data are available, it can be observed that the richest quintile of income has Internet access at home at least ten times greater than those in the poorest quintile. The maximum level of discrepancy appears in Peru (polarization ratio equal to 119 in 2008) and in Ecuador (104.5 in 2008). In both cases, the average of households with Internet access is around 7%. That means that the majority of the (few) Internet connections in these countries are highly concentrated in the richer segments of the population.

Table 3. Household with mobile phone, fixed phone and Internet connection (%) and Polarization Index (PI = Q5/Q1). Selected Latin American countries.

		Mobile phones, broken down by income quintile							Fixed phones		Internet	
		1st	2nd	3rd	4th	5th	Total	PI	Total	PI	Total	PI
Bolivia	**2005**	6.2	25.9	45.2	46.7	66.2	39.2	10.7	18.8	67.7	3.5	-
	2007	18.0	50.9	68.5	70.0	78.8	57.0	4.4	20.9	22.5	3.3	-
Brazil	**2007**	47.8	64.4	69.6	69.8	84.7	67.5	1.8	45.2	6.2	20.1	30.7
	2008	59.1	73.8	72.1	82.8	90.0	75.7	1.5	44.3	5.9	23.6	22.8
Chile	**2006**	78.9	79.7	81.7	83.0	90.7	83.8	1.1	47.3	3.8	19.2	12.0
Colombia	**2007**	52.0	66.3	73.1	80.4	88.3	71.5	1.7	46.5	4.0	7.3	37.0
Costa Rica	**2008**	35.0	52.1	64.6	77.8	90.3	68.1	2.6	65.0	1.9	14.6	41.7
Ecuador	**2008**	47.1	62.3	70.1	79.0	86.4	69.9	1.8	37.1	8.8	6.9	104.5
El Salvador	**2007**	46.8	58.4	64.7	69.4	79.9	65.0	1.7	40.4	5.6	2.8	-
Guatemala	**2006**	33.0	47.7	56.4	67.7	81.6	54.8	2.5	18.9	9.9	1.8	68.0
Honduras	**2005**	3.2	9.6	19.0	33.2	50.0	21.6	15.6	19.5	20.8	1.5	71.0
	2006	16.6	29.3	43.9	55.1	68.2	41.4	4.1	29.2	10.6	1.4	65.0
	2007	28.2	48.9	63.1	73.6	84.4	58.4	3.0	33.7	7.8	2.5	50.5
Mexico	**2007**	32.4	50.9	64.0	67.3	86.7	55.2	2.7	53.0	2.0	12.0	12.3
Nicaragua	**2006**	37.6	53.4	66.0	74.5	85.8	61.7	2.3	18.0	7.8	0.5	-
Panama	**2007**	33.6	63.7	75.5	80.6	85.9	69.0	2.6	38.2	5.6	8.9	67.0
Paraguay	**2005**	21.0	32.8	49.2	54.7	70.6	49.0	3.4	18.6	34.1	1.7	-
	2006	39.3	60.2	67.0	71.5	80.2	64.4	2.0	17.4	52.8	2.6	-
	2007	54.6	68.5	79.5	83.2	87.0	75.0	1.6	18.6	17.8	3.0	61.0
Peru	**2008**	19.4	42.3	60.2	70.9	79.9	56.7	4.1	29.5	28.0	7.3	119.0
Uruguay	**2007**	71.8	70.1	66.6	68.8	76.4	70.8	1.1	67.4	2.8	15.8	25.7
Venezuela	**2005**	17.5	21.7	27.0	27.9	33.9	25.7	1.9	34.5	3.1	2.5	11.0
	2007	35.9	41.8	44.6	44.5	50.1	43.4	1.4	37.8	2.8	5.7	31.8

Source: OSILAC (http://www.eclac.org/tic/flash/, last accessed: June, 2010)

3.1 – Common patterns among countries

Latin American countries can be classified in two main groups, according to a cluster analysis that takes into account (1) the average of households that have mobile phone, fixed phone and Internet connection, and (2) the distribution of these technologies among income quintiles. After analyzing 2007 data (or circa), we were able to identify a first cluster formed by 9 countries (Bolivia, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Paraguay, Peru and Venezuela); while the second one gathers 7 (Brazil, Chile, Colombia, Costa Rica, Mexico, Panama and Uruguay). The first cluster shows a lower degree of communication equipment, which is always more unevenly distributed, as the polarization index tends to be higher (see Table 4). Besides this, the first cluster is formed by comparatively less developed countries with lower GDP per capita (2,587 vis-à-vis 4,765 USD). However, inequality measured in terms of the Gini coefficient is slightly higher in cluster 2 (55 versus 51 in cluster 1).

The most interesting result from this basic analysis is the fact that penetration rates are almost equal in both clusters (71% versus 73%). That is, from the point of view of the supply-side we would conclude that there are not significant differences between these two groups of countries. In spite of this, the available demand-side indicators allow us to obtain a better description of the situation that cannot be achieved by only analyzing penetration rates from ITU. More specifically, demand-side data show a clear difference between the two clusters: 56.7% for first one, as compared to an average of 69.5% of households accessing a mobile phone for the second one. Mobile phone access, therefore, shows more than 10 percent points (p.p.) of difference. Following the same path already described, the polarization index is higher in the cluster with less diffusion (2.3 in the first versus 1.7 in the second cluster).

Table 4. Main characteristics of the two clusters in Latin America. Year 2007 (circa)

	Cluster 1	Cluster 2
GDP per capita (2,000 constant USD)[1]	2,587.26	4,764.741
Gini Coefficient (0=total equality; 100=total inequality)[2]	51.31	54.68
ITU mobile phone penetration Subscriptions per 100 hab.	71.26	73.14
Mobile phone		
Households (%)	56.66	69.48
PI (Q5/Q1)	2.28	1.74
Fixed phone		
Households (%)	30.19	47.60
PI (Q5/Q1)	6.68	3.52
Internet		
Households (%)	4.83	17.75
PI (Q5/Q1)	70.43	19.06
Radio		
Households (%)	64.74	73.20
PI (Q5/Q1)	1.01	1.18
Television		
Households (%)	78.24	86.79
PI (Q5/Q1)	1.76	1.13

[1] Average 2004-2007. [2] Average 2003-2006.
Descriptive statistics for each cluster: population weighted averages.
Cluster 1 (9 countries): Bolivia, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Paraguay, Peru and Venezuela.
Cluster 2 (7 countries): Brazil, Chile, Colombia, Costa Rica, Mexico, Panama, and Uruguay.
Average cluster of k-means analysis, based on three variables: household with mobile phone, household with fixed phone, household with Internet connection.
Source: Own elaboration, based on OSILAC, ITU (mobile penetration, population), CEPAL (Gini coefficient) and WDI (GDP per capita).

4. Conclusion

In this paper we give a broad overview of the diffusion of mobile telephony in Latin America by using demand-side indicators that are gathered through household surveys at a country level. These data complement and improve, but do not substitute, supply-side data on mobile subscriptions per 100 inhabitants gathered by the International Telecommunication Union.

Regarding the specific results on Latin America, a region which is above the world average penetration rates, household data show a similar trend to that which we have already observed from supply-side data: mobile telephony is growing at a very fast pace; its diffusion is higher than any other interpersonal communication technology (that is, fixed phones and Internet); and in general, it is not as popular as mass media (TV or radio).

However, household share of mobile telephony lies below advanced economies, such as Japan, US or Europe. This trend is even more pronounced in terms of mobile broadband connectivity, which is residual in Latin America. This would be a relevant aspect for those households that would like to access the Internet despite their lack of a wired connection. Indeed, the technical capacity of devices and deployed networks frames the effective access to (advanced) ICT services.

As diffusion increases, mobile telephony in Latin America shows lower polarization indexes in terms of geographic areas (urban vs. rural) and also in terms of household income. Therefore, data on households show that mobile telephony is reaching population segments that belong to lower socioeconomic groups that have never before had access to other interactive communication technologies (such as, for instance, fixed telephony). Indeed,

distribution of mobile telephony among different income groups is distributed in a much more equitable way than fixed phones and the Internet.

Finally, the comparison between mobile penetration rate and data on household access to mobile telephony show that similar figures from the supply-side do not always correspond to same levels of mobile diffusion collected from the demand-side. From the analysis we performed it can be seen that, given the current levels of diffusion, when two countries (or groups of countries) show the same level of mobile penetration, the geographic area in which mobile access is more unevenly distributed is where mobile access at a household level is lower.

Summing up, demand-side data allows the depiction of a nuanced picture of the effective reach and distribution of mobile telephony at a country level. For this reason, further development of household surveys on ICT access will contribute to better understand the phenomenon and will help policy makers in the definition of accurate policies on information and communication technologies.

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The Anatomy of Mobile Handsets: On the development of effective cell phone services

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Abstract: The pervasiveness of cell phones in emerging economies has converted these devices in an ideal platform to cater services to underprivileged communities. In recent years, international organizations and mobile software developers have made an effort, together with local NGOs, to understand the needs of disadvantaged groups. However, in order to provide adequate solutions with real impact, it is also critical to understand the types of handsets used in these countries. Failure to do so will prevent services from being used by the people they were designed for. This paper presents a taxonomy aimed at characterizing cell phone features and understanding the types of services that could be developed. Using such taxonomy, we evaluate one-million handsets from subscribers in a Latin American emerging economy. Our findings show that in order to give coverage to large groups, services should use small amounts of memory, monochrome screens and simple connectivity features like SMS.

1. Introduction

In the last 10 years, the penetration rates of cell phones in emerging economies have experienced a steady growth, even leapfrogging landline infrastructures. For example, recent studies carried out by the International Telecommunication Union (ITU), show penetration rates of 96% in Venezuela, 42% in Kenya and 30% in India, as well as ratios of mobile cellular subscriptions to fixed telephone lines of 4.3:1, 25.2:1 or 9.2:1 respectively [1]. It is fair to say that cell phones are a pervasive technology in emerging countries across Asia, Africa and Latin America, and as a result these devices constitute an important part of the citizen's livelihoods.

In parallel to the growing penetration rates, we have also observed an important increase in the number of mobile software developers, international institutions and carriers interested in developing cell phone-based applications and services to promote economic and social growth. Initiatives like Vodafone's *Betavine Social Exchange* [2] or the Inter-American Development Bank's *Mobile Citizen Program* [3] focus on bringing together local needs expressed by NGOs working on the field with developers and partners that might live in different geographical areas and who may not be aware of the local needs. Both initiatives have successfully managed to identify important requirements related to urban security, education, community information or health in disadvantaged social groups in Latin America and Africa.

These initiatives demonstrate that in order to develop services with social or economic impact, it is important to first discover the local needs where cell phones could provide a solution. However, it is also highly critical to understand the most common features of the actual cell phones used in the region where the service is going to be deployed, in order to avoid developing services that are either too technologically sophisticated or on the contrary, too backward.

To date, very little research has been carried out to classify and understand the features available on cell phones in different geographical areas. Such analysis would promote appropriate service design for specific regions by answering questions such as *"If I were to develop an application for an emerging economy that needs to use WAP and a camera, what is the percentage of the population that would have access to it, given their cell phone characteristics?"* We believe that mobile developers, who often times tend to focus on high-end cell phones like smartphones, could benefit from such a study. In fact, by understanding local cell phone features, we might help assess whether common generalizations such as "*their phones are similar to ours*" or "*in Latin America, even poor people own very expensive cell phones with lots of features*" are misconceptions or actually apply.

In this paper, we propose a taxonomy for mobile handset features that classifies the main characteristics of cell phones in terms of programming features, service features, connectivity features and economic features. This taxonomy aims to provide a framework to understand, plainly, the types of services that could be developed given the existing mobile handsets in a specific country or region. Additionally, we present a case study that uses the proposed taxonomy and a dataset of 1 million IMEIs. An IMEI (International Mobile Equipment Identity) is an identifier that uniquely characterizes a mobile handset brand and its model. The IMEIs in our study have been drawn from a carrier in an emerging economy in Latin America[1], and are completely anonymous (they cannot be correlated to a cell phone number). The case study evaluates the taxonomy features across the one million handsets, and analyzes the types of services that could (not) be developed to serve large social groups in the emerging economy. Thus, the main contributions of this paper are twofold:

- A taxonomy based on features that classifies the main characteristics of mobile handsets.
- An in-depth analysis of the types of mobile handsets used by 1 million subscribers in an emerging economy in Latin America, and the services that could be developed for them.

The rest of the paper is organized as follows: Section 2 summarizes related work, Section 3 describes the mobile handset feature taxonomy, and Section 4 presents an in-depth analysis of the types of handsets among one million subscribers in an emerging economy in Latin America, and the services that could be offered. Finally, in Section 5 we describe our main conclusions and future work.

2. Related Work

Although previous attempts have been made at reaching mobile handset feature taxonomies, these tend to be either very general or hard to reproduce due to platform constraints. Schiefer proposed a general taxonomy to study the different classes of mobile terminals (notebooks, handhelds, smartphones and feature phones) and described each group [4]. Gansemer proposed a more complex taxonomy based on the ER Model, a relational database model and a product-specific database implementation [5]. The lack of a simple taxonomy to structure and organize the actual features available on the handsets clearly prevents us from understanding the types of services that could be offered given a particular set of characteristics. Our aim is to provide a feature taxonomy for mobile handsets that is both complete and easy to replicate by others so as to be able to share analyses and results in a simple manner.

In terms of analysis of the mobile handset ecosystem, most of the results in this area root from mobile advertising companies that analyze handset technology worldwide and profile users' behavior in an attempt to offer personalized services and ad campaigns to different

[1] Based on the 2009 International Monetary Fund (IMF) World Economic Outlook Country Classification, www.imf.org/external/pubs/ft/weo/2009/02/weodata/groups.htm

markets. In fact, we have witnessed in recent years a tremendous increase in mobile internet traffic mostly from developed economies. This growth has sparked the creation of mobile ads companies like *Actionality, ScreenTonic, Enpocket, Quattro Wireless* or *AdMob.* Some of these have been recently acquired by large Internet or Telecommunication companies to carry out mobile analytics aimed at gaining a better understanding of the worlds' mobile ecosystem and trends. Other companies like *Wapalizer, Bango, Amethon* or *Mobilytics* focus more on analytical aspects rather than advertising, but carry out similar evaluations.

The mobile analyses developed by these companies are typically web-based i.e., the information about user behaviors and handset models is gathered when the user accesses information on the web (via mobile web or mobile wap browsers). Although results about the handset models around the world are publicly available in some cases [6, 7], these statistics suffer from a major drawback: the bias due to the lack of information from users that do not have cell phones prepared to access the web or users that fear the costs associated with that access, who in the case of emerging economies constitute a significant percentage.

In this scenario, telecommunication companies can play an important role to help understand the types of handsets and their main features for all users in the mobile handset ecosystem. In fact, these companies have access to the updated IMEIs of their subscribers, which guarantees that a handset characterization and classification can be done for all types of subscribers and not just for those with access to mobile internet. Hence, our goal is to provide a replicable feature taxonomy for mobile handsets that allows to model users from all socio-economic levels in an emerging economy and to understand the type of services that could be deployed for this specific population.

3. A Feature Taxonomy for Mobile Handsets

We propose taxonomy aimed at characterizing and classifying mobile handsets according to four differentiated groups of features: programming features, service features, connectivity features and economic features. Compiling these features for a specific geographic region will allow us to determine the type of services that can be developed to guarantee their usability by large social groups.

3.1 – Programming Features

We use two indicators to characterize the programming capabilities of a mobile handset. Studying these capabilities allows us to determine the programmability of cell phone platforms and how usable and accessible these are to developers.

3.1.1 – Memory. This feature characterizes whether the mobile handset has internal or external memory, as well as its size. The internal memory not dedicated to the phone's Operating System (OS), can be used to allocate applications and games that might be downloaded by the user or might be pre-installed on the cell phones. Some handsets also have external memory cards, which might provide additional memory space for personal use like pictures, ringtones, or in the case of smartphones even for executable applications.

3.1.2 – Operating System and Software Platforms. In terms of the Operating System, we have divided the mobile handsets into proprietary and open source software. Examples of open source operating systems are Google's *Android* or Nokia's *Symbian^3* or *^4* platforms. This type of operating systems is generally associated to smartphones, and allows for the development of high-end applications and services ranging from location-based services to translation or driving routes applications.

On the other hand, we also evaluate whether the operating system provides at least one of the following: (i) an SDK for open source development like the *iPhone SDK*, *Nokia S40* series or Samsung's *Bada*; or (ii) a software platform like JavaME (Sun) or BREW (Qualcomm), to develop applications that can be downloaded to the mobile handset.

3.2– Service Features

These features explore the hardware and multimedia characteristics present on mobile handsets that might have an impact on the type and the quality of the service or application.

3.2.1 – *Type and Resolution of Screen*. This indicator characterizes the resolution of the mobile handset screen, as well as whether it is monochrome or color-based.

3.2.2 – *Battery Life*. This is another important feature of a mobile handset, especially for emerging economies where the access to the grid power is scarce. Specifically, we measure the talk-time battery life.

3.2.3 – *Music Player*. This indicator specifies the presence of a music player on the mobile handset, which can be used to develop music-based services.

3.2.4 – *Camera*. This indicator specifies whether the mobile handset has a camera available or not, which can be used to implement applications that use image capture.

3.2.5 – *GPS*. This feature determines whether the mobile handset has a Global Positioning System, which can be used to developed geo-localized services.

3.3 – Connectivity Features

The connectivity features provide an understanding of the types of connectivity with the outside world offered by mobile handsets. As with the other features, a good understanding of these indicators will clear the path towards the development of connect-to-others' services, that are adequate to the majority of the users in an emergent economy.

3.3.1 – *Type of Network*. This feature indicates the type of network capability: 2G, 3G, etc. This indicator is of high importance when developing mobile wireless-based services given that, 3G capabilities and higher allow for always-on data access and for high data transmission rates, which are necessary for demanding applications like live streaming videos.

3.3.2 – *EMS.* This indicator determines whether the mobile handset can execute the Enhanced Messaging Service, which is an extension of the SMS service with functionalities like text formatting and limited picture and animation support.

3.3.3 – *MMS*. This variable characterizes whether the mobile handset has the Multimedia Messaging Service enabled. This service allows the submission of videos, audio and pictures to other cell phones.

3.3.4 – *Bluetooth*. This variable specifies the presence of Bluetooth on the mobile handset, to allow direct connectivity to other cell phones or computers over short distances.

3.3.5 – *Mobile Web and Wi-Fi*. This indicator studies whether the mobile handset offers access to the web and the process used for such end so as to understand the quality of the navigation service. We evaluate the presence of WAP or WEB (HTML) browsers, and the availability of Wi-Fi. In general, WAP browsers are simpler versions of HTML Web browsers. Its basic version (WAP 1.0) is text-based and has no security features. Its more recent version (WAP 2.0) is graphic-based, and offers a navigation experience almost similar to WEB browsers. While WAP browsers typically require the existence of a WAP gateway for optimized service, WEB browsers use standard HTTP over TCP/IP to connect to the web servers.

3.4 – Economic Features

We use a unique indicator to model the economic features of mobile handsets: *the price*. This feature characterizes the average price (in Euros) of a mobile handset model. Mobile handsets that are acquired through a contract with a carrier are typically offered at subsidized prices or might even be provided for free. Thus, in order to represent the real amount that the subscriber spent on the cell phone purchase, we only consider subscribers that have a pre-paid option with the carrier as good proxies to model this feature. Although one might find that this selection limits the coverage of the analysis due to the elimination of the users with a contract, it is important to highlight that in emerging economies in Latin America; typically a 95% of the total subscriber population uses the pre-paid option.

Finally, in order to account for the difference in prices due to the *age* of the handset *e.g.*, the cost of a mobile handset that entered the market in 2005 compared to one that entered the market last year; prices have to be updated to the current year by taking into account the yearly CPI (consumer price index) in the emerging economy under study and the *year of entrance to the market* of the mobile handset. The price indicator attempts to capture the maximum amount of money that citizens are willing to spend on their cell phones. It is in fact an upper bound price, given that handsets acquired in second hand markets will probably be priced at smaller quantities.

4. Taxonomy-Based Handset Analysis for an Emerging Economy

In this section, we apply the taxonomy presented above to carry out an analysis of the main mobile handset features drawn from 1 million pre-paid subscribers at an emerging economy in Latin America. Given that the IMEI uniquely specifies the cell phone manufacturer, the model type and the country of approval of the handset, we identify the IMEIs of the one million subscribers and analyze the types of mobile handsets observed.

These subscribers, whose identities are anonymized, have been randomly selected from the total population of the country. As a result, we posit that the sample constitutes a varied representation and a good approximation of the types of cell phones across urban and rural environments. Our final aim is to investigate the basic handset features available to the population and to evaluate the type of services that could be developed as well as the percentage of the population that could benefit from such services (*coverage of the service*).

Figure 1 shows a histogram with the percentage of the one million subscribers that own a different mobile handset model. The *x axis* shows the brand and model of the cell phone and the *y axis* represents the *coverage* or total percentage of the population in the study that owns such a handset model. For clarity purposes, the Figure only shows the most and the least popular handset models in terms of coverage (out of a total of 400 handsets in the sample).

We can observe that, in general, the market is very fragmented with lots of different handset models owned by small percentages of the total population. The most popular handset is the *Motorola C139*, with the largest coverage among all handset models: approximately a 3.67% of the total population under study. This cell phone has a price of 16

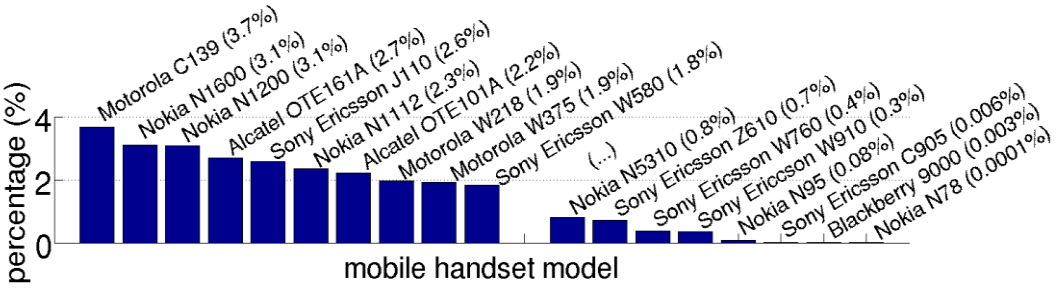

Figure1: Percentage of the population covered by different mobile handset types.

Euros and very basic features: a TFT 65K color-screen, 96*64 pixels and no user-available internal or external memory. In addition, it relies on proprietary software and does not offer Java support, radio, camera, MMS or EMS. Thus, we can infer that the type of services that could be developed for this handset model must be voice- or SMS-based, since these are the only features available for communication. The other two most popular cell phones are the *Nokia 1600* and the *Nokia 1200* with coverage of 3.1% of the total population. Compared to the *Motorola C139*, these two models have 4MB of internal memory available. Additionally, while the *Nokia 1200* has a monochrome screen, the *Nokia 1600* has a 65K color-screen.

At the other end of the spectrum, we observe that handset models with the lowest coverage rates (below 0.006% of the total population under study) are mostly smartphones with average prices above 170 Euros (see right hand side of the histogram in Figure 1). These handset models include the *Sony-Ericsson C905*, the *Blackberry 900* or the *Nokia N78*. Although not very popular across the population, these models offer all sorts of high-end features including 3G or 3.5G networks, 240*320 pixels-screens with 65K to 16M colors, internal and external memories available up to 8G, Java support, MP3 player, camera, mobile web, MMS and Bluetooth. It is obvious that these types of mobile handsets invite to the development of high-end services and applications, almost PC-like. However, it is important to highlight that these handsets are used exclusively by a very small percentage of the total population, and that any service specifically developed for such models will have low impact on the bulk of the population.

The following sub-sections describe in detail the *programming, service, connectivity and economic features* that we have observed across all the mobile handset models under study. For each feature, we evaluate two parameters: (i) the total *coverage of the feature i.e.,* the percentage of the population whose mobile handsets have that feature available (out of a total of one million subscribers), and (ii) the percentage of different mobile handset models where the feature is available (out of a total of 400 different handset models). We envision this type of analysis as a useful tool for mobile application developers that want to understand the availability of specific features across the population before designing useful and effective services for large social groups. Throughout our analysis, the features will be either *numerical features*, like the amount of internal memory available or the screen resolution, or *categorical features* like camera or MMS that simply state whether the feature is available or not on a handset model. For each numerical feature, the analysis will show a CDF (Cumulative Distribution Function) or a histogram describing the percentage of population and the percentage of handset models that share a specific value for that feature. For each categorical feature, the analysis will simply compute the percentage of the population and the percentage of handset models that have that feature available.

4.1 – Programming Features

Table 1 shows the percentage of the population (*%Population*) and the percentage of handset models (*%H.Models*) that have particular memory and software capabilities available for use. We observe that around 51% of the total population has mobile handset models with internal memory available (58% of the handset models under study). In order to visualize the exact amounts of memory in stock, Figure 2 shows the CDF for the percentage of population and the percentage of mobile handset models with internal memory and the specific amounts available (in MB). As can be seen, approximately 8% of the population with internal memory available owns handsets with 1MB or less (around 6% of the handset models with internal memory); nearly 68% of the population with handsets with internal memory available have between 1MB and 5MB; 17% of the population (20% of the handset models) have available between 5 and 15MB, and the remaining 7% of the population with handsets with internal memory owns cell phones with more than 15MB. This 7% of the population is represented by almost 40% of the handset models (160 different models), which suggests a wide variety of mobile handsets with large memory for a small percentage of the population.

Going back to Table 1, we see that only around an 18% of the total population in our study has the possibility to add external memory. The typical external memory cards are M2 (Memory Stick Micro) and microSD, and offer sizes of 1MB, 2MB or 8MB. In terms of the Operating System, Table 1 shows that all the handset models under study have a proprietary OS. Among these, a 13% of the handsets offer open source development via an SDK, most of which are *Nokia S40 and S60* (which correspond to Symbian OS v9.2 and v9.3 that are not open source). In terms of software platforms, approximately a 41% of the total population has JavaME-enabled handsets. We have found no mobile handsets providing BREW.

From this analysis, we can determine that the development of applications for mobile handsets with open source OSs or with SDKs is of little use for this emerging economy in Latin America, since these services will cover a very small percentage of the population. Thus, developers should highly focus on understanding what type of SMS-based or JavaME-based applications could be developed. Additionally, it is critical for mobile software developers to understand that half of the population does not have internal memory available and that approximately 75% of the other half will not be able to download applications larger than a few megabytes (1-5MB).

Table 1:

Programming Features across handsets in an emerging economy. We evaluate the presence of internal and external memory, the type of OS, and the software platforms available.

Feature	%H. Models	%Population
Internal Memory	58%	51%
External Memory	36%	18%
Proprietary OS	100%	100%
SDK	13%	5%
JavaME	53%	41%
Brew	0%	0%

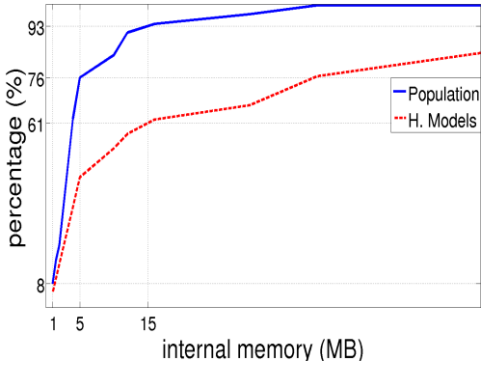

Figure 2: CDF for the amount of internal memory (MB) available in terms of (i) % of the population with internal memory and (ii) % of handset models with internal memory.

4.2 – Service Features

Table 2 shows a comparison of the service features in terms of percentage of population (*%Population*) and percentage of handset models (*%H.Models*) that share common characteristics. We observe that approximately 34% of the population owns mobile handsets with a colour screen. To better understand the colours available, Figure 3 shows the histogram for the number of colours observed across handset models with a colour screen and across the population that owns them. We see that approximately 76% of the population with colour-screen handsets has 65K colours (63% of the colour handset models), 21% of the population with colour-screen handsets has 256K, and the remaining 3% owns handsets with 16M colours.

In terms of screen resolution, Figure 4 shows that around 46% of the population under study owns handsets with screen resolutions of up to 96*68 pixels; around 42% of the population (26% of the handset models) has handsets with screen resolutions between 96*68 and 128*160 pixels; 11% of the population owns handsets with screen resolutions between 128*160 and 240*320 pixels and represent around 120 different handset models (a 30%). Finally, only 1% of the total population owns handsets with screen resolutions of 480*320.

Table 2:

Service Features across mobile handsets in an emerging economy: colour and screen resolution, battery, music player, camera and the presence of a GPS.

Feature	%H. Models	%Population
Colour Screen	69%	34%
Screen Resolution	see Figure 4	
Battery Life	see Figure 5	
Music Player	50%	41%
Camera	47%	30%
GPS	16%	2%

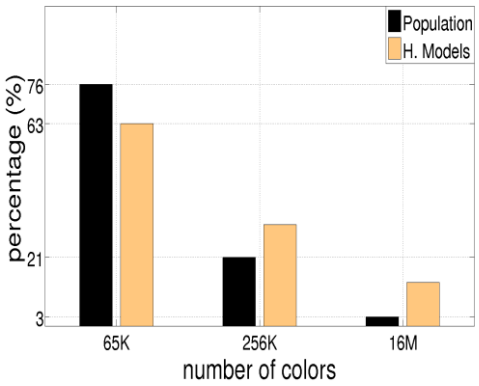

Figure 3: Histogram for the number of colours available in terms of (i) % of the population with colour screens and (ii) % mobile handset models with colour screens.

Figure 5 shows the analysis on the talk-time battery life. Around 42% of the total population (42% of the mobile handset models) has an average talk-time battery life of up to 5 hours; around a 26% of the population has between 5 and 7 hours; around 24% of the population has between 7 and 9 hours and the remaining 8% has more than 9 hours (representing an 6% of the handset models, around 24 different mobile handset models).

Finally, Table 2 shows that 50% of the handset models have a music player, 47% include a camera, and a 16% have GPS. In terms of population covered by these services, approximately 41% of the total population has access to a music player, around a 30% has a camera available (2/3 of which also have video), and around a 2% has access to a GPS.

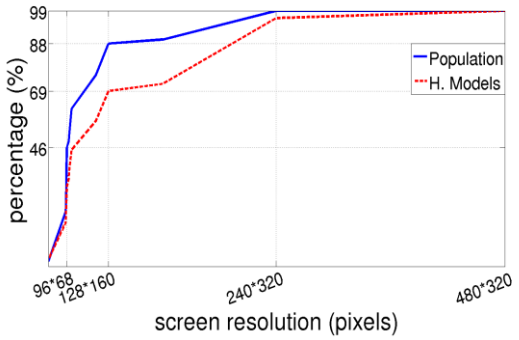

Figure 4: CDF for different screen resolutions across % handset models and % of population

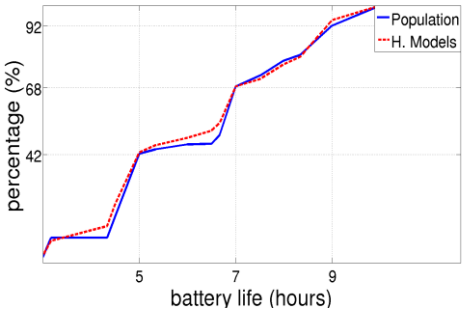

Figure 5: CDF for talk-time battery: % of handset models and % of population covered.

To summarize, we give a few hints on service and application development customized to the emerging economy under study. We note that applications and services based on colour screens will fail to serve approximately a 66% of the population whose cell phones are monochrome and with resolutions of up to 96*76 pixels. Music players and cameras seem to be available to around 30-40% of the population, with a talk-time battery life of 5 to 7 hours for almost 70% of the population. Finally, GPS-based services are only available to around 2% of the population unless the service is run by the carrier itself, in which case any handset model can be automatically localized with the subscriber's consent.

4.3 – Connectivity Features

Digging into the main connectivity features shared by the mobile handsets under study, can give us an insight into the type of connections to the outside world that new services or applications on these cell phones could use. Table 3 and Figures 6 and 7 summarize this analysis.

In Figure 6, we see that almost 97% of the total population owns 2G handsets (and all have GSM systems). In terms of mobile handset models, 80% of them have a 2G network; 5% have 3G, and the remaining 15% have a 3.5G network. Although all mobile handset models under study have SMS service available, Table 3 shows that only a 25% of the population has access to the EMS service. A similar availability is found for MMS, where a 30% of the population under study has access to that service. Connectivity between cell phones or with other devices via Bluetooth is present for approximately 25% of the population. Finally, the mobile web feature is analyzed in Figure 7. Approximately 52% of the population under study does not have access to WAP/WEB capable handsets, 21% of the population (14% of the handset models) has access to WAP 1.x and 27% of the population has access to handsets with WAP 2.0. Additionally, a 15% of the population has access to both WAP and HTTP/HTML Web browsers. Finally, only a 0.18% of the population (11% of the mobile handset models) has Wi-Fi available on the handset.

To recapitulate, this analysis shows that 97% of the population only has access to 2G networks, 52% of the population does not have access to WAP/WEB capable handsets, and 99% do not have access to Wi-Fi connections through their cell phones. These results highlight that web browsing through mobile phones in this emerging economy is not available to almost half of the general population. Alternatively, voice-based browsing or SMS-browsing should be taken under consideration. On the other hand, EMS, MMS and Bluetooth are only available to 25%-30% of the population under study.

Table 3:

Connectivity Features across handsets in an emerging economy: type of network, EMS, MMS, Bluetooth and Mobile Web.

Feature	%H. Models	%Population
Type of Network	See Figure 6	
EMS	22%	25%
MMS	47%	30%
Bluetooth	42%	25%
Mobile WEB	See Figure 7	

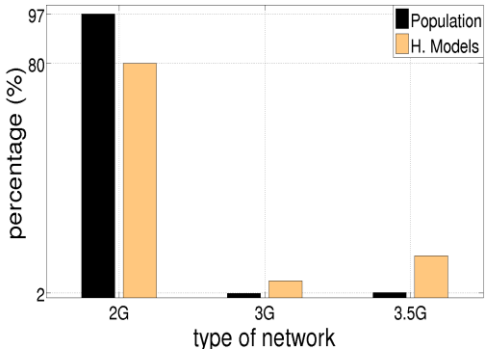

Figure 6: Histogram for the types of networks available in terms of (i) % of the population and (ii) % of mobile handset models.

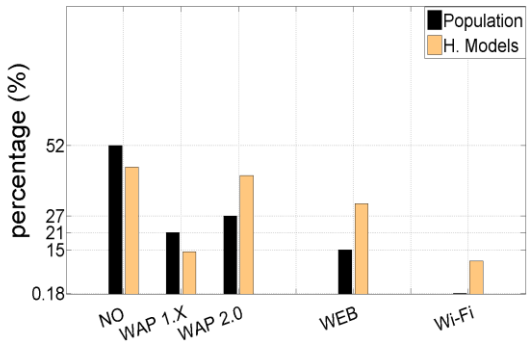

Figure 7: Histogram for Mobile Web access across % of mobile handset models and % of population.

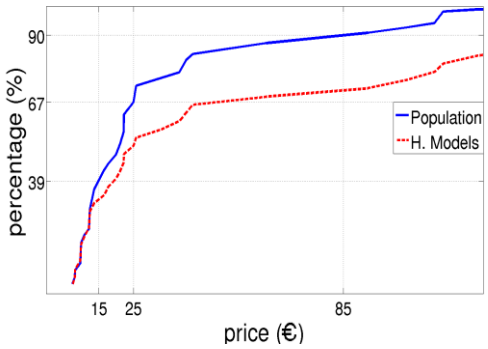

Figure 8: CDF for price feature in terms of % of population and % of handset models.

4.4 – Economic Features

Figure 8 shows the CDF for the percentage of handset models (*H.Models*) under study that cost up to a certain price, and the percentage of the population (*Population*) that spent up to a certain amount of money on their handsets. We observe that 39% of the total population has paid less than 15 euros to acquire their handsets (which represent 32% of the handset models). Around 28% of the population spent between 15 and 25 euros; a 23% spent between 25 and 85 euros, and the remaining 10% spent more than 85 euros on their handsets. In terms of *age* of the handsets, a 25% of the population owns a phone from before '05, a 67% owns a phone dated between '05-'07 and the remaining 8% owns cell phones from '07 to date.

5. Conclusions and Future Work

We have presented a mobile handset feature taxonomy that allows a relatively easy characterization of the features available on the handsets of a specific geographical region. The analysis of these features can then be used to suggest the types of services and applications that could be developed. Additionally, we have presented a case study that uses the taxonomy to understand the main characteristics of the cell phones from 1 million subscribers at an emerging economy in Latin America. Our results show that services that aim to cater solutions to a large percentage of the population should consider the small amounts of memory available (1-5MB), the widespread presence of monochrome screens, simple connectivity features like SMS, and the relative availability of JavaME and WAP.

We expect that telecommunication companies and mobile developers with a focus on emerging economies will find the proposed taxonomy useful and continue to explore its application to other countries. By sharing this information across developers it might be possible to achieve a clearer understanding of the types of applications and services that could be developed for different countries. Future work will focus on studying whether there are correlations between the types of mobile handsets in a specific geographic area, and its demographic or socio-economic indices in an attempt to ensure a better service design for different social groups.

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Farmers' use of Mobile phones in Receiving Agricultural Information towards Agricultural Development

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Abstract: Focusing on determining the extent of use of mobile phones by the farmers in receiving agricultural from the input dealers, the data were collected from 76 mobile phone user farmers in 8 selected villages of two unions under Sadar Upazila of Mymensingh district during 12 September to 15 October 2009. For ascertaining the extent of use of mobile phones by the farmers in receiving agricultural information in four major aspects, such as availability of inputs, quality of the inputs, market price of the inputs, and appropriate doses of the inputs were covered. Farmers were asked whether their contacts with the input dealers were regular, occasional or not at all (based on the number of times per season). More than half (54 percent) of the farmers had medium use of mobile phones in receiving agricultural information while 14 and 32 percent of them had low and high use of mobile phones, respectively.

1. Introduction

Agricultural production can only be increased if appropriate technologies are used by the farmers who are the primary unit of adoption of improved practices. Diffusion of proper knowledge on modern agriculture among the rural people demands on effective communication system. In addition, immediacy and effectiveness is also valuable dimension of information. The farmers should receive agricultural information as fast as possible so that they understand, interpret, accept and use the information to get the desired benefit.

In a country like Bangladesh, farms are extremely small, cultivation is dependent on the uncertainties of variable rainfall and average output is generally low. Value addition in agriculture requires technological, institutional and price incentive changes designed to raise the productivity of the small farms (Todaro, 2000). In rural Bangladesh opportunities outside agriculture sector are extremely limited. In 1991 the top ten percent of landowners owned sixty percent of the land, while the bottom sixty percent of landowners had only one percent of the land (Ullah and Routray, 2007). The structure of the agrarian system in Bangladesh is considered as a major impediment for balanced rural development (Rogaly, *et al.* 1999). Small farmers are entangled within a vicious cycle. The situation of the vulnerable farmers is exacerbated by the land erosion, drought, flood, deforestation and other natural calamities. This together with lack of financial muscle power reduces farmers' propensity to take risks. Their bargaining power in the input market is not very strong either. Lack of bargaining power reduces farmers' earnings against their produce.

Agricultural extension is an important means of enabling farmers to benefit from agricultural research and development taking the inventions and innovations to them. Its role becomes still more significant in a developing economy like Bangladesh that has low levels of literacy and high incidence of poverty, particularly in rural-areas. The low levels of socio-economic development indicators also limit the farmers' ability to derive full advantage from other sources of information, like newspaper and television, while underscoring the importance of interactive extension services to meet the informational needs of the farmers.

The popular uses of mobile phones in agricultural operations included getting to know the market-prices of crops at various places, receiving instantaneous solutions regarding seed-variety, fertilizer and pesticide availability, calling distant livestock-doctors and so on. Significant saving in both time and money/fuel were reported by farmers on account of mobile communication. The 59th round of NSS survey conducted in year 2003 revealed that only 40 percent of farmers in India have access to modern technology for farming from any source of information. Access to 'modern technology for farming' means access to scientific information on hybrid-seed varieties, fertilizer-application, plant protection, farm machinery, harvesting, marketing and animal-husbandry. The survey further revealed that just 5.7 percent of farmers have access to information from the extension workers. This clearly shows that the current number of extension workers is inadequate to meet the needs of farmers. Further, they do not reach most of the backward and remote areas that either lack of proper connectivity or lodging facility or both. In addition, the government, due to budgetary constraints cannot increase its expenditure on extension services. The research also provides evidence on the key role that mobile phones are playing in improving the information transfer between farmers and research institutions, government and private input companies, input-dealers, and other farmer. Now the farmers of Gujarat of India use mobile phones to control irrigation; farmers use their mobile phones to remotely monitor and switch on irrigation pump sets in far flung locations (Anonymous, 2009).

A research study made by Jensen (2007) in India estimated the welfare impact of introduction of mobile phones among the fishing community in some of the districts in Kerala. The study concluded that the economic impact of mobile is likely to be strongest when the absence or inadequacy of existing telecommunications facilities acts as a barrier or bottleneck to private economic activities, but also when enough, other infrastructure exists to permit the effective use of telecommunications. Mobile phones enabled farmers to access this information from a host of information providers such as scientists from seed and pesticide companies, cooperative committee office-bearers, input dealers, government agriculture extension officers, market-commission agents/traders, veterinary doctors, and so on. Mobile has started playing an increasingly useful role in the daily business of Indian farmers by providing them with much needed agricultural information related to modern farming techniques and market prices. The mobile based agricultural services are also getting enthusiastic response from the farming community and are also willingness to pay for these services.

Recently in the Philippines the use of mobile phone has been introduced for the farmers in the light of agricultural development. Mobile phones help farmers feed their fields; agricultural extension programme in the Philippines has started to deliver fertilizer advice by text message over mobile phones.

Mobile phones are now extensively used by the Kenyan, Nigerian, Tanzanian and Zambian farmers in seeking technical advice on agriculture from the extension personnel. Kenyan farmers, for example, can insure some of the costs of seeds, fertilizers and pesticides of growing crops against bad weather by using mobile phone technology that link solar-powered weather stations to an insurance company. An insurance product that caters for farmers, inputs like fertilizers and certified seeds is being delivered through the use mobile phone.

The most significant and dramatic improvement in the use of mobiles by the farmers has occurred in Uganda. The farmers have been significantly benefited from the cell phone

applications through Applab Uganda. The Applab Uganda has developed and deployed applications in the areas of health, weather, agricultural tips and advice, and the agricultural marketplace (Anonymous, 2009$_{a)}$.

In Bangladesh the use of Grameen phone is increasing steadily. A recent study conducted by Kashem (2009) shows that among 12 communication media used by the farmers in receiving technological information mobile phone ranked 5th in position (cf. Figure 1). This fact clearly demonstrates that rural Bangladeshi farmers are now shifting their preferences from traditional communication media to electronic and interpersonal communication media. Although Bangladesh is the pioneering country in introducing Grameen phones in the rural areas, however, no systematic investigation has so far been reported on the exclusive use of the mobile phone by the farmers in getting technological information. Hence, the researcher felt it necessary to undertake a research study to assess the extent of use of mobile phones by the farmers in receiving agricultural information from the input dealers towards agricultural development.

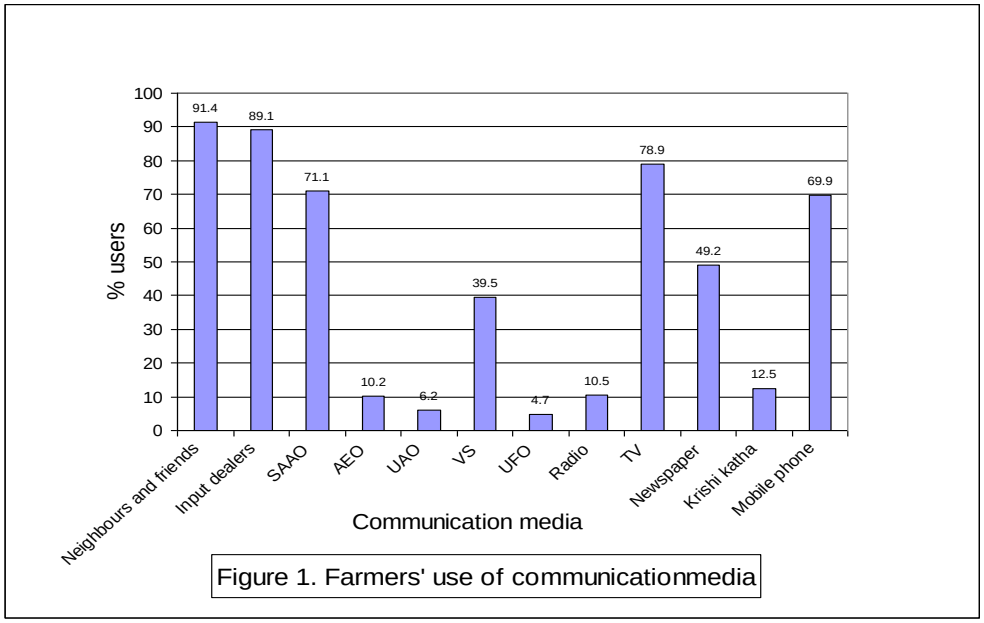

Figure 1. Farmers' use of communicationmedia

2. Methodology

The study was conducted in Sadar Upazila (Sub-district and the lowest administrative unit of the local government in Bangladesh) of Mymensingh district. The mobile phone user farmers of six villages of boira and two villages of Bhabokhali union (the lowest functional unit in Bangladesh) of the Sadar Upazila constituted the population of the study. The total number of the mobile phone user farmers in these eight villages was 305. About twenty five percent of the farmers were selected as samples following the simple random sampling method. Thus 76 farmers were selected as sample for the present study. Data were collected through pretested and predesigned personal interview schedule during 12 September to 15 October 2009.

Use of mobile phones by the farmers in receiving agricultural information was the dependent variable. The variable was measured on basis of using mobile phones in receiving agricultural information from the input dealers in four major aspects, such as availability of inputs, quality of the inputs, market price of the inputs, and appropriate doses of the inputs; each of the aspects covered four dimensions (cf. Table 3). Farmers were asked whether their contacts with the input dealers were regular, occasional or not at all (based on the number of times per season) for each of the dimensions. A weight of 2, 1 and 0 were assigned for regular, occasional and not at all

responses respectively. Thus, extent use of mobile phone by the farmers was computed through adding scores of all items of 16 dimensions. Total possible score could range form 0 to 32, where '0' indicated no use and '32' indicates high use mobile phone in receiving agricultural information from the input dealers.

With a view to get a comparative picture on the use of mobile phone for each of the sixteen dimensions a Mobile Phone Use Index (MPUI) was computed by using the following formula:

$$MPUI = N_r \times 2 + N_o \times 1 + N_n \times 0$$

Where,

N_r = Number of farmers using mobile phone regularly
N_o = Number of farmers using mobile phone occasionally
N_n = Number of farmers never using mobile phone

Thus, MPUI could vary form 0 to 152 where 0 indicates no use and 152 indicate regular use of mobile phone. Each dimension was ranked according to obtained score.

However, in order to measure the problems faced by the farmers in communicating with the input dealers while using mobile phone each respondent was asked, against 10 pre-identified problems, (problems were identified through Focus Group Discussion –FGD) to indicate the extent of problems in a 4-point rating scale such as not at all, low, medium and high with a score of 0, 1, 2, and 3 respectively. The possible scores of the respondent ranged from 0 to 30 where 0 indicates that the respondent had no problem and 30 indicate his highest problem.

For clear understanding of problems faced by the farmers in using mobile phone, rank order for each of the problems was computed by developing Problem Facing Index (PFI). The PFI was measured by using the following formula:

$$\text{Problem Facing Index (PFI)} = (P_h \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0).$$

Where,

P_h = High problem faced by the farmers while using mobile phone
P_m = Medium problem faced by the farmers while using mobile phone
P_l = Low problem faced by the farmers while using mobile phone
P_n = No problem faced by the farmers while using mobile phone

Thus, PFI of an item could range from 0 to 228, where 0 indicated no problem at all and 228 indicated high extent problem faced.

3. Findings and Discussion

The findings have been presented in four sections, each section deals with some specific issue.

Selected Individual Characteristics of the Mobile User Farmers

Human life is the aggregation of variety of attributes by his characteristics. For this reasons, it can rightly be assumed that the characteristics of different farmers might have differential influence on the use of mobile phone in receiving agricultural information. In the present study ten selected characteristics such as age, literacy level, agricultural knowledge, farm size, annual income, organizational participation, non-localise behaviour, aspiration, self-confidence and attitude towards technology and their use of mobile phone were studied. The salient findings of the characteristics of the farmers are presented in Table 1.

Table 1: Characteristics profile of the farmers

Characteristics	Measurement (unit)	Possible range	Observed range	Categories	Respondents		Mean	% CV
					number	%		
Age	Actual years	-	25-66	Young (up to 35) Middle-aged (36-45) Old (>45)	24 23 29	31.6 30.3 38.2	42.66	26.25
Literacy level	Year of schooling	-	0-12	Illiteracy (0) Primary education (1-5) Secondary education (6-10) Above secondary education (>10)	8 10 36 22	10.5 13.2 47.4 28.9	8.20	42.20
Farm size	Actual (in ha)	-	0.19-2.56	Small (≤ 1 ha) Medium (1.01-3 ha) Large (> 3)	53 23 0	69.7 30.3 0	0.85	60.73
Annual income	Actual (1=Tk.000)	-	0.98-475	Low income (≤ 100) Medium income (101-200) High income (>200)	39 29 8	51.3 38.2 10.5	121.87	62.32
Organizational participation	Rated score	-	0-11	No participation (0) Low participation (1-5) Medium participation (6-10) High participation (above 10)	3 63 9 1	3.9 82.9 11.8 1.3	3.80	55.50
Non-localite behaviour	Rated score	-	3-11	Low (>5) Medium (6-10) High (>10)	15 60 1	19.7 78.9 1.3	7.13	26.44
Agricultural knowledge	Computed score	0-28	10-27	Low (up to15) Medium (16-20) High (>20)	18 35 23	23.7 46.1 30.3	18.61	19.43
Aspiration	Computed score	5-15	10-15	Low (up to11) Medium (12-13) High (>13)	12 51 13	15.8 67.1 17.1	12.54	8.87
Self-confidence	Computed score	5-15	10-15	Low (up to11) Medium (12-13) High (>13)	19 46 11	25 60.5 14.5	12.36	9.22
Attitude towards technology	Rated score	10-50	20-42	Unfavorable (up to 31) Moderately favorable (32-36) Favorable (>36)	15 39 22	19.7 51.3 28.9	34.25	12.29

Use of Mobile Phones by the Farmers in Receiving Agricultural Information from the Input Dealers

The possible scores of using mobile phone by the farmers could range from 0 to 32. The computed mobile phone using scores ranged from 8-26 with an average of 14.66 and coefficient of variation 27.53 percent. Based on their mobile phone using scores the respondents were classified into three categories as shown in Table 2.

Table 2: Use of mobile phone by the farmers in receiving agricultural information

Mobile phone using farmers			**Mean**	**% CV**
Categories (score)	**No.**	**Percent**		
Low (up to 10)	11	14.50	14.66	27.53
Medium (11-16)	41	53.90		
High (>16)	24	31.60		
Total	76	100.00		

Data presented in Table 2 show that more than half (53.90 percent) of the respondents had medium use of mobile phones in receiving agricultural information from the input dealers while 14.50 percent and 31.60 percent of them had low and high use of mobile phone, respectively. The finding clearly indicates the importance of using mobile phones by the farmers in receiving agricultural information from the input dealers. About one-third of the respondents had high use of mobile phones in receiving agricultural information from the input dealers while only a negligible portion of them (14.5 percent) had low contact.

Most of the farmers preferred mobile phones for communicating with their family members, neighbors and relatives. Therefore, it is necessary to encourage the farmers to receive agricultural information regarding availability, quality, market price and doses of different inputs like seeds, fertilizers, pesticides and herbicides through mobile phones. The Mobile Phone Use Index (MPUI) of the farmers was computed in order to ascertain their preferences of using the mobile phones. The MPUI of a respondent on any dimension could vary from 0 to 152 where 0 indicating no use and 152 indicating the regular use of mobile phones. The findings are presented in Table 3.

Table 3: Ranking of sixteen dimensions of mobile communication with the input dealers

Aspects of using mobile phones	MPUI	Rank order
Availability of Inputs		
• Availability of fertilizers	142	1
• Availability of seeds	131	2
• Availability of pesticides	117	3
• Availability of herbicides	57	13
Quality of the Inputs		
• Better seeds	112	4
• Balanced fertilizers	58	12
• Appropriate pesticides	76	10
• Appropriate herbicides	32	14
Market price of the Inputs		
• Market price of fertilizers	104	5
• Price of the different seeds	98	6
• Price of pesticides	94	7
• Price of herbicides	24	15
Appropriate dose/Quantity of Inputs		
• Different fertilizer doses	65	11
• Seed rate of different crops	79	9
• Pesticide doses	97	8
• Herbicide doses	20	16

The findings of Table 3 reveal that "availability of fertilizers" ranked 1st followed by availability seeds, and availability of pesticides respectively. It is quite likely that farmers in Bangladesh in many cases remain anxious about the availability of agricultural inputs, especially fertilizers, seeds and pesticides. This has been rightly reflected in the findings since these issues topped the ranked by the farmers while contacting with the input dealers for agricultural information.

Relationship between the Selected Characteristics of the Mobile User Farmers and their Use of Mobile Phones in Receiving Agricultural Information

The purpose of this section is to examine the relationships of ten selected characteristics of the farmers with their use of mobile phones in receiving agricultural information from the input dealers.

Each of the characteristics constituted independent variables while use of mobile phones by the farmers in receiving agricultural information was the dependent variable. The null hypothesis formulated as $H_{0:}$ "There are no significant relationships between the selected characteristics of the farmers and their use of mobile phones in receiving agricultural information". The hypothesis regarding the dependent and independent variables were examined through computing the Pearson's Correlation Coefficient (r). The findings have been shown in Table 4.

Table 4: Relationships between the selected characteristics of the mobile phone user farmers and their use of mobile phones in receiving agricultural information (N=76)

Dependent variable	Independent variables	Values of correlation coefficient ("r")
Use of mobile phone by the farmers	Age	-0.319**
	Literacy	0.320**
	Farm size	0.041
	Annual income	0.260*
	Organizational participation	-0.036
	Non-localite behaviour	0.465**
	Agricultural knowledge	0.364**
	Aspiration	0.487**
	Self-confidence	0.441**
	Attitude towards technology	0.287*

*** significant at 1% level of probability*
** significant at 5% level of probability*

The findings at Table 4 reveal that literacy, annual income, cosmopoliteness, agricultural knowledge, aspiration, self confidence and attitude towards technology of the mobile phone user farmers had significant positive relationships with their use of mobile phones in receiving agricultural information from the input dealers, while the age of them had significant negative relationship with the use of mobile phones in receiving agricultural information from the input dealers. From the findings it is clear that if the literacy level of the farmers and their knowledge can be increased through some means of non-formal education, it is expected that their use of mobile phones in receiving agricultural information from the input dealers as well from other sources would be increased. This is of course important for the administrators and concerned others for policy implications.

Problems Faced by the Farmers in Communicating with the Input Dealers while Using Mobile Phone

The mobile phone user farmers were asked to indicate their intensity of problems against ten predetermined problems identified during pre-testing of the research instrument. The findings have been presented in Table 5.

Table 5: Problems faced by the farmers while using mobile phone with rank order

Sl. No.	Problems in using mobile phone	Obtain score for each problem	Rank order
1.	High call rate	203	1
2.	Difficulty in loading money to mobile set	201	2
3.	Failure to contact other mobile phone users instantly	181	3
4.	Lack of adequate mobile credit	172	4
5.	Damage of mobile	139	5
6.	Lack of repairing facilities	131	6
7.	High cost for repairing	113	7
8.	Mobile operating problem	75	8
9.	Lack of electricity for charging mobile	69	9
10.	Network problem	32	10

It is evident from Table 5 that the "high call rate to contact with input dealers" appeared as the number one problem followed by difficulty in loading money to mobile set, failure to contact other mobile phone users instantly, and lack of adequate mobile credit. All of these problems are, in fact, associated with money on which the policy makers little control. Any way attempt may be taken by the concerned authorities to think how these problems can be reduced for increasing the contact of the farmers through mobile phones with the input dealers and other sources of information for increasing production and income towards livelihood improvement of the farmers.

4. Conclusion

Among the sixteen dimensions of contact, farmers had the highest contact with the input dealers through mobile phone in respect of the availability of agricultural inputs, such as fertilizers, seeds and pesticides. Farmers become very anxious to know the availability of agricultural inputs before starting any crop growing season and as such their use of mobile phone with the input dealers topped the rank. Hence, it would wise if arrangement can be made by the concerned agencies for toll free mobile call by the farmers to the input dealers. This would not only increase the effective mobile call by the farmers but it would also increase agricultural production through the increased use of agricultural inputs in appropriate time.

More than half (54 percent) of the mobile phone user farmers had medium use of mobile phones while 31 percent had high and only 15 percent had low use in receiving agricultural information from the input dealers. Hence, it is concluded that there is ample scope to increase the use of mobile phones by the farmers in receiving agricultural information not only from the input dealers, but from other sources of information in the area. The findings reveal that literacy and non-localite behaviour of the farmers had significant positive correlations with the use mobile phone by the farmers. This indicates the importance of literacy and farmers' visits to areas other than own localities. Literacy and non-localite behaviour of the people helps to increase their contact with new ideas through traveling outside their own social system. It helps an individual collect new ideas and information through interactive communication media like mobile phones. With the increase of literacy and non-localite behaviour of the farmers, their use of mobile phones would also be increased. Hence, it is necessary to increase the literacy level of the farmers through arranging mass literacy campaign and non-localite behaviour of the farmers through arranging tours, visits to research stations and other places of agricultural importance.

Aspiration and self-confidence the farmers and had significant positive relationships with their use of mobile phones in receiving agricultural information. Through aspiration an individual becomes hopeful about his future situations and becomes self-motivated to work hard to make his fortune. Achievement motivation leads one to be confident in acquiring information towards his welfare and improvement. Thus it may be concluded that there is possibility of increasing farmers' use of mobile phones if the arrangement can be made to increase their aspirations and self-confidence though non-formal education or any other practical means.

High call rate, difficulty in loading money to mobile set, and failure to contact other mobile phone users instantly appeared as the top three problems of using mobile phone by the farmers. Arranging toll free call for the farmers in respect of their queries regarding agricultural inputs may be helpful to overcome the problem of high call rate. Arrangement for more and more flexi load shops in the rural areas may help to reduce the difficulty in loading money to mobile set while increasing the network towers may be useful in reducing the network problem of contacting other mobile phone users for interpersonal communication for exchanging views about agricultural inputs.

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Preliminary insights to the role of the private sector in developing mobile services for low-income segment: Case M-Pesa and Ovi Life Tools

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Abstract: Private sector role in information and communication technologies for development (ICT4D) research remains an understudied issue. To fill this gap, this paper offers preliminary insight into business view and private sector role in ICT4D. This is done by introducing business related concepts of bottom of the pyramid (BoP) and corporate responsibility (CR), and combining these two concepts with discussion on disruptive innovation. M-Pesa in Kenya and Ovi Life Tools in India are used as case examples for disruptive low-income segment innovations. This study argue that, when better understood, private sector can contribute significantly to ICT4D, especially by integrating core service strategies to ICT4D to create commercially sustainable and scalable social change.

1. Introduction

Heeks (2008) argues that so far information and communication technologies for development (ICT4D) research has focused mainly on computer science, information system science and development studies. Mobiles for development (M4D) is a sub-branch of ICT4D. ICT4D and M4D address adoption, use and impact of ICT (Sein, and Harindranath 2004; Donner 2008) among people living in different poverty levels (Chen and Ravallion 2008) to support sustainable well-being. Mobiles are in focus of this study caused by the hope of mobiles to connect the remaining 5 billion people (Heeks 2008) to global information network (Castells et. al. 2007). It is good to remember not to consider mobile technologies as imperative (Toyama 2010). Recent research indicates that Internet connections via PC remain at 1.6 billion, while mobile phones have reached the current penetration rate of 4.6 billion by 2009 and is expected to reach at 5 billion by the end of 2010 (ITU 2009).

Current ICT4D research treats partnership between government, private sector, and non-governmental organizations (NGOs) as a fundamental part of ICT4D (Kumar, 2005; Kuppusamy et. al., 2009; Reinhard and Madacar 2006). However, none of these studies really focus on better understanding the private sector motives and objectives in low-income segment. Review on three top journals focusing on ICT4D (Heeks 2010) show that private sector role remains understudied issue in ICT4D research.

The purpose of this study is to better understand the "murky" role of private sector in ICT4D: "*Private firms are increasingly investing in ICT4D for reasons which appear to lie at the rather murky interface between CSR (corporate social responsibility) and BOP (seeing the poor as bottom of the pyramid consumers)* (Heeks 2009)." In other words, the research questions of this study are as follows: How can we better explain successful private sector innovations in ICT4D?

First, bottom of the pyramid (BoP) market oriented view is discussed and reflected on current approaches on low income markets. Second, corporate responsibility (CR) is discussed. Traditional view in CR is challenged by introducing social innovation and CR innovation to clarify how companies can better contribute to ”D” in ICT4D and M4D in new innovative ways. Last and third, disruptive innovation is introduced as an emerging concept in low income BoP markets.

Most of the M4D services are still in pilot phase (Donner 2008; Hellström 2010), but some have already raised global interest. Two of these are mobile banking and payment service M-Pesa in Kenya and agricultural information service Ovi Life Tools (OLT) in India. One interview was conducted in Nokia to understand better the OLT concept and material from secondary sources was used to analyse M-Pesa. Finally, private sector role in ICT4D is discussed and future research directions are pointed.

2. Theoretical Background

The Bottom of the Pyramid (BoP) concept was introduced by Prahalad and Hart (2002). They refer to market-based approach to reach the untapped market of billions living at the bottom of the pyramid while same time contributing to global poverty alleviation and development. However, during the last years, this world view has received criticism (Karnani 2007; Landrum 2007; Crabtree, 2007). First, it seems that activities of private sector in BoP markets do not reach the poorest of the poorest (1.4 billion people living in extreme poverty). Second, actually there is no fortune seen in BoP market defined by Prahalad (2004). Karnani (2007) argues that this is caused by the fact that BoP markets are often geographically disperse, culturally heterogeneous, weak in infrastructure and transactions are usually small leading to high costs. Third, consumer oriented view by selling products or services designed for rich (pro-poor approach) many times does not respond to demand in low-income market, and most importantly does not contribute to social and economic development of people living in different poverty levels.

Prahalad (2004) ignores the corporate responsibility (CR) as main a driver for companies to target BoP and argues that multinational companies (MNCs) should include BoP to their core business. As seen from Karnani (2007), as there is not enough financial incentives in low-income markets compared to more lucrative high-end markets for most of the multinational companies (MNCs), not many MNCs will target their core business to BoP (Karnani 2007; Halme and Kandachar 2008). This would mean corporate responsibility to remain the main link between private sector and ICT4D.

Halme and Laurila (2008) define corporate responsibility (CR) as policies and activities that go beyond mandatory obligations such as economic responsibility (being profitable) and legal responsibility (obeying the legislation and adhering to regulation). In CR, private sector balances between financial and social outcomes. It seems that private organizations are focusing on CR activities mainly for financial purposes (Orlitzky et. al. 2003). This indicates that private sector has very different motives on ICT4D than NGOs or social entrepreneurs, meaning that better approaches and understanding of private sector are needed from ICT4D professionals and researchers.

Kanter (1999) gives deeper understanding of social responsibility by arguing that private sector could see social sector as beta site for innovations. To understand better what Kanter (1999) means by social sector as beta site, we need to turn to the disruptive innovation theory. Disruptive innovation theory was a response to a need to understand what drives innovation in the context of specific industries and products, technologies and market environments (Christensen and Bower 1996, Lyytinen and Rose 2003) and was popularized by the seminal works of Christensen (1997) and Christensen and Raynor (2003). Christensen and Raynor (2003) defined sustaining innovations to describe evolutionary nature and disruptive to describe revolutionary nature of technological innovations.

Disruptive innovation is seen as a powerful approach when broadening and developing new markets and providing new functionality, which in the end may disrupt existing markets

(Adner 2006, Christensen and Raynor 2003 and Govindarajan and Kopalle 2006). Following Christensen (1997), disruptive technological innovation is defined as technology that is different from mainstream technologies and is initially inferior to mainstream technologies with dimensions of performance in traditional attributes and cost. Govindarajan and Kopalle 2006 added that disruptive innovation can also could also be inferior in performance and have higher price as the cellular phone. Still, disruptive innovation normally serves initially niche markets that value non-standard performance as new value propositions. While in mainstream markets evolutionary mobile services based on electronic services using WAP and GPRS are developed, some corners of the world technologies as SMS and USSD are preferred. In this research, augmented SMS based mobile services play the role of disruptive innovation defined. This creates new low end service markets and might, but not necessary will, disrupt the existing markets in unexpected ways. Business logic of disruptive innovation comes from the expectations that further development of disruptive technology, to product and finally business model will reach sufficient level of established performance of mainstream markets. Govindarajan et. al. (2009) call disruptive innovation as a reverse innovation when innovation is developed and implemented first in emerging market context to respond low-income segment demand, and afterwards distributed to global markets.

To understand better the factors of disruptive innovation Yu and Hang (2009) divide current disruptive innovation discussion into four different perspectives: 1.) the context and external environment; 2.) customer and marketing perspective; 3.) and the technological perspective; 4.) the internal management perspective including business models. To highlight disruptive innovation to ICT sector Kallio et. al. (2006) framework is used for four key external factors determining suitability of ICT business models within different markets: 1.) Government policy and regulation; 2.) Customer base; 3.) Technological advances and constrains; 4.) Value chain dynamics between network operators and suppliers.

To conclude, first, most probably private sector will not target dedicated core businesses to low-income markets with pure financial means. Second, we can also conclude that corporate responsibility will remain as the main driver and channel for private sector to contribute to ICT4D and poverty reduction. The question remains, whether ICT4D community can better understand the motives of private sector and include private sector better to ICT4D activities and via versa. Third, the theory of disruptive innovation was presented to better understand how to move from whether CR innovation or BoP low-income market innovation to real social business innovation. Disruptive innovation theory was explained to clarify how companies can move towards CR innovation and to create sustainable business models for low-income markets.

3. Methodology

Research on mobile services in developing country context is still scarce (Donner 2008) and most of the services are still in pilot phase (Donner 2009; Hellström 2010). Even though many of them are still in pilot phase, some mobile services developed in low-income context have already raised interest in global level. Two of these are M-Pesa (Economist 2010) in Kenya and Nokia Life Tools (Economist 2009) in India.

Comparative case study method is chosen to this research as it appropriate in early stages of research or when a fresh perspective is needed (Yin, 1994). Case study follows analytic induction (Orlikowski et. al., 1991) as this approach is suitable in qualitative studies where continuous iterative discussion is done between empirical data and existing theoretical discussion. The purpose of this study is not to build a new theory as such but combine existing theories in the way to support better understanding of the case specified in this study and phenomenon around it.

The two case examples analysed are: Nokia Life Tools (from June 2010 Ovi Life Tools) in India and M-Pesa in Kenya. In the case of Nokia, one open unstructured interview was conducted with a senior Nokia manager responsible for the Ovi Life Tools service. In the case of M-Pesa, secondary material was searched for using Google Scholar to find all

relevant studies indicating M-Pesa mobile payment service in Kenya. The articles chosen to this study, were based on their relevance and direct connection to M-Pesa case studied. M-Pesa is a well-studied service and we were able to find enough secondary material to answer the research question of this study. On the other hand, Ovi Life Tools is not yet a widely studied service, which meant that interviewing was chosen. Open unstructured interview was chosen because of the exploratory nature of the study.

The author takes full responsibility of subjective selection and analysis of selected secondary documents, and unstructured interview results, still arguing that total material analysed gives a valid initial picture on the of private sector role in ICT4D, and contributes to our understanding on disruptive innovations in low-income context.

4. Analysis

4.1. Context and environment

Disruptive innovation in the low-income context depends on the variation of pre-existing contextual factors, such as, government policies and regulations of the country in question. We will discuss these two factors.

First, Porteous (2009) argues that developed regulatory regimes do not always provide beneficial environment for mobile banking diffusion, and the lack of coordination among regulators remains one of the biggest obstacles to progress in mobile banking. It seems that while developed countries are seeking for optimal regulatory frameworks to launch mobile payment systems, Kenya and M-Pesa have taken a different road. Instead of establishing a regulatory environment first, Kenya has provided an environment where innovations have been able to develop and diffuse first and regulation follow this progress (Mas and Radcliffe 2010). Second, economic conditions in both countries, India and Kenya, have been suitable for mobile service innovations because of national policies supporting networks as well as recent stable economic growth and political stability. However, M-Pesa has faced unexpected challenges when trying to expand to the neighbouring country of Tanzania, where people have not been used to any kind of banking services, and the lack of national ID system have made registering for M-Pesa service challenging (Camner and Sjöblom 2009). Last it could be said that both M-Pesa and NLT have gotten also support from Safaricom's and Nokia's markets positions. Safaricom has 80% market share in Kenya and Nokia has over 60% markets share in India. In addition, Nokia is seen as the most admired brand in India and Safaricom is highly trusted in BoP communities in Kenya.

To conclude, this chapter shows how low-income context can be favourable for disruptive innovations if there is no strict regulatory environment in place. Local country conditions do, however, raise challenges for innovation in the low-income context. It seems that incumbents are many times in the best position as market makers with their high penetration rates and trusted brands. This perspective could be used to persuade more private sector players, small and big, to invest and focus more on ICT4D initiatives.

4.2. Business model perspective

From business model point of view, M-Pesa was originally developed from corporate responsibility initiative to support micro-finance institutions to allow un-banked population to receive and re-pay small loans with their handsets. “Initial purpose of the M-Pesa was to contribute on millennium development goals in part of Vodafone to offer easy access to micro loans by unbanked market segment (Hughes and Lonie, 2007)”. However, currently only 30% of the M-Pesa users are from initial market segment of extreme poor. Ovi Life Tools (OLT), in turn, was based on a strategic decision to target the underserved low-income markets. Instead, Nokia conducted extensive market research of nearly 14 000 quantitative and 200 qualitative interviews in 17 countries. These two cases well represent two different perspectives, CR and BoP, of private sector in emerging markets context. Next business perspective in innovating in BoP context is highlighted: Business logic, internal executive

level support and dedicated core teams. From business model perspective institutional arrangements are highlighted.

First, one of the key success factors of disruptive innovation by Christensen (2006) is the expectations of financial return and evaluation in non-traditional financial measurements. Henderson (2006) claims that the incumbents fail to capture disruptive innovations when focusing too much on existing customers and high margin opportunities. To compete with other internal projects for funding, M-Pesa applied for and received $1 million external development funding from U.K. government Department for International Development (DFID) for the project (Hughes and Lonie, 2007). M-Pesa strategy was not about generating revenue directly, but instead to be part of a strategy to decrease churn (Mas and Rosenberg, 2009) and to contribute to private sector corporate responsibility (Hughes and Lonie, 2007). The same principle applies for Nokia: NLT is not seen as immediate "gold mine" for Nokia, and the success in not measured in direct financial outcomes. The purpose of OLT is to contribute a growing customer base, and its retention in future, and to allow for experimenting with new service concepts.

Second, both M-Pesa and OLT received high level executive support, M-Pesa for CR initiative (Hughes and Lonie, 2007) and NLT for new business unit initiative. Third, M-Pesa got dedicated team from Vodafone and local operator Safaricom to develop and implement the service (Hughes and Lonie, 2007). Nokia went even further by initiating new Emerging Markets Services unit around the OLT. Both services indicate long term commitment to service from executive levels.

Last, institutional cooperation is seen as most challenging part of service implementation. Michael Joseph, the CEO of Safaricom, argued that the greatest challenge in implementing M-Pesa has been creating the new institutional relationships that needed to be established before the launch to create sustainable growth for the service from very beginning (Hughes and Lonie, 2007). Institutional relationships are also named as the biggest challenge for NLT: "Agreeing with local content providers was expected to be a hard task for OLT developers, but it came as a surprise how much time and resources it finally took to provide locally relevant content in the way all including partners were satisfied with."

To conclude, this chapter executive level support and dedicated core teams, in case of CR or BoP market initiative, are seen crucial for scalable innovation development in BoP context. For ICT4D community to better understand private sector, retention and growing future customer base are the key issued to address. Large scale institutional cooperation capability seems to be also major benefit from private sector to ICT4D initiatives.

4.3. Customer orientation and marketing perspective

Lack of understanding the real customer needs makes companies handicapped in creating disruptive innovations (Christensen 1997). M-Pesa simulates well known dual system thesis, among development professionals, where urban migrant workers maintain strong ties with rural areas (Mas and Morawczynski 2009). M-Pesa is pervasive as it fits into already established everyday routines and interests by helping people to do better what they were doing before the technology was introduced (Mas and Morawczynski 2009). OLT decreases the information asymmetries that have existed between individual farmers and middlemen selling seeds and information, and buying products. In simple terms, OTL facilitates cutting the middleman and provides locally relevant information. Customer orientation is reflected also in pricing. M-Pesa is made affordable by customer pricing and agent commission structures (Mas and Ng'weno 2009). NLT has SMS based monthly fee structure to offer unlimited information flow with affordable price.

In marketing, Safaricom has build from initial 350 agent network an impressive structure of 17 000 agents network spreading all around the country to support M-Pesa service diffusion (Camner and Sjöblom 2009; Mas and Morawczynski 2009). Partnership with institutions that are close to customers and have existing contact with customers and engaging them have been important part of success (Hugh and Lonie, 2007) meaning agents

have had important role in registering customers and educating new users (Mas and Radcliffe 2010). NLT instead currently relies on their existing delivery network and pre-installed service in their low end phones sold on Indian markets where they have 60% markets share.

To conclude, customer orientation is the key issue on developing services for people living in different poverty levels. ICT4D professionals could contribute on this and benefit from scalability offered by private sector with their marketing channels. Private sector can also offer business models that are commercially sustainable rather than financially sustainable (See Furuhold 2009).

4.4. Technological Perspective

Existing technological legacy systems have been absent in both cases studied. M-Pesa replaced an ineffective and untrusted remittance system (Mas and Radcliffe 2010; Morawczynski, 2008). NLF offered new ways of doing agricultural business and facilitated the agricultural business in simple and effective way. In both cases there were no effective PC broadband based structures to compete with the mobile service base.

M-Pesa and OLT have created innovative service solutions from existing technologies (SMS) that are inferior to existing mainstream technologies (GPRS and WAP). Current mobile service discussion in high end markets is mainly dominated by GPRS and WAP based services. Emerging smart phones and app stores are examples of this development. However, innovation in emerging markets requires different mindset as market penetration of low end phones, and lack of 3G network coverage. The solution has been creative new ways of utilizing existing SMS functionality to create augmented SMS services.

Technological simplicity is reflected by M-Pesa use of SMS technologies to transmit information and service is integrated to phone's menu making response time fast even with low cost phones. The same applies to NLT where Nokia developed innovative technological solution to transfer binary data via SMS channel and functionalities which enable easy organization of data from multiple sources.

To conclude, while there is now existing legacy systems to slow down the service adoption these simple technological innovations could motivate private sector mobile service developers to target emerging markets as test labs for service innovations (See Kanter 1999). Innovations in low-income context reflect well the disruptive innovation mindset where inferior technological attributes to mainstream technologies and low cost are the key issues.

5. Discussion and conclusions

To answer the research question, disruptive innovation theory was used to reflect CR and BoP innovations which represent two different approaches" How can we better explain successful private sector innovations in ICT4D?".

In this study we showed how favourable emerging markets and low income BoP segments are for disruptive innovations as there are no established technological legacy systems, no existing technologically oriented user habits, and no established regulatory environment on place. This should motivate more private sector involvement to ICT4D and M4D activities, and work as counter argument for current research on mobile services which sees many times Western countries as the most advanced and sophisticated test markets for new mobile services (Constantiou et. al. 2007; Bouwman et. al. 2009; Carlsson et. al. 2006). M-Pesa and Ovi Life Tools (OLT) clearly show disruptive nature of innovation where service with inferior attributes from mainstream technologies offered with low cost have created new markets. The future shows, if these services will spread globally creating reverse innovation phenomenon discussed shortly on our research.

Disruptive technologies are technologies, products or business models that provide values from mainstream (Western markets in this study) and are initially inferior to mainstream technologies along the dimensions of performance that are most important to mainstream customers. While adopting disruptive mindset, companies could set up learning laboratories

in emerging regions of the world, where they could stretch their thinking, extend their capabilities, experiment with new technologies, get feedback from early users about service potential, and gain experience on working with underserved and emerging markets. To refer prominent mastermind and blogger in M4D Erik Hersman:

"Africa is a big sized lab for the latest innovations for both high-end and low-end kind of phones (Hersman 2010)."

Disruptive mindset seem to fit very well to context when developing services for BoP consisting 5.15 billion people living different poverty levels. We argue that disruptive innovation theory related management thinking can be used to understand better ICT4D and M4D from private sector perspective. To reflect recent discussion in ICT4D there is clearly a need for more research on role of private sector in ICT4D. This study represents private sector as one partner to resolve sustainability issues by providing commercial business models without direct financial outcomes, and scalability for ICT4D initiatives by providing marketing channels and institutional cooperation capabilities to support ICT4D activities.

This study also showed with two case examples how private sector with marketing networks, trusted brands, and institutional cooperation capacity can contribute on scalability of ICT4D and M4D initiatives. In addition, commercially oriented business models were seen to contribute on sustainability of ICT4D and M4D initiatives. To support previous statement, while there is strong debate on failures of ICT4D projects in recent history (Heeks 2009; Heeks 2002), it seems that ICT4D projects have been better off when there has been strong private sector involvement (Kumar, 2005) or when there has been better business understanding of ICT use (Furuhold, 2009; Kumar and Best 2006; Wellenius 2003).

With disruptive in nature innovation strategies Vodafone is showing the global lead on m-banking business models that are commercially sustainable as Nokia is showing the way on building scalable service bundles. The question arises from how MNCs such as Nokia and Vodafone could facilitate service diffusion on ICT4D and M4D. Following current online discussion, it seems that the major issue seem to be how OLT and M-Pesa could open their APIs for external service developers to offer platform for new mobile services? For future research, disruptive innovation could be extended to include open innovation to better understand benefits from collaboration between incumbents and socially oriented start-ups. Bringing incumbents' R&D closer to start-ups could provide needed customer orientation, scalability and commercial sustainability needed in ICT4D initiatives. Also further studies are needed on business models for start-ups in M4D, and how they fit on incumbents disruptive innovations strategies.

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Farmers Empowerment, Opportunities and Risks: The Role of Mobile Phones in Babati District in Tanzania

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Abstract: The most widespread information technology in developing countries today is the mobile phone. A majority of people in the least developed countries still live in rural areas and their livelihood is depending on the primary industries. This study looks into the actual use of mobile phones among farmers in rural Tanzania in order to fill in with empirical data on the developmental role of this technology. Our data show that the improved access to communication and information that mobile phones represent affects the entire cyclic farming life, and have resulted in considerable changes in the entire livelihood constructs, increased opportunities and reduced risks for rural farmers.

1. Introduction

The 'digital divide' refers to "the global disparities in access to the Internet and other information and communication technologies that propelled globalization" (United Nations: Year In Review 2005, 2010). The global digital divide is a term often used to describe the gap between more and less developed countries. At the national level, there is often an urban-rural divide. In developing countries in particular, we see clear tendencies of increased concentration of information flow into urban and central areas. Economically disadvantaged countries and rural and peripheral districts within these countries tend to fall further behind in human resource development as well as in economic progress and political participation (Furuholt, 2009).

Developing countries are those nations (primarily in Africa, Asia, and Latin America) that have little or no industrial base. Characteristically, they have high rates of population growth, high infant mortality, short life expectancy, low levels of literacy, and poor distribution of wealth (World Encyclopaedia, 2005).

To create and support development in developing countries, trade, knowledge development and education are important issues. Information technology has the potential to support this development, mainly through providing access to information and through building communication lines between people (Sein and Harindranath, 2004; Furuholt, 2009).

The most widespread information technology across the world today, developing countries included, is the mobile phone. The use of mobile phones has been a huge success and has spread to the most remote areas of developing countries during the last few years.

Evidence from selected studies done by UNCTAD (2007) shows that mobile phones have become the most important mode of telecommunication in developing countries. For the vast majority of the low-income populations mobile telephony is the sole tool connecting them to

the information society. It is continued to be the only ICT use sector, where the developing countries are catching up quickly.

A majority of people in the least developed countries still live in rural areas and their livelihood is depending on the primary industries. Tanzania, which is the focus of this research, and its East African neighbours, are among the least developed countries; Tanzania ranges number 151 out of 182 ranked nations, by Human Development Index (UNDP, 2009) and more than 30% of the 40 million inhabitants are living below the poverty line. According to The World Factbook (CIA, 2010), 70% of the population live in rural areas and 80% of the labour force are working within the agricultural sector. Traditionally, lack of reliable communication channels of smallholder crop farmers in Tanzania has contributed to low opportunities that translate into high transaction cost and general poor level of development.

Today, however, we know that many of these people have access to mobile phones. People in rural areas use the mobile phone mainly for voice calling and person-to-person SMS (Hellstrom, 2010). A few initiatives have been taken to build up extended livelihood services in these areas, like platforms for information sharing, marketing and financial transaction services, but they are still in their pilot phases (Donner, 2009). There has been some research documenting the rapid spread of mobile phones in rural Africa, mainly from a supply perspective. Our intention is to study the actual use of this information technology, in order to fill in with empirical data on the developmental role of mobile phones. We have therefore conducted an exploratory study, and framed our research question:

How does access to information facilitated by increased use of mobile phones contribute to empowering of smallholder farmers in rural Africa, and help them in reducing vulnerability to risk?

We have chosen the Babati district in Tanzania as our research site. The study context is further described in section two, while section three provides a literature review on ICT for development (ICT4D) in general and use of mobile technology within the agricultural sector in particular. In section four, we present our research methodology, while section five describes and discusses the empirical findings. Section six contains our conclusions and recommendations.

2. The study context.

The population of Tanzania is young and poor. More than 42% of Tanzanians are younger than 15 years, with an average age of 18.3. People in Tanzania can expect to reach 52 years, and 36% of the population is defined as poor (CIA, 2010).

With more than 40 million people and an area of 945,000 square km, Tanzania remains one of the least urbanised African countries; the majority of the population (i.e. 75 % of all Tanzanians) still lives in rural areas. According to the Tanzanian Ministry of Planning, Economy and Empowerment (2006), 2.3 million people are unemployed, but the majority of people are self-employed and most work is seasonal in the agricultural and informal sector. About 80 percent of the employed working age population is engaged in agriculture.

The most common agriculture products are coffee, sisal, tea, cotton, cashew nuts, tobacco, cloves, corn, wheat, cassava (tapioca), fruits, vegetables and meat, while coffee, cashew nuts and cotton are among the most important export commodities (CIA, 2010).

Like in the rest of the world, the mobile phone diffusion has had enormous growth in Africa in recent years. Table 1 shows some key figures describing this trend. The diffusion has brought communication to new groups of users, users that earlier were excluded from the telecommunications systems.

Table 1: Mobile cellular subscriptions (ITU, 2010)

Country	2004 (Mill.)	2009 (Mill.)	Per 100 inhabitants 2009
Tanzania	1.9	17.5	39.9
Uganda	1.2	9.4	28.7
Kenya	2.5	19.4	48.7
Africa	88*	295	37.5
World	1,763.0	4,676.2	68.3

*) 2005.

The table shows the number of mobile phone subscriptions, but this is not necessarily the actual number of cell phone users in these countries. That number is probably even higher. Hellstrom (2010) claims that the actual number of people and handsets behind the subscribers can differ quite substantially, mainly due to multiple SIM ownership and the way service providers report their subscriber data. He further states that a clear majority of people in East Africa has access to mobile communication, either direct or indirect through some sort of intermediaries.

Lack of access to information has traditionally made rural farmers in East Africa vulnerable to several risks, both during farming and during transport and marketing of their crop. Today, we learn from literature that the rapid spread of mobile phones has the potential to change this situation considerably (e.g. Hellstrom, 2010:41).

In order to study this potential closer, and to answer our research question, we have chosen the Babati district in central Tanzania as our research site (see maps, figure 1 and 2). Babati district is one of five districts in the Manyara region. Administratively Babati is divided into 4 divisions, 21 wards and 80 villages. It covers an area of approximately 6,069sq km and lies between 1,000m–2,500m above sea level. The northern and north-eastern parts of Babati are dominated by plains, with two prominent lakes: Lake Manyara and Lake Burungi.

Figure 1: Research site – Babati District in Tanzania

Figure 2: Research site – Babati district

To the south and west the landscape gradually becomes more mountainous, while the eastern part of the district is dominated by the Maasai steppe. The land resources of the area is divided into forest and game reserves which cover about 12 per cent of the total area, while cultivation and grazing constitute 65 percent. The major land based economic activities are agriculture, forestry and livestock keeping. Agriculture is the main economic activity in the district, and about 20 percent of the land is suitable for cultivation. Both smallholder peasant farmers and large-scale commercial producers practice agriculture. A variety of crops are cultivated, including, maize, sorghum, beans, pigeon peas, wheat and millet, while cash crops are made up of groundnuts, sunflowers, sugarcanes, bananas and coffee.

The Agricultural Sector Review (URT, 2008) has identified some key challenges facing the sector, among those being marketing information, in the crop, livestock and marketing sub-sectors in Tanzania. Current market information system is characterized by isolated efforts, for example from the sector specific organs like Sisal and Cotton boards and respective ministries, departments or agencies. According to the Agricultural Sector Review, the system is not comprehensive in the sense that it just covers small parts of Tanzania, and dissemination of market information is disorganised and not co-ordinated. Players and dealers give, for example, wrong market information to customers in order to increase their market advantages. Ministry of Industry, Trade and Marketing, has made some efforts trying to curb the problem and have established market price information on agricultural and livestock products, weekly distributed through media (newspapers) and directly to all interested stakeholders. The ministry is also building up a national database for market price information, crop types, dealers and stocks, based on data from information centres in the regions (URT, 2008).

3. Literature review

ICT has the potential to bridge the digital divide and to support development in developing countries by providing access to information and by building communication lines between people and communities around the world (Furuholt, 2009).

In their Mobile Development Report, Nokia recommends that, in order to enhance rural development, mobile phones could be used in the following four levels (Sood, 2006):

1. to provide communication
2. to provide access to information
3. for passive or inter-passive consumption of media
4. to interact with systems, institutions, communities and other users

Due to high prices of advanced mobile equipment and to expensive and poor infrastructure in poor areas of the world, the use of mobile technology in rural areas is still limited to the first level of this categorisation. We can, however, still see important traces of developmental effect by this use, presented in research literature. Some of this literature describes cases in primary industries in developing countries, for example communicating fish price information among fishermen in Kerala, India (Jensen, 2007) and SMS access to real-time seed stock inventory in the Philippines (Mendes et al., 2007). The empirical data on use like this is still limited and covers only sporadic cases.

From Africa, two reports (Menda et al., 2005; Stienen et al., 2007) describe how ICT can make a difference in agricultural livelihoods, but both of them are covering traditional computer data base solutions and not use of simple mobile technology.

Two promising examples of improving livelihood for African fishermen are presented by Myhr and Nordstrøm (2006) from Tanzania and Rashid and Elder (2009) from Senegal. In the Tanzanian study, they (Myhr and Nordstrøm) found that the fishermen used mobile phones to find buyers and thus cut the time for bringing the fish to the consumers, which lead to better quality and higher price of their products, and also made them less vulnerable to loss because of damaged catch. The project in Senegal collected fish prices and uploaded them to a central database using mobile phones. Farmers in the field were able to check prices before they set off to find out the best offer of their produce (Rashid and Elder, 2009). It was found that the farmers made about 15% higher profits for their catch after having paid net costs including cost of the information services. In addition, like in the case of Tanzania, the fishermen were able to reduce the amount of spoiled fish while in search for a market buyer.

The smallholder crop farmers and the fishermen share considerably similar environments and challenges; they all spend time away from their families and they are often away from the markets in the more urban centres. In order to improve revenues, these farmers need to capture better market prices through reliable access to information facilitated by the use of mobile phones. Mobile phones also help the farmers to control business environment and situations and reducing chances of vulnerability to several risks.

In the SIDA report on innovative use of mobile applications in East Africa (Hellstrom, 2010:41), K.S. McNamara discusses multiple dimensions of mobiles' contribution to agriculture and rural development. McNamara claims that mobile devices and services can help create a "virtuous circle" of innovation that can benefit even the poorest farmers and increasingly integrate them into local, regional and global markets. There are many ways that mobiles can support agricultural development, and help people into this virtuous circle, and these improvements can come along the entire agricultural value chain, and can benefit all participants in the value chains:

- Mobile devices can improve smallholders' access to timely information about prices, market, and farming practices.
- By helping to make markets more efficient and transparent mobiles can reduce waste and empower smallholders in negotiation with wholesalers, traders and transport

providers, and link smallholders to distant markets and higher-end agricultural value chains.

- Mobile applications can improve advance warning of weather risks, pest and other environmental risks, and provide timely, locally-relevant information on how to respond to these.
- They can also facilitate access to vital complementary services, particularly financial services.
- And mobile phones can help the rural poor in general; to connect with one another for more effective collective action, both as producers, and as citizens (Hellstrom, 2010:41).

A survey done by Souter et al (2005) in Tanzania, India and Mozambique, presents some empirical data describing the actual use of mobile phones in these countries. The results show the importance of information to people's livelihood and general well-being, ranging from information about family members, to information related to their livelihood strategies (crops management, remittance, market prices, government, and legal requirements, etc). They (Souter et al.) confirm the importance of interactive communication in order to engage in dialogue with others, whether in social or business transactions. Particularly important are those interactions linked to social capital, conversations between members of family or within a wider social network.

The survey suggests that, of the five main categories of livelihood assets (human, social, natural, financial and physical capital) telephony is most closely associated with social capital. In respect of natural capital (soil, water, trees, growing crops, etc), weather and market information are important to enable farmers to manage their resources.

Souter et al (2005) states that the potential of mobile phones, in order to reduce vulnerability, lies in people's ability to obtain information that allows them to deal with seasonal factors (e.g. weather information and security), reduce the imbalance between themselves and those they trade with (e.g. price information) and respond more quickly and effectively to shocks. It is in this latter area that the respondents in these countries acknowledge the beneficial impact of the mobile phone.

The analysis of the study shows that those who are engaged in business activities and those of higher economic status believe that the use of mobile phones has brought them significant economic benefits. Other categories, however, see no economic benefit, specifically; there is no correlation in any of the three countries between changes in household income and frequency of mobile phone use or perceived change in access to telecommunications.

4. Methodology

The Babati district in northern Tanzania was chosen as our research site because district division, wards and villages represent a typical rural, smallholders farming area in Tanzania. Thirteen surrounding villages were selected and one farmer within each village was invited for interview.

This exploratory study mainly uses, as a starting point, the levels presented by Nokia and the link between mobile technology and the agricultural value chain pointed to by McNamara, both presented in the literature review above. We realise that rural farmers in Tanzania mainly use their cell phones for communication, and we want to trace this use across the entire value chain. For this purpose, we organised our interviews as described in table 2, below.

Table 2: Farmers' activities examined in order to investigate their use of mobile phones.

Period	Activity
Preparations for farming	• Coordinating labour pool (Voluntary-based families and neighbours collectively working routinely to different family farm yards) • Weather information • Review of seeds price • Preparation kraal manure for planting (Unlike fertilizer, kraal manure is mainly used by the farmers in the area only during planting)
Farming period	• Pooling of labour for cultivation and weeding • Organizing farm-yard manure used during planting • Sharing of rain info • Hiring/borrowing of farms implements e.g. hand hoes, oxy plough, harrows etc • Knowing price of tractors for cultivation per acres • Ordering of and hiring of oxy for cultivation • Info about emerging new types of seeds • Arrange for and ordering of seeds • Knowing labour cost per unit during cultivation and weeding in the neighbouring villages • Organizing fertilizer for growing plants • Obtaining info about availability of the extension officers and subsidized farm implements from the local authorities • Coordinating info and deliveries of pesticides
Harvesting period	• Organizing and pooling of labour for harvesting • Arrange for storage materials and warehouses/stores • Arrange for and ordering of preservative chemicals against mouse and "scania"
Post-harvesting (during marketing)	• Organize transport from the farms to warehouse/homes (tractors or oxy trailer) • Call markets centres, players, dealers, and check prices and stocks of crops before settings deals with middlemen/agents or deciding to travel to capture better opportunities. • Call for and ordering rapid transportation during prices (favourable) changes • Selling crops via mobile phone • Contact with distant families/relatives (decisions, sending money) • Money transfers and payments

Along the time-line, *preparation for farming* is taking place between October and December, *farming period* is taking place between December and March, and the two last phases, *harvesting period* and *marketing* go on between June and September. From this cyclic timeline, we examined how the farmers' use of mobile phones influence on their livelihood constructs opportunity, empowerment, and vulnerability to risk.

We conducted semi-structured face to face interviews with the farmers. The sample was selected by taking into consideration the different characteristics of respondents from different villages, and addressed respondents from 13 surrounding farm-villages of Babati

district: Nakwa, Mamire, Nekamsi, Bagara, Galapo, Dareda, Riroda, Duru, Komoto, Endagwe, Miomboni, Singe, and Magugu villages. Only those farmers who sell their crops during and after harvesting seasons were interviewed.

In addition, document analysis was done through visits to different sources like Tanzania Communication Regulatory Authority (TCRA), Research on Poverty Alleviation (REPOA), Economic and Social Research Foundation (ESRF), Ministry of Agriculture, Food Security and Cooperatives, Ministry of Livestock and Fisheries, and Ministry of Industry, Trade and Marketing, to solicit related information.

5. Findings and discussion

The newly acquired possibility to own or access a mobile phone has brought radical changes to the way Tanzanian farmers communicate, receive information and support decision making, and this study reveals some of the rare new usage and impact brought by the mobile phone use. As categorized in the methodology part, this study reveals how the farming life is affected by the use of mobile phone in the cyclic pattern of the life of the farmers.

5.1. Preparations for farming and farming period

During preparation for farming and cultivation, farmers use mobile phones, mostly when calling agricultural extension officers for agricultural related advice, about prices and types of seeds, and organizing mnure and fertilizers. Farmers spent most of the time in the farm areas in the villages. Mobile phones also helped them in communicating with agrovets shops, seeking types of seeds and fertilizers to be used given the nature of the season. For example, due to delays of rains, farmers are sometimes advised to use short-term seeds. One of the respondents said:

> ”*…through the use of mobile phones, in seeking advises on types of seeds and fertilizers to use, and also through accessing markets information, my life has improved a lot. I can surely say my life have moved from one step to the other”*.

Farmers save money and time that had to be used for travelling to look for best seeds and get advice from the extension officers. These uses of mobile phone has given the farmers the possibility of coordinating activities, gaining knowledge to control situations and increasing their bargaining power and hence lower all associated costs.

Another opportunity is to seek information about the subsidized farm implements and their respective prices. Through mobile phones communication with extension officers, they find availability of the subsidized fertilizers and seeds. According to one farmer mobile phones are helping in cross-checking with companies that have produced seeds and fertilizers, and with people in neighbouring villages, if prices and advices given by the agricultural extension officers at villages are true and reliable.

One popular mobile phone usage during preparation, cultivation and planting is for mobilizing of labour from distant farms and villages. They call people they know, and when they arrive, the workers are already prepared for their tasks. Their agricultural system is labour intensive, and mobile phones make the mobilising easier.

It was also mentioned that mobile phones helps in knowing different cost per unit per labour and hence helps farmers to incur low cost of cultivation and weeding. Te phones save farmers’ time, empowers them by giving them power to control their situation and widen up channels of increasing revenues by being efficient.

Some farmers also collect rain information via the phones, in particular when their farms are located away from their village residences. This is due to the mountainous natures of the district, whereby weather conditions are different from one village to another. In Galapo village, for example (located at the windward side of Mount Kwaraha,), they grow maize and wheat and are experiencing different rain conditions compared to villages like Singe, Magugu, Riroda and Nakwa, located on the other side of the mountain. So those owning

farms in Galapo and living in other villages have to rely on mobile phones communication to get needed rain information in order to start planting and maintain their fields.

Farmers in Babati argued that the mobile phones help a lot in hiring tractors for cultivation purposes and negotiating prices.

"*… in two minutes you make three calls and choose the cheapest one and when to get the tractor*", said one of the respondents. Another respondents said that: "*we call owners of tractors in Babati, I am in a rural area, and while continuing with my activities…I can talk, and agree on the price of tractors for cultivation per acres…at the end I have saved time, and used fewer resources, say 2000 Tanzanian shillings to make a call….honestly mobile phones has improved our life to a great level*".

As an extra effect, respondents have also described situations where groups of farmers mobilise and negotiate tractor prices together and then achieve even better prices. This would never have been possible without the mobile phones.

The phones also play a role in facilitating communication for hiring and borrowing of farm implements. Respondents told that they borrow from each other because it is not possible to have all the equipment. During planting seasons, farmers communicate across villages to hire or borrow oxy plough, the oxy themselves, harrows etc. Setting deals with relatives or neighbours when to come and collect implements provides farmers with a greater command of their circumstances; it was found that mobile phones has given them a great sense of empowerment on that.

It was also revealed that mobile phone helps in communication when farmers face a tractor breakdown out-in-the farms fields. One of the farmers explains that:

> "*sometimes you might have a tractor breakdown or running out of fuel in the middle of the farms, what you do is to call the mechanic, who are mostly located in the urban (district headquarters) areas…he comes to the farm and repair the tractor, instead of pulling the tractor to the garage which is financially and time costly".*

When farmers contact mechanics in urban areas to help them in breakdowns, they well-before-hand reduces the vulnerability to risks of spending nights in the bushes, being robbed, or sufferings weather shocks.

5.2. Harvesting and marketing period

Harvesting season is the peak season for farmers. Extent of mobile phone usage increases at that time. We found that mobile phones facilitates, though to a lesser extent, in mobilization of labour, transport from farms to home to warehouses, and transport to markets. This doesn't mean that these activities are unimportant, but respondents found them minor in using air-time. Arranged in order of importance, and not how they happened, farmers during harvesting season, use mostly mobile phones in the following ways;

- *first:* calling markets centres, agents, players and dealers for prices,
- *second:* selling crops via mobile phones,
- *third:* arrange for storage materials and booking for warehouses,
- *fourth:* arranging and ordering of preservative chemicals,
- *and fifth*: contacting distant family members.

The largest market centre for smallholder crop farmers in Babati is Arusha. Before selling their crops, farmers have to call brokers or agents in Arusha to know current market prices. They, again, are usually working for businessmen from Namanga or Nairobi, in Kenya. After knowing the prices and got satisfied, they then decide to travel to Arusha to sell their crops or sell to middlemen in Babati. The supply chain of crops business can't get away from the involvement of the middlemen. If they avoid them at the village or district level, they will meet them at the major markets in Arusha. It was told, for instance, that currently there is a high demand for beans due to low production last year; middlemen are now flocking in Babati, wanting to buy beans at cheaper prices. But due to access to information enabled by the mobile phones, farmers are calling businessmen in Arusha and check and confirm the

actual market prices before deciding to sell. Farmers sometimes also call each other and ask for the current crop prices before deciding to sell or not. Communication like this gives them the possibility to negotiate better with agents and middlemen. This balances their power asymmetric relationship; it empowers farmers and gives them prospect of grasping best opportunities for increasing income.

After agreeing on the prices and size, the broker might decide to come to the village to advise farmer(s) via mobile phone to personally load and transport the crop to Arusha or anywhere else. This mode is widely used; almost every farmer is selling crops using mobile phones. One of the respondents recited that:

> "*we talk directly with Indian businessmen from Arusha about prices of maize or 'mbaazi'…they usually offer good prices…and if you have more than one ton of 'mbaazi', they come directly to your household and purchase them".*

One farmer, who is also a businessman, gave an example, whereby he used to buy crops from individual households through mobile phone communication while he was in the market in Arusha. This means that through mobile phones, nowadays farmers are rarely selling their farm products at home at throw-away prices. Selling farm products via mobile phones increase their efficiency and income. They do not need to carry the crops themselves over long distances on poor road conditions.

Access to mobile phones also helps farmers to communicate with the owners of warehouses in surrounding villages, and book storage place for their crops, after agreeing on the price. "*Without a phone, I would have forced to walk or biking and look for the owners and make a deal….that would have take time and resources…"* narrated one of the respondents.

During harvesting season, farmers are calling agricultural extension officers seeking advices on better crops storage mode and types of pesticides used to preserve the crops from pests. Purchase and ordering of the pesticides is done either from agrovets in Babati, or seeds and pesticides agents in the villages. Farmers often contact the agent's headquarters, in order to verify prices, giving the farmers a sense of control on the market.

Through mobile phones, farmers in Babati have a possibility to keep contact with their relatives far away. Before the mobile phones, they were either cut from contacting their relatives or had to postpone the farming during family emergencies. Nowadays they are able to participate in family decision making while farming. This was substantiated when one farmer enlightened that:

> *"…where I am working and make my farming activities is far from where my family lives. Through the use of mobile phone, I can easily communicate with my family, knowing their problems, advice and finding solutions before the matter has gone bad. Sometimes when a child is sick, I m calling them and tell them to go to hospital and I am sending money for covering the expenses through another person."*

Nonetheless, this study has found that farmers are prone to diverse risks during harvesting and marketing season. The interviews show that most of these are travelling-to-markets-related risks. Accounts from farmers have shown that mobile phone give farmers' great support in reducing or avoiding vulnerability to risks in several ways. They argue that the roads to the markets most of the time are in bad conditions. Knowing roads conditions helps in saving time and avoiding risk of road delays, spending nights in the road or of being robbed. One farmer confirmed this argument by saying:

> "*Robbers are sometimes hijacking transporters between Babati and Arusha, mobile phone communication helps a lot; our roads are bad, sometimes we are forced to spend nights in the roads, and all this jeopardize our security especially if you are carrying with you things like money. So we usually call and make sure that the road is accessible. Relatives or friends, who knows that you are on the same road, will call you and notify that the" road is dirty"…this helps us a lot, we can now control roads security situation*.

6. Conclusion and recommendations

This study was set out to examine the role of mobile phones as an empowering tool, a factor enhancing opportunities for increased income and a tool for reducing vulnerability to risks of smallholder crop farmers in Babati district in Tanzania. Evidence shows that the improved access to communication and information that mobile phones represent have resulted in changes in the entire livelihood constructs empowerment, opportunity and risk that this study intended to examine. This affects the entire cyclic farming life and value chain, and hence helps them controlling their situation.

We have also seen how farmers have become able to reduce several risks associated with their business. Mobile phones have in many ways made them proactive in taking care of their businesses. Enhanced access to market information via mobile phone has lifted up the amount of opportunities available. These positive changes have led to higher monetary income for the farmers and in turn improved the livelihood indicators.

The experience we gained during data collection laid the groundwork for giving some recommendations on how mobile phone use can best continue to improve farmers' life. The Ministry of Industry is trying to send updated market prices via mobile phones to the farmers, but this effort is not effective and our observations show that farmers in Babati are not aware of this service. Therefore, we recommend for mobile phones companies to establish a wider, affordable and effective service or product offering instant market prices. Prices printed in the newspapers are not useful for all farmers, because not all farmers can or have an interest of buying newspapers.

We also suggest arranging for better systems for money transfer through mobile phones, in order to make it more reliable and affordable in rural areas like Babati, where banking services are very limited. Farmers have emphasized that money transfers through mobile phones will reduce the risk of being robbed considerably. Currently money transfers services are offered by Vodacom Tanzania, but our survey shows that almost all interviewed farmers, are Zain Tanzania subscribers where this service is not offered.

Efforts to control market prices through warehouse systems established by the government should be extended to crop farmers all over Tanzania, rather than concentrating on cash crops like cashew nuts and coffee. This will for sure increase their revenues and reduce lots of risk associated with travelling to markets centre far away.

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Using Mobile Phones for Personal Finances Accounting

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Abstract: Mobile phones are by far the most successful and widespread ICTs today in developing regions where other technologies notably the Internet have not penetrated. They therefore provide platforms on which innovative applications can be developed to address locally relevant challenges. In this paper, we design and implement a mobile tool for easy and convenient management of personal finances which we call *PAAM*.
PAAM, which stands for Personal Accounting Application for Mobile Devices, is a standalone application that permits users to track down their personal transactions at anytime, anywhere. It allows users to record their incomes and expenses as they happen and provides alerts in case the specified expenditure limit is reached. PAAM also provides reports or trends on user's incomes, expenses, and savings which allows users to easily analyze their financial transactions. We tested the implemented system and showed that it is fit for the intended purpose.

1. Introduction

Over years, Information and Communication Technologies (ICTs) are continuing to spread rapidly throughout the world revolutionizing communication, access to information and services thereby playing a significant role in social and economic development. Despite mobile phones having several resource constraints such as low processing power, low memory capacity, small storage, small keyboards, small display screens, low network bandwidth, limited energy since they are battery-driven entities, they are by far the most successful and most widespread ICT tool today especially in developing regions [3], [9],[20].

Mobile phones are basic low-cost ubiquitous computers that are carried by billions of people around the world anytime and anyplace. They are constantly within reach of the users and continuously connected to a broader communications network [22] making them the most ubiquitous technology. They are no longer single use devices but rather can be used to provide a variety of functionalities. In addition to their traditional uses of making calls, sending SMS while on the move, they are increasingly being used for several functionalities such as scheduling events, capturing still images and video, transferring data with other devices, checking weather forecast, stock market forecast, news, email, web surfing, chatting and location aware applications [10], [19].

Surprisingly, mobile communications are experiencing faster growth rates in developing regions much more than in developed regions in recent years [7]. The ability to informally share mobile phones between people, the formation of private resellers of mobile services and the provision of mobile phones for public use, all have increased their accessibility, even in rural communities [7]. Mobile phones are the first digital ICTs that have reached poor households and communities. In many developing countries, micro-entrepreneurs view their phones as an instrument for increasing the productivity of their business [8].

For only ten years, the mobile phone penetration rate is estimated to have risen from an average close to 0% to 49.5% with over four (4) billion mobile cellular subscriptions by the end of 2008 [3]. Mobile phones being affordable and rapidly adopted, country governments and developing agencies are expanding and extending mobile services as a way of alleviating poverty, encouraging economic and social growth and overcome the perceived 'digital divide' [6].

Perhaps the most popular mobile phones applications and services in developing countries fall under m-banking and m-commerce areas [12], [16]. Indeed, the lack of access to formal banking to many individuals in developing countries has led to an exponential growth in m-banking resulting to millions of dollars in revenues for service providers. The underlying applications for these services however are based on client server architecture where the system needs a back-end infrastructure (servers) at the service providers' premises for the service to be accessed on the mobile phones (clients).

In this paper, we implement a standalone application (i.e., does not require backend servers) that allows management of personal finances. We call the application PAAM, which stands for Personal Accounting Application for Mobile Devices. With PAAM, users can record and view their financial transactions at any place and any time. Users can categorize their incomes, expenditures in PAAM, and can set a monthly expenditure limit. We implemented PAAM on Symbian OS using Python for Series 60 (PyS60) and was tested by several mobile phone users. Testing of PAAM reveals that it provides the intended services.

The rest of this paper is organized as follows. We discuss mobile phones and their increasing capabilities (Section 2) and describe the proposed PAAM (Section 3). We then describe how PAAM was implemented (Section 4) and then its functionalities (Section 5). We finally conclude the paper in Section 6.

2. Mobile Phones and their increasing capabilities

Mobile phones have been known to have several inherent constraints that limit development of standalone applications. These constraints include low memory capacity, small storage, low processing power, varying computational power, capabilities and different specifications (e.g., input systems, mobile connectivity options, operating systems and programming platforms) requiring multi-device support [14], [17], [20]. Any application development on mobile phones also faces additional development challenges including a) developers repeatedly upload, debug, and update their software on the actual devices – a process that is often time consuming and fraught with errors; b) programmers ensuring that the software runs on the different device types, and c) developers need to update already deployed applications, e.g., for bug-fixing [5]. These constraints and development challenges make it extremely difficult to develop and deploy new mobile applications and/or upgrade existing ones.

Modern phones such as smart-phones are however becoming increasingly more capable, and are becoming affordable for developing markets. They have higher processing capabilities, higher storage with extendable memory cards, longer battery life, touch screen capabilities, sensors, a nearly always-on network connection, better audio and display systems [14], [15]. Smart-phones are basically mobile phones with advanced capabilities other than the usual voice calling and SMS, and the user can install new applications on the device.

The availability of more capable phones will pave a way for new and complex applications to run on mobile devices. Example of these applications already developed include a language learning platform for high-end phones [15], 1D/2D bar code recognition application using the mobile phone's camera to link information to retail products [4], location based applications utilizing the phone's built-in GSM, GPS or WLAN modules [21], and many more applications based on touch and sensing capabilities embedded in phones. This further opens a new market for developers particularly in developing countries.

3. Proposed Personal Finances Accounting Application

Many people manage their personal finances mentally using their heads. Others use a manual system of writing their incomes and expenses, and then trying to balance them while very few use a desktop personal accounting or a general desktop accounting application. Since millions of people always carry their mobile phones everywhere, a mobile application would help them to easily and accurately manage their personal finances.

We develop PAAM to enable users to use their mobile devices to track down their personal transactions at anytime and anywhere. In the next sections, we discuss how user requirements were gathered, analyzed, the system architecture which was adopted for PAAM and how PAAM would monitor the specified monthly expenditure limit.

3.1 PAAM User Requirements

The initial user requirements of PAAM were obtained using personal experiences; scenarios of how most people manage their personal finances and reviews of existing desktop personal accounting applications. The requirements were then simplified and prioritized to enable the user manage his personal transactions without much complication and minimal input.

3.2 PAAM System Architecture

In this section, we discuss the system architecture that was adapted for PAAM. Due to the several mobile phones' resource constraints and development challenges discussed in Section 2, we incorporated several architectural and design patterns (i.e., layers, repository and singleton patterns) to reduce the complexity in the application, reduce the coupling between the different layers/tiers and increase flexibility and maintainability of code. Figure 1 shows the architecture which was adopted for PAAM.

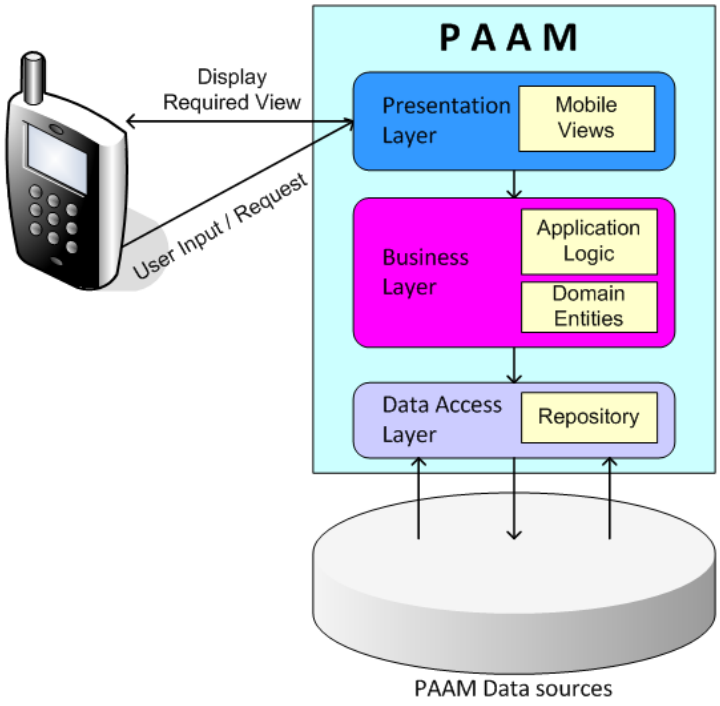

Figure 1: PAAM System Architecture

PAAM System Architecture consists of four major layers which include:

- *Presentation Layer* for displaying processed information to the user and collecting user input. It contains several mobile views for presenting summary or graphical views of the different category, transaction, application settings and reports data as requested by the user. The user is also able to enter transaction and category details using this layer.
- *Business Layer* which concerns both the domain entities and the application logic.
- *Data Access Layer* for easy retrieval of data. It abstracts all the data access logic from the database layer to the business layer. This layer was implemented using the repository and singleton pattern.
- *Database Layer* for easy storage and management of data. It utilizes the in-built relational database engine included in Symbian OS thereby removing the need to send and/or receive data to a "real" database on a server.

3.3 Monitoring Monthly Expenditure Limit

One of the most important functionalities of PAAM was to monitor the user's expenses against the specified monthly expenditure limit so that the user is alerted by how much the specified monthly expenditure limit is exceeded. We used the activity diagram in Figure 2 to model how PAAM would monitor monthly expenditure limit without much user complication.

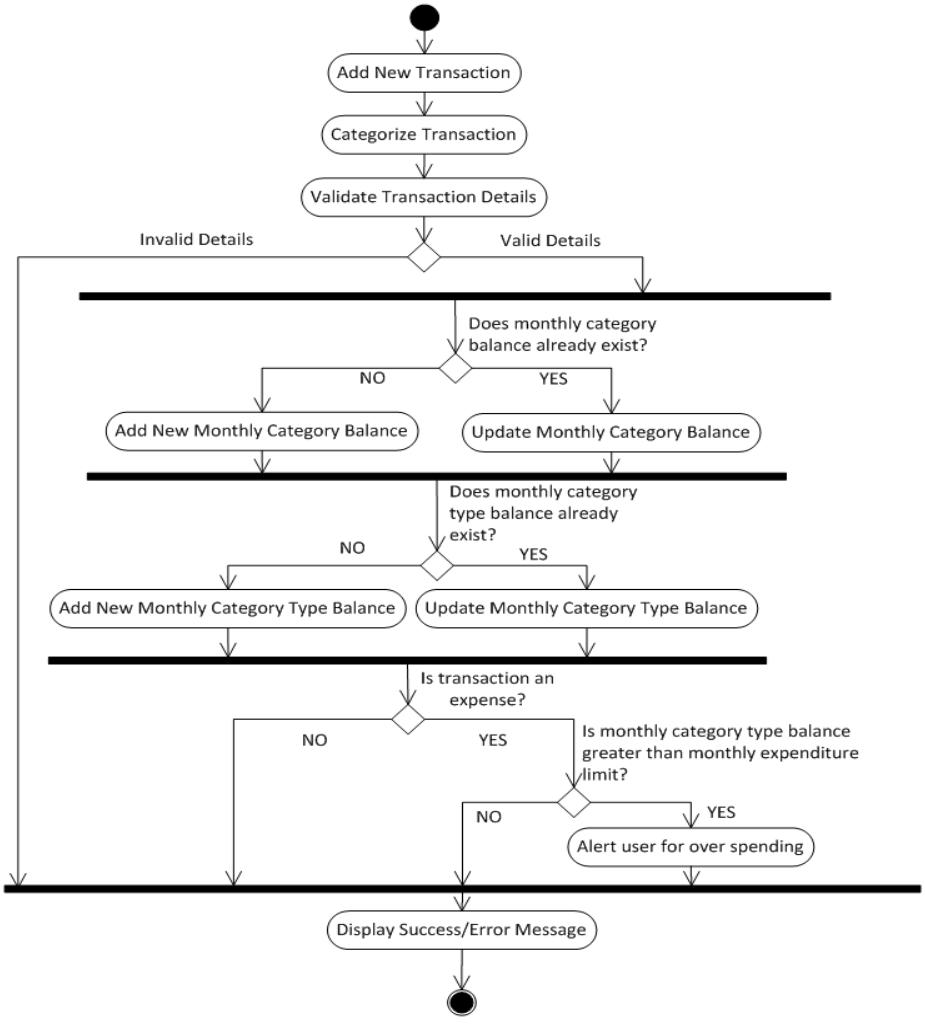

Figure 2: PAAM Monitoring Monthly Expenditure Limit Activity Diagram

From Figure 2, PAAM monitors the monthly expenditure limit through the following steps:

1. User adds a new transaction and categorizes it.
2. If the monthly category balance already exists, the transaction amount is added to the existing monthly category balance.
3. If the monthly category balance does not exist, a new monthly category balance is created and transaction amount added to it.
4. If the monthly category type balance already exists, the transaction amount is added to the existing monthly category type balance.
5. If the monthly category type balance does not exist, a new month category type balance is created and the transaction amount added to it.
6. If the transaction is an expense, check if the monthly category type balance is greater than the monthly expenditure limit.
    a. If the monthly category type balance is greater than the monthly expenditure limit, alert the user for overspending
7. Display success or error message.

The presented PAAM system architecture in this section provides a basis on which PAAM was implemented. We discuss PAAM system implementation in the next section.

4. PAAM System Implementation

This section discusses the tools and technologies which were used to implement PAAM. PAAM was implemented to be usable on Nokia S60 devices based on Symbian Operating System (OS) to target the big market of the most recent Nokia smart-phones.

4.1 Operating System

The application was implemented to run on Symbian OS, an operating system designed for mobile devices with lots of libraries, user interface frameworks and reference implementations of common tools. Symbian OS was preferred because it is still the leading operating system being shipped with 46.6 percent of the worldwide smart-phone market for Quarter Three (3) of 2008 [2].

4.2 Programming Language

Python for Series 60 Platform (PyS60) was used to implement the mobile application. S60 is a software platform for mobile phones based on Symbian OS and is one of the leading smart-phone platforms in the world [18]. PyS60 was preferred over Java 2 Mobile Edition (J2ME) because it drastically reduces development time and makes rapid prototyping on mobile platforms easy and efficient by wrapping complex, low-level technical details in simple interfaces [18].

4.3 Database Management System

The in-built relational database engine included in Symbian OS was used since the application is a data intensive application requiring performing of queries frequently against the inputted data. Having a local database removed the need to send and/or receive data to a "real" database on a server which would be costly to the user of the application.

5. PAAM System Description

In this section, we describe the entire features and modules of PAAM. We use emulator snapshots to demonstrate each level of user interaction with PAAM and show the expected output of the application.

5.1 PIN Protection

PAAM protects the user's data preventing the user's personal finances from being exposed to any phone user by requiring a PIN before the user is able to use the application. This PIN is set up the first time the application is opened for use.

Figure 3: PIN Protection

Figure 3 above shows the user interface used for user authentication into PAAM. Upon successful login, the user is then able to utilize the application's functionalities.

5.2 Category Module

The category module allows the user to generalize his/her transactions. Categories provide a simple yet powerful mechanism for specifying where the income (payment) came from (e.g., salary, side-business, etc.) or where expense was spent (e.g., food, insurance, education, etc.). When you first run PAAM, you are prompted to add new categories for your transactions. The categories can either be of type Income or Expense.

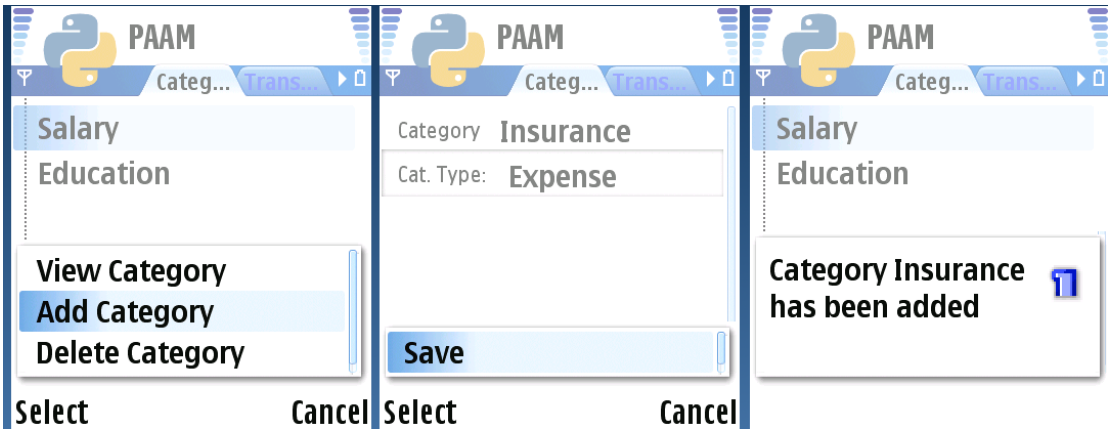

Figure 4: PAAM Category Module – Add A New Category

In Figure 4, we illustrate how a user can add a new transaction category. Under the *Category* tab, the user selects *Add Category* from the *Options* menu. He/She then fills the *New Category* form with the new category details and then selects *Save* from the *Options* menu. The data entered is then validated and a success message is displayed in case of valid data or an error message is displayed in case of invalid data.

5.3 Transaction Module

A transaction is basically any type of activity that affects an individual's income and/or expenditure e.g., receiving salary, paying school fees or insurance fees, etc. The Transaction module allows the user to record his/her transactions whenever he/she spends or receives an income/payment with extra options of viewing and deleting transactions.

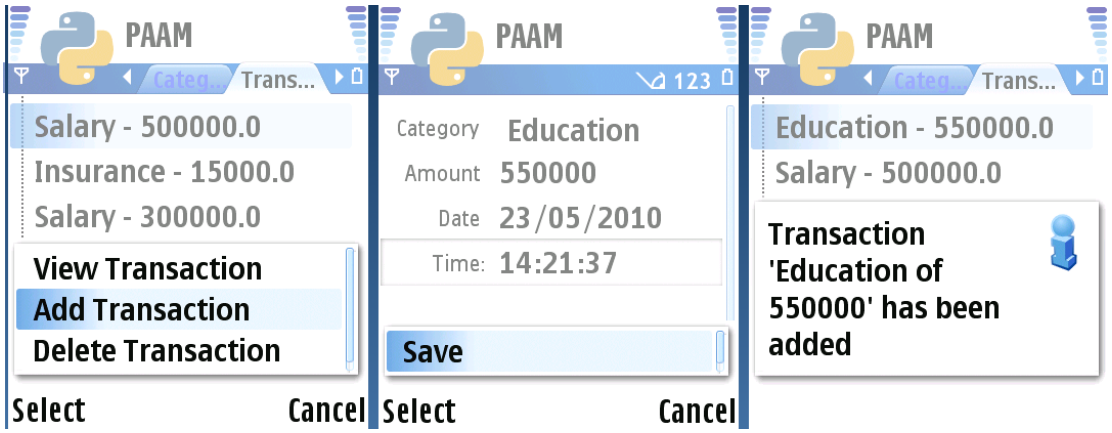

Figure 5: PAAM Transaction Module – Add A New Transaction

Figure 5 shows how a user can add a new transaction when he/she spends or receives an income/payment. Under the *Transaction* tab, the user selects *Add Transaction* from the *Options* menu. He/She then fills the *New Transaction* form with the new transaction details and then selects *Save* from the *Options* menu. The data entered is then validated and a success message is displayed in case of valid data or an error message is displayed in case of invalid data.

5.4 Report Module

The Report module allows the user to obtain several reports from the application using the transactions and category information entered using the above modules. The report module allows the user to view his/her income, expenses, savings, trends and expenditure limit tracking reports. All these reports are compiled by the application automatically whenever the user enters his/her new transactions allowing him/her to easily monitor his/her incomes and expenses.

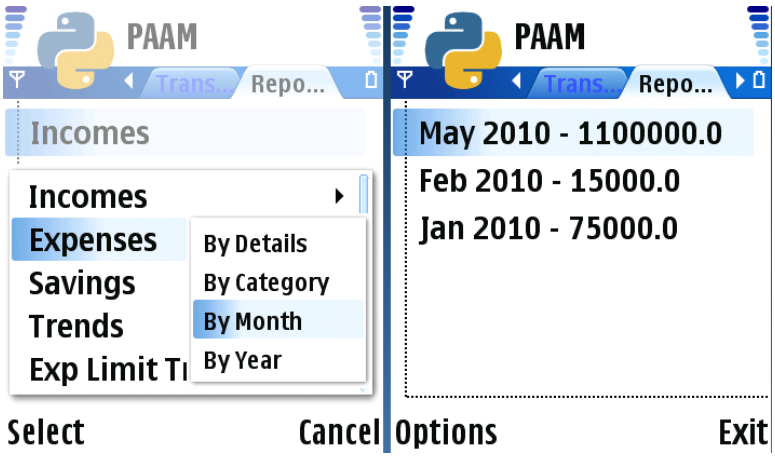

Figure 6: PAAM Report Module – Monthly Expenses Report

Figure 6 shows an example of how a user can obtain a monthly expenses report using PAAM. Under the *Reports tab*, the user selects *Expenses* menu and then *By Month* submenu. The user is then presented with monthly expenses report showing a list of months and his/her expenditure for those months.

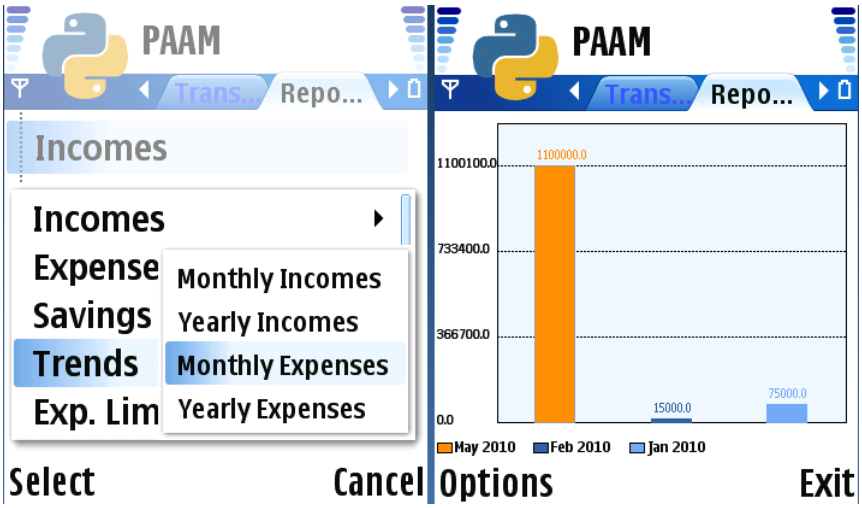

Figure 7: PAAM Report Module – Monthly Expenses Trend

Figure 7 shows an example of how a user can obtain a monthly expenses trend report using PAAM. Under the *Reports* tab, the user selects *Trends* menu and then *Monthly Expenses* submenu. The user is then presented with a monthly expenses trend bar graph showing the latest nine months versus his/her expenditure for those respective months.

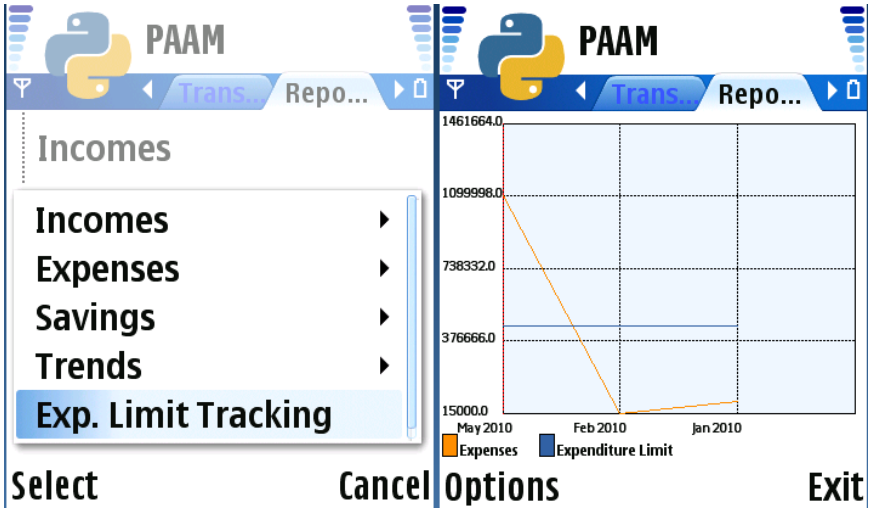

Figure 8: PAAM Report Module - Expenditure Limit Tracking Report

Figure 8 shows an example of how a user can obtain an expenditure limit tracking report using PAAM. Under the *Reports* tab, the user selects *Exp. Limit Tracking* menu. The user is then presented with an expenditure limit tracking report.

5.4 Application Settings Module

The Application Settings module allows the user to manage the application's settings including PIN and the monthly expenditure limit. Using this module, the user can also purge transactions (i.e. delete transactions' data without affecting any balances to reduce amount of storage being used up) or clear all the data in the application.

In this section, we used an emulator to demonstrate the functionalities of PAAM. We have shown how PAAM provides personal finances management. The emulator is used in the paper because it was easier to get good snapshot for purposes of the paper. We also converted the python scripts into an installation (.sis) file which was installed on various Nokia S60 phones. The application was then tested by several potential, users and the test results showed that it works and served its purpose.

6. Conclusion

In this paper, we presented methods leading to the design and implementation of a standalone mobile phone application for personal finances accounting which we call PAAM. We implemented the application using Python for S60 on Nokia Symbian OS. We used snapshots of the emulator to demonstrate the functionalities of the application. PAAM was also installed on various Nokia S60 phones to realistically test it using potential users. The tests proved that PAAM offers the functionalities it was intended for. Further more, users attested that the application was user friendly, easy and simple to use. It is clear that Symbian OS is not the only OS of mobile phones. In the future, we plan to extend PAAM to other mobile OS to enable all users of mobile phones benefit from the tool.

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Mobile Money Use in Uganda: A Preliminary Study

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Abstract: As mobile phones proliferate in the developing world and Mobile Network Operators (MNOs) look for ways to diversify from voice and SMS, mobile money has emerged as an opportunity. While currently used mainly for money transfers, mobile money advocates are enthusiastic about its capability to transform the financial fabric of society, particularly for the poor. We report on a study of mobile money users in Uganda across 3 MNOs. Besides understanding current usage of mobile money, we explore different daily financial transactions of respondents. We investigate the relative importance of these transactions, their frequency, and methods of payment used. Satisfaction with current payment methods and strength of intention to use mobile money if offered for these transactions are captured. The goal is to identify potential new ways to use mobile money in Uganda.

1. Introduction

As mobile phones proliferate around the developing world, new services are emerging as mobile network operators (MNOs) diversify services to compliment voice and SMS in a progressively competitive environment where the goal is improving customer retention and reducing churn (Mendes, Alampay et al. 2007). A prominent emerging service is mobile money—a term used to loosely refer to money stored using the SIM (subscriber identity module) as an identifier as opposed to an account number in the conventional banking sense. A notational equivalent in value is then kept on the SIM within the mobile phone, which is also used to transmit payment instructions. The corresponding cash value is physically held by the MNO, a bank or another third party depending on the business model (Porteous 2006; Donner and Tellez 2008; Comninos, Esselaar et al. 2009). MNOs and their agents provide an interface between the two sides through cash-out (issuing cash on demand) or cash-in (convert cash to notational equivalent) functions providing convertibility between mobile money and cash (Morawczynski 2009).

There is great excitement about mobile money for two main reasons. Firstly, mobile money through an increasingly large mobile phone user base provides a platform that could potentially be leveraged to service the financial needs of the poor (Hughes and Lonie 2007; Lyman, Pickens et al. 2008; Mas and Kumar 2008; Morawczynski 2009). In the developing world, where the reach of banking infrastructure is severely limited, this is a big deal especially if we can reach more people faster and cheaper. Secondly, others believe that successful mobile money has the ability to enable and catalyse the development of mobile commerce (Herzberg 2003; Hu, Li et al. 2008), particularly in the developing world. The downside is that current implementations tend to operate only within an MNO's network locking-in customers, and excluding other potential players in the sector (Ndiwalana and Popov 2008).

This exploratory study looks at the nascent usage of mobile money in Uganda. Besides understanding current usage patterns, the study investigates different transactional needs and priorities of a selected sample as an opportunity for diversifying the utility of mobile money. The next section provides a background that outlines related work and presents the methodology of the study. The third section details current usage of mobile money, covering the various types of transactions currently supported. Section four provides an assessment of everyday financial transactions and how users deal with them. A conclusion highlights the main findings and indicates how we can take advantage of existing gaps in the financial fabric of user transactions to extend the utility to mobile money.

2. Background

Mobile subscribers continue to increase as competition improves amongst the 5 MNOs—MTN Uganda, Orange Uganda, Uganda Telecom, Warid telecom and Zain Uganda (soon to be Airtel). There are now about 9.9 million mobile phone subscribers across all MNOs. About 0.6 million of these coming in the first quarter of 2010 and helping to raise mobile network penetration to 31.4 lines per person compared to a national tele-density of 32.2 lines across the whole telecommunications sector. Network traffic is still largely dominated by voice, with in-network traffic (local to MNO's network) still most prevalent thanks to the success of promotions like Warid's Pakalast and Pepeya (Warid Telecom 2010); Zain's Kika and Orange's Gyekiri (Orange Uganda 2010) that allow unlimited calling within networks for defined periods (that range from an hour to a week) on payment of a fixed fee (Uganda Government 2010).

SMS usage grew by 28% in first quarter 2010 to about 176 million messages (compared to 138 million in fourth quarter 2009) as MNOs encourage use through campaigns and innovative services like missed call alerts, call me back, etc that tend to be free. SMS usage is also still largely dominated by in-network usage. Mobile Internet access has grown thanks to increasing competition in data services amongst MNOs. The arrival of cheaper bandwidth via undersea cables coupled with increasing 3G-network coverage is driving down the cost of data services. In addition, MNOs have partnered with social networking sites like facebook to provide free mobile access (Uganda Government 2010).

Of the 5 MNOs, only 3 currently have a mobile money offering—MTN Mobile Money (MTN Uganda 2010), M-Sente from UTL (Uganda Telecom 2010) and Zap from Zain (Zain Uganda 2010). To comply with financial services regulation the MNOs have partnered with banks—MTN is working with Stanbic Bank, UTL with DFCU and Zain with Standard Chartered Bank. There is a reported partnership between Warid and Crane Bank, although no mobile money offering has been launched to date (Uganda Government 2009). There is no authoritative number of registered users of mobile money since MNOs are not mandated to disclose this information either to the financial regulator—Bank of Uganda nor the telecommunication regulator—Uganda Communications Commission. MTN Mobile Money, the first of the three to launch and arguably the biggest given MTN's position in the market, reportedly has registered more than 1,000,000 customers, setup over 1,500 agents/outlets across the country and transferred more than UGX 590 billion (US$ 245 million) since its launch in March 2009 (MTN Uganda 2010). Zain launched Zap in July 2009, while UTL launched M-Sente in March 2010.

The 3 mobile money offerings are largely similar, allowing registered users to load money into their accounts (cash-in), make transfers to other users (both registered or not), buy airtime top ups as well as withdraw money (cash-out). Each type of transaction attracts a predetermined charge, which varies across offerings. A fundamental difference perhaps is that transaction charges are automatically deducted from the user's account by the system in MTN Mobile Money and M-Sente, while Zap agents directly collect transaction charges. Zap charges are only recommended, implying that an agent can freely alter them according to supply and demand. Transactions costs are based on tiers that range from amounts as low as

UGX 5,000 to 1,000,000, the maximum transfer amount per day per user. Other house keeping functions like balance check, mini statements and PIN changes are also available.

The MNOs have presented their mobile money service to potential customers differently. MTN positioned their Mobile Money offering as a way to send money to others, just like M-Pesa did in Kenya (Mas and Morawczynski 2009). Subsequent offerings thus had to find ways to differentiate them. Zain's Zap touts itself as being "much more than money transfer," although it was not much different at inception, granted their aspiration seems much wider as evidenced by options in their SIM menu application (Zain Uganda 2010). UTL's M-Sente, the latest offering to-date, has positioned their offering as a general payment method with "simply pay with M-Sente." Besides money transfers, other transactions are beginning to emerge and we discuss these as part of the study in the next section.

2.1. Related Work

Contrary to the great excitement about the potential for mobile money to address the financial needs of the poor, there is a shortage of studies that investigate actual financial needs of the poor (Donner and Tellez 2008; Duncombe and Boateng 2009). Even amongst the growing number of studies reporting on various mobile money implementations around the world (Wishart 2006; Hughes and Lonie 2007; Mendes, Alampay et al. 2007; Mas and Morawczynski 2009; Morawczynski 2009), only a few tend to depend on data from actual adoption and usage of the various systems (Ivatury and Pickens 2006; Mas and Morawczynski 2009; Morawczynski 2009). Donner & Tellez decry the lack of scholarly research on adoption and impact of mobile payments in the developing world and highlight the need to consider the social, economic and cultural environments within which such systems operate (Donner and Tellez 2008). While the focus on policy and regulations that facilitate innovation is important (Lyman, Pickens et al. 2008; Mas and Kumar 2008; Ndiwalana and Popov 2008), taking into account actual needs, usage and varying contexts can only help improve mobile money adoption. In addition, this can highlight new opportunities for MNOs and other innovators to help the poor by transforming mobile money beyond basic money transfers. It is towards this goal that this exploratory study aims to make a contribution.

M-Pesa from Safaricom (an affiliate of Vodafone) in Kenya is arguably the most famous mobile money implementation at the moment (Hughes and Lonie 2007; Morawczynski 2008; Mas and Morawczynski 2009; Morawczynski 2009; Morawczynski and Pickens 2009). While M-Pesa was not the first (launched March 2007) large-scale implementation, its rapid uptake is perhaps what differentiates it from Smart Money or G-Cash from the Philippines (Wishart 2006; Mendes, Alampay et al. 2007). Morawczynski and her colleagues have extensively studied M-Pesa (Hughes and Lonie 2007; Morawczynski 2008; Mas and Morawczynski 2009; Morawczynski 2009), which is predominantly used for domestic money transfers between different parts of the country (Morawczynski 2008; Morawczynski and Pickens 2009). International money transfers as well as linkage with Equity bank to provide M-Kesho—a bank account that links to M-Pesa enabling users to transfer money between the two (Equity Bank 2010) are some of the new features. They also noticed an interesting trend of users beginning to leverage M-Pesa as a savings vehicle (Morawczynski 2009). Vodafone has since been replicated M-Pesa in Afghanistan, Tanzania and more recently in South Africa. It remains to be seen whether the service will be as successful, particularly in South Africa, where the penetration of banking services is much better and Vodafone lacks similar market dominance.

Smart Money from Smart Communications (launched May 2003) and G-Cash from Globe Telecom (launched October 2004) in the Philippines are the other pioneer mobile money offerings (Wishart 2006; Mendes, Alampay et al. 2007). While they do not have many documented user studies, the two offerings have been an invaluable learning ground for other mobile money implementations around the world, showing us the contrast between different models of collaboration that can exist between the two critical sectors of banking and

telecommunications. The unique role of international remittances within the context of the Philippines also greatly influenced their development, forcing them to explore international partnerships that allowed money inflows that were later widely distributed domestically. On the domestic front, G-Cash has collaborated with the Rural Bankers Association of the Philippines to extend mobile money further into the rural areas on the Philippines.

Wizzit in South Africa stands out amongst other mobile money offerings because of its independence from any MNO, allowing it to freely operate across all networks. Like Smart Money, it is also coupled with a bank account and debit card, enabling the service to easily leverage existing financial infrastructure like ATMs and bank branches in addition to Wizzit agents. Ivatury & Pickens undertook a study of 215 Wizzit users and found that while indeed many had low incomes, they were much better off than the average poor in South Africa and tended to be more technology savvy (Ivatury and Pickens 2006).

Comninos et al. (Comninos, Esselaar et al. 2009) analysed data collected from an e-Access & Usage Household Survey across 16 African countries with a representative sample in all but 2 countries which highlighted that more people had mobile phones compared to bank accounts. Amongst the unbanked respondents, between 41.2% – 69.8% indicated lack of a regular income as the main obstacle, compared to perceived high banking costs (0.2% – 20.7%) or perceived inability to qualify for a bank account (0.2% – 21.8%). In all countries, both domestic and international remittances played a role in supporting households with informal channels of money transfer being most predominant. Airtime transfers were common across all countries, usually as a favour to friends or family and in a few instances as payment for goods or services. The paper discusses limitations of airtime to cash convertibility within existing regulatory constraints and explores attitudes of respondents towards mobile banking as an offering.

3. Survey

Using a multi-stage process, we created a survey instrument for the study. Initially we reviewed literature and identified studies and theories pertinent to our work. The theories revolved around diffusion and acceptance of innovation as well as human behaviour. From this emerged questions that were polished through two focus group discussions of 12 individuals each. The focus groups also helped identify financial transactions that participants encountered daily and considered important. The resulting questions were used in interviews and discussions with high-level managers in both the telecommunication and financial sectors within Uganda. The whole process helped us appreciate different factors that both sides felt were important and how they could impact the use of mobile money within the country.

The resulting questionnaire was pilot tested with 10 mobile money users, resulting in three modified questions to eliminate ambiguity and two eliminated for redundancy. All survey questions were structured and included either single-option or multi-option variable. A 5-point likert scale was used for responses on an interval scale and an “other” option along with writing space provided wherever necessary to catch responses that did not match the structured options.

The final instrument was in English, with a luganda translation on hand that enumerators turned to when the need arose. The survey was interview-based with an enumerator asking respondents questions and then completing the questionnaire. Since the unit of analysis was an individual with prior usage experience of mobile money, we successfully sought access permission from providers and agents to be based outside agent locations and randomly selected users as they left an agent's office. A typical session with a respondent lasted 30 minutes and each was given a reward of airtime worth UGX 5,000 (about 2.5 US$) on a network of their choice for participation.

All respondents were drawn from different parts of Kampala, the capital of Uganda. The decision to focus on Kampala was made after discussions with service providers indicated that the bulk of transactions were happening in Kampala and even when they included a rural component, most transactions were initiated from Kampala. Actual data collection occurred in July 2010 and covered agent locations from all three MNOs, who currently provide mobile money services in Uganda—MTN Mobile Money, M-Sente from UTL and Zap from Zain. Please note that this sample was not selected to be nationally representative.

In the survey, we examined current use of mobile money for money transfers and other types of transactions, respondent motivations for using the service as well as perceptions about different aspects of the service—ranging from registration, customer care at agent locations to trust and privacy of their information amongst a wide range of issues. For this paper, we focus primarily on current usage of mobile money and respondents' intention to use mobile money, if it were offered for new types of transactions. In addition, the study explored the relative importance of a range of financial transactions that people encounter in their daily lives. For each transaction, respondents were asked to register importance—to help prioritise different transactions; method of payment—to identify how respondents currently make payments and potential gaps; frequency of payments—to gauge potential new application areas for mobile money; and level of satisfaction—to help gauge respondent' willingness to seek alternative payment methods.

3.1. Demographics

The demographic characteristics of the sample are summarised in Table 1. The sample had 463 respondents with a 321:139 male:female ratio and the majority aged between 21-30 years. In terms of educational level, 56.2% had a post-secondary school qualification, helping to explain the high-level of self-reported literacy in own language of 94.3% across the whole sample.

Table 1: Demographic characteristics of respondents

Rank	Financial transaction	Frequency	%-share
Gender	Female	139	30.0%
	Male	321	69.3%
	Cumulatively	460	99.4%
Missing data		3	0.6%
Cumulatively		463	100.0%
Age	Below-20	36	7.8%
	21 – 30	292	63.1%
	31 – 40	98	21.2%
	41 – 50	29	6.3%
	51 – 60	5	1.1%
	Above-60	3	0.6%
Cumulatively		463	100.0%
Education	No formal schooling	7	1.5%
	Incomplete primary school	9	1.9%
	Complete primary school (P7)	13	2.8%
	Incomplete secondary school	76	16.4%
	Complete secondary school (S6)	94	20.3%
	Post secondary e.g. certificate, diploma, degree	205	44.3%
	Degree and above	55	11.9%
	Cumulatively	459	99.1%
Missing data		4	0.9%
Cumulatively		463	100.0%
Access to bank account	No	105	22.7%
	Yes, I have a personal account	330	71.3%
	Yes, through another household member	6	1.3%
	Yes, through work	7	1.5%
	Yes, through someone else	3	0.6%
	Cumulatively	451	97.4%
Missing data		12	2.6%
Cumulatively		463	100.0%
Number of SIM cards	5 SIMs	6	1.3%
	4 SIMs	14	3.0%
	3 SIMs	35	7.6%
	2 SIMs	143	30.9%
	1 SIM	263	56.8%
	Cumulatively	461	99.6%
Missing data		2	0.4%
Cumulatively		463	100.0%

Contrary to expectation (Ivatury and Pickens 2006; Hughes and Lonie 2007; Comninos, Esselaar et al. 2009), most respondents (72.6%) reported having access to other financial services through a personal account in a formal financial institution, perhaps a reflection that our sample is more affluent than an average Ugandan. This roughly corresponds to the 72.7% who reported being currently employed. Employment in this survey was defined as having done a paying job in the last seven days prior to participating in the survey (Esselaar, Stork et al. 2007; Comninos, Esselaar et al. 2009). Only 22.7% indicated not having any form of access to a bank account and in-turn roughly correspond to the 27.3% who also reported being unemployed. All of the survey respondents had access to a mobile phone either through sole or shared ownership, with 69.8% indicating having shared ownership compared to 30.2% sole owners. Respondents were largely prepaid subscribers on different network and many had multiple SIMs as shown in Table 1.

4. Current Usage of Mobile Money

From anecdotal evidence and discussions with different service providers it emerged that mobile money is currently predominantly used to transfer money between users without

necessarily any accompanying exchange of goods or services (Morawczynski 2008; Morawczynski 2009; Morawczynski and Pickens 2009). As a result we paid particular attention to this type of transaction and we discuss our findings in section 0. Other emerging types of transactions and their usage are dealt with in section 0.

4.1. Money Transfers

More respondents (44.1%) indicated having both sent and received mobile money compared to those that had either only sent (25.9%) or only received (26.8%). On the whole, users that send money seem just as active with 48.1% having at least one transaction a month as compared to those that receive money, where 47.9% have at least a transaction a month. Usage frequency across the whole sample in terms of sending and receiving transfers is summarised in Figure 1. Amongst age groups, respondents send more than they do receive, with the exception of the 21-30 age group, who tend to send (49.1%) and receive (52.6%) similarly; and respondents below 20 years of age who receive (58.3%) more than send (27.8%). Perhaps this highlights the notion of dependence on others (Morawczynski 2008).

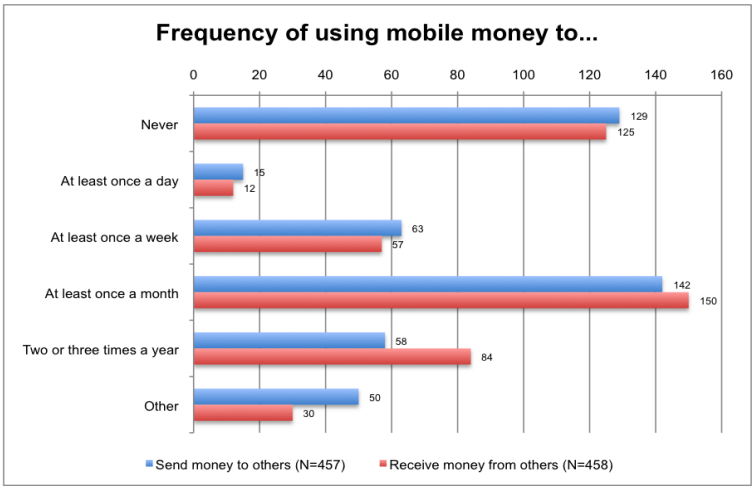

Figure 1: Frequency of using mobile money to send or receive money amongst respondents

Delving into the primary reasons that respondents use mobile money transfers, support for immediate family members dominated in all cases (Morawczynski 2008; Comninos, Esselaar et al. 2009) as indicated in Figure 2. Amongst the group that both sends and receives mobile money, payment for goods and services is the most common reason with 40.8% highlighting this as the primary reason that they receive money. But when it comes to sending money, 53.1% amongst the same group indicate supporting immediate family compared to 26.2% for goods and services as the primary reason. The survey differentiated between members of one's nuclear or immediate family verses the other relatives or extended family. In all cases support extended to the immediate family was more than that given to the extended family.

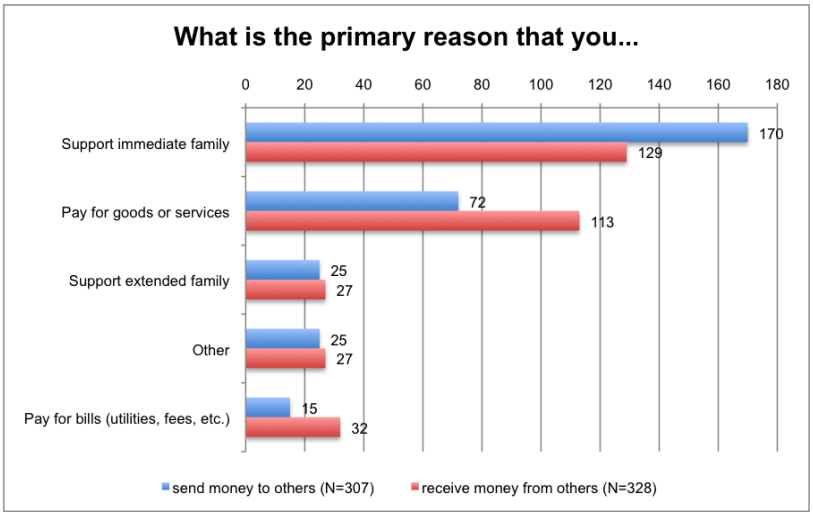

Figure 2: Primary reasons why respondents sent to or received money transfers from other people

Amounts of money sent and received via mobile money varied across the groups. On the recipients' side, 20.4% of respondents received between UGX 125,001-250,000, while 19.2% received between UGX 60,001-125,000 at the top end of the spectrum compared to 58.3% who received between UGX 5,000-30,000 and 9.7% below UGX 5,000 at the lower end. On the senders' side, the lower end of the spectrum is similar with 69.4% sending between UGX 5,000-30,000 and 8.8% UGX below 5,000. The upper end however differs in that while 21.5% sent between UGX 60,001-125,000, the next category was UGX 5,000-30,000 with 18.4% of survey respondents. The amount range was selected to coincide with the ranges used by the mobile money services for billing purposes.

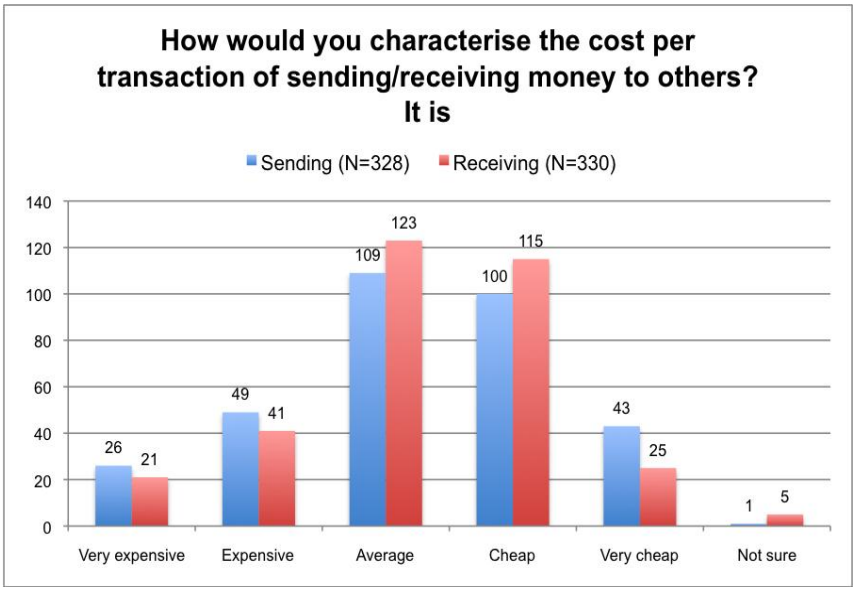

Figure 3: Respondents' perceptions on cost of sending or receiving money transfers with mobile money

Most respondents thought the cost of sending or receiving money transfers was average or cheap as highlighted in Figure 3. Amongst the groupings, 47.5% of respondents that had only received transfers thought that the service was expensive. This might be explained by the fact that informal money transfer methods like using the bus or someone carrying the

money that respondents used prior though risky, normally they have no cost implications for the recipients (Mas and Morawczynski 2009).

4.2. Other Types of Transactions

Use of mobile money for other types of transactions besides money transfers is emerging. The most common usage is to buy airtime from your provider as indicated in Figure 4. Users can buy airtime (or credit) either for themselves or others by entering a destination number on the parent network of the mobile money service. The cost is then deducted from their mobile money balance. Operators have heavily promoted this service, not least because it reduces costs that they incur along the conventional airtime distribution channel.

Other transactions have been introduced across different networks, but are yet to catch on like payment of cable television bills (DStv) and more recently school fees or tuition. The latter periodically causes congestion at banks as parents and students rush to meet payment deadlines, usually before the start of examinations. While banks offer both services, they normally charge a fee of about UGX 2500 (about 1.25 US$) for depositing school fees. Paying utility fees tends to be free because banks accrue other benefits from having the utility company as their client.

When asked about the main benefit of using mobile money for these other transactions, most (77.7%) responded that mobile is faster than other methods (speed). Other benefits cited included having their mobile phone (hence their mobile money) with them all the time (69.5%) and cheaper than other methods (69.1%) (Comninos, Esselaar et al. 2009) rounding up the top three main benefits. Conversely, respondents were concerned about the liquidity of agents or their lack of cash (34.8%) (Mas and Morawczynski 2009), the fear of losing one's mobile phone (hence mobile money) by 31.5% and long queues at the agents' location (29.4%) as the top three main drawbacks.

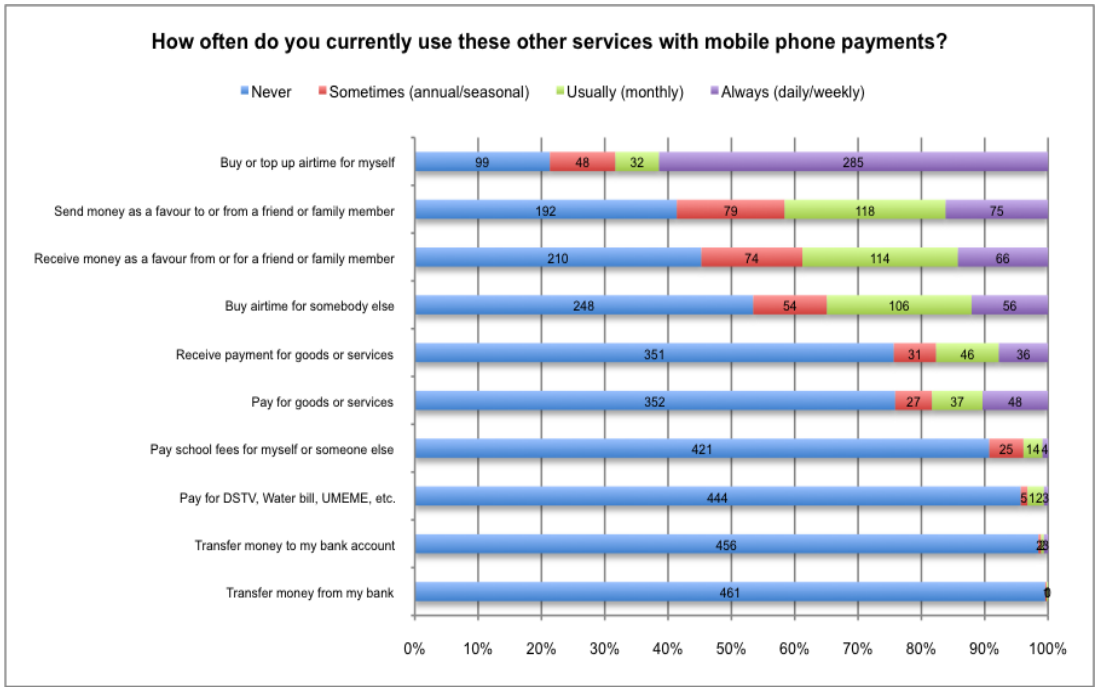

Figure 4: Respondents' usage of mobile money for other types of transactions (in descending order)

5. Financial Transaction Needs

Given that the bulk of our respondents already had access to formal financial institutions, they correspond with early adopters identified in other countries (Leishman 2010). But do not

fit the conventional mould of users that most literature expects to gain most advantage from use of mobile money (Porteous 2006; Lyman, Pickens et al. 2008; Mas and Kumar 2008; Comninos, Esselaar et al. 2009). Perhaps this is an indication of the limitations and coverage of the formal financial sector in Uganda, signifying the need for more collaboration between financial institutions and MNOs. In this section, we explore some of the different financial transactions that respondents deem important, their frequency and current methods of payment that respondents use to perform these transactions as well as their satisfaction with these methods.

5.1. Importance of Transactions

There are three types of transactions that respondents ranked more important than domestic money transfers as highlighted in

Table 2. First, is the need to make airtime purchases or top-ups for mobile phones which comes as default with all mobile money offerings, followed by the need to pay transport (taxis/matatus, buses, etc.) and then hospital/clinic bills. While mobile money can feasibly be used within the transport sector as is, the Ugandan context has some peculiarities that warrant closer scrutiny. Besides sharing the same means of transport, for example a taxi, users can get on and off as well as pay anywhere in-between the start and end of their journey. In addition, the fare is not always fixed as different people can pay different fares even when they start and end in the same places. How does the matatu conductor ensure that all passengers have paid him in all of this confusion?

Most of the other transactions could be easily supported within the current mobile money framework. Besides solving the chicken and egg problem between merchants (getting merchants to sign up as agents while customers are still few) and customers (getting mobile subscribers to sign up as customers while agents are still few), perhaps the other challenge is to ensure timeliness of the transaction, particularly in point-of-sale scenarios like paying for petrol at a station or for groceries at the supermarket. Implementations for utility bills and school fees using mobile money are in early stages; it will be interesting to see how their usage and costing evolves vis-à-vis the bank. Banks tend to make a fortune from such transaction fees and now suddenly have to share them with MNOs or even lose them entirely.

Table 2: Importance of various financial transactions to respondents (ranked)

Rank	Financial transaction	Mean score	N
1	Airtime purchases (pre-paid top-up)	2.44	425
2	Transport (taxis, cabs, buses, etc.)	2.26	400
3	Hospital/clinic bills	2.02	356
4	Domestic money transfers to/ from other people	2.01	376
5	Markets purchases (owino, kalerwe, etc)	1.84	333
6	Utility bills (Umeme, Water, DSTV, etc.)	1.68	299
7	Supermarkets, groceries, pharmacies	1.52	309
8	School fees (tuition)	1.50	264
9	Paying restaurants/bars/ fast food	1.41	294
10	Contributions (weddings, churches, funerals, harambes, etc.)	1.26	270
11	Petrol/Paraffin at Petrol Stations	1.15	217
12	Receive your monthly salary payments	0.87	154
13	Mobile banking (access to you bank account for withdrawals and deposits)	0.78	142
14	International money transfers to/ from other people	0.72	145
15	Internet or online purchases	0.60	121
16	Send money to myself (i.e. load mobile in one location and withdraw cash in another for safety)	0.59	116
17	Pay taxes to Uganda Revenue Authority	0.58	139
18	Tickets to movies, concerts, other events	0.51	124
19	Radio announcements, promotions (Birango)	0.46	101
20	Betting, lottery (g-lotto, sports betting)	0.34	86

(Scale: 0 = n/a; 1 = not important; 2 = important; 3 = very important)

Ranking in importance is largely similar between male and female, except for *send money to myself* ranked 14th by male respondents compared to 19th by females and *tickets to movies, concerts and events* ranked 15th by female respondents compared to 19th by males. Indications perhaps that men are more security conscious about cash, while women tend to care more about social engagements. Amongst different age groups, those below-20 ranked *betting, lottery* higher (10th) compared to most others who ranked it last, while older people (51 and above) ranked *radio announcements, promotions* much higher, reflecting their inclination towards social obligations.

5.2. Payment Methods and Level of Satisfaction

Cash is the most dominant payment method amongst respondents. There are only two transactions where cash's dominance was challenged and in both its limitations are obvious. In the domain of International money transfers (N=139), 33.8% of respondents reported using forex bureaus, 32.3% western union/moneygram compared to 19.4% who reported use of cash. The other is when users load money onto mobile phones for security reasons to avoid travelling with cash. For former, it is not always easy to find travellers going across borders coinciding with one's need to send cash, while for the latter travelling with cash is the actual problem respondents are trying to avoid. Even when it comes to domestic transfers and airtime purchases, where mobile payments are making inroads, cash was still the most dominant payment method across respondents. For airtime purchases (N=421), 79.3% of respondents reported using cash compared to only 18.1% who use mobile money while for domestic transfers (N=371), 58.5% of respondents reported using cash compared to 33.2% who use mobile money.

There is some correlation between importance of a transactions and satisfaction with the current method of payment as indicated in Figure 5. Some of the highly ranked transactions in terms of importance, for which there is low satisfaction include:

1. Utility bills (Umeme, Water, DSTV, etc.)
2. School fees (tuition)
3. Hospital/clinic bills
4. Transport (taxis, cabs, buses, etc.)

These transactions feature prominently amongst potential mobile money usage scenarios for which respondents indicated likely/very likely intention to use, if they were offered. The proportion of respondents who indicated a likelihood of using mobile money for various transactions is summarised in Figure 7.

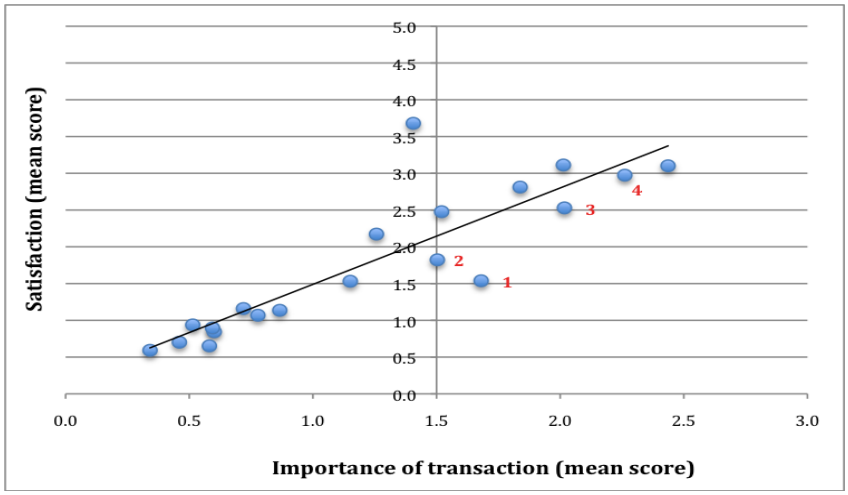

Figure 5: Correlation between satisfaction and importance of given financial transaction

5.3. Frequency of Transactions

The frequency with which respondents make payments for transactions tends to match the importance that they attribute to those transactions as highlighted in Figure 6. Payments for some of the transactions that respondents indicated as important happen rarely or infrequently. These include:

1. Hospital/clinic bills
2. School fees (tuition)
3. Utility bills (Umeme, Water, DSTV, etc.)

There are also some transactions for which respondents do make regular payments, but were not regarded as particularly important. Examples include:

4. Supermarkets, groceries, pharmacies
5. Paying restaurants/bars/ fast food
6. Markets purchases (owino, kalerwe, etc)

Perhaps one aspect to take away for MNOs and innovators who would like to build solutions on top of mobile money is the fact that the infrequent transactions tend to involve more money than more frequent transactions, and as such users might be willing to pay bigger premiums for the convenience of completing them. Variations in frequency of payments across gender and age groups are not significant except for *betting, lottery* amongst the below-20s where it ranked it 9th compared to 19th across the whole sample.

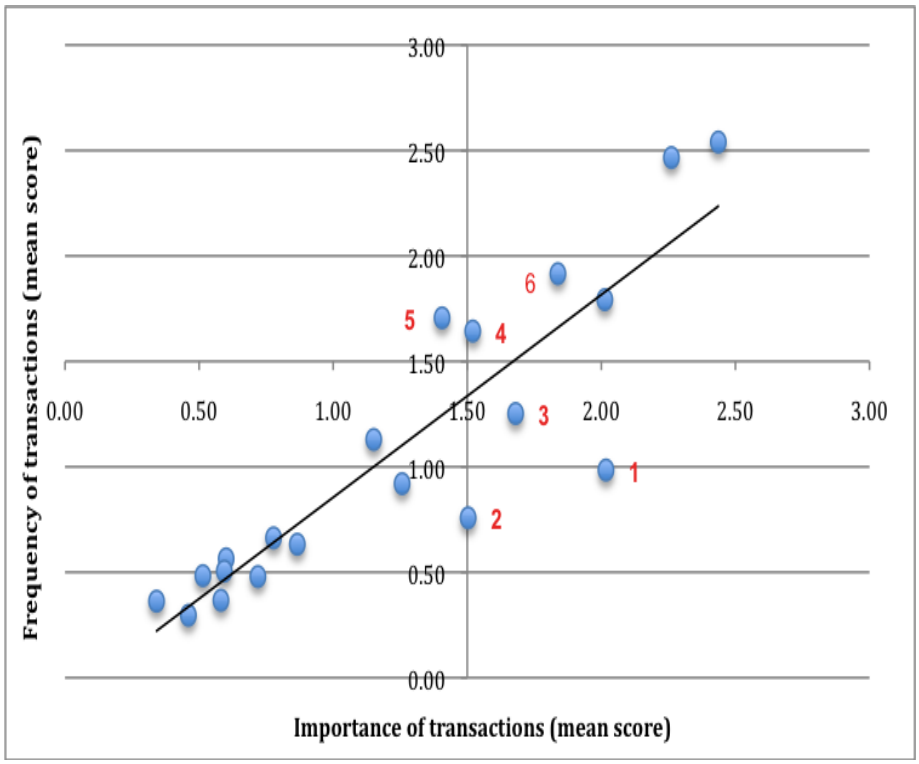

Figure 6: Correlation between frequency and importance of given financial transaction

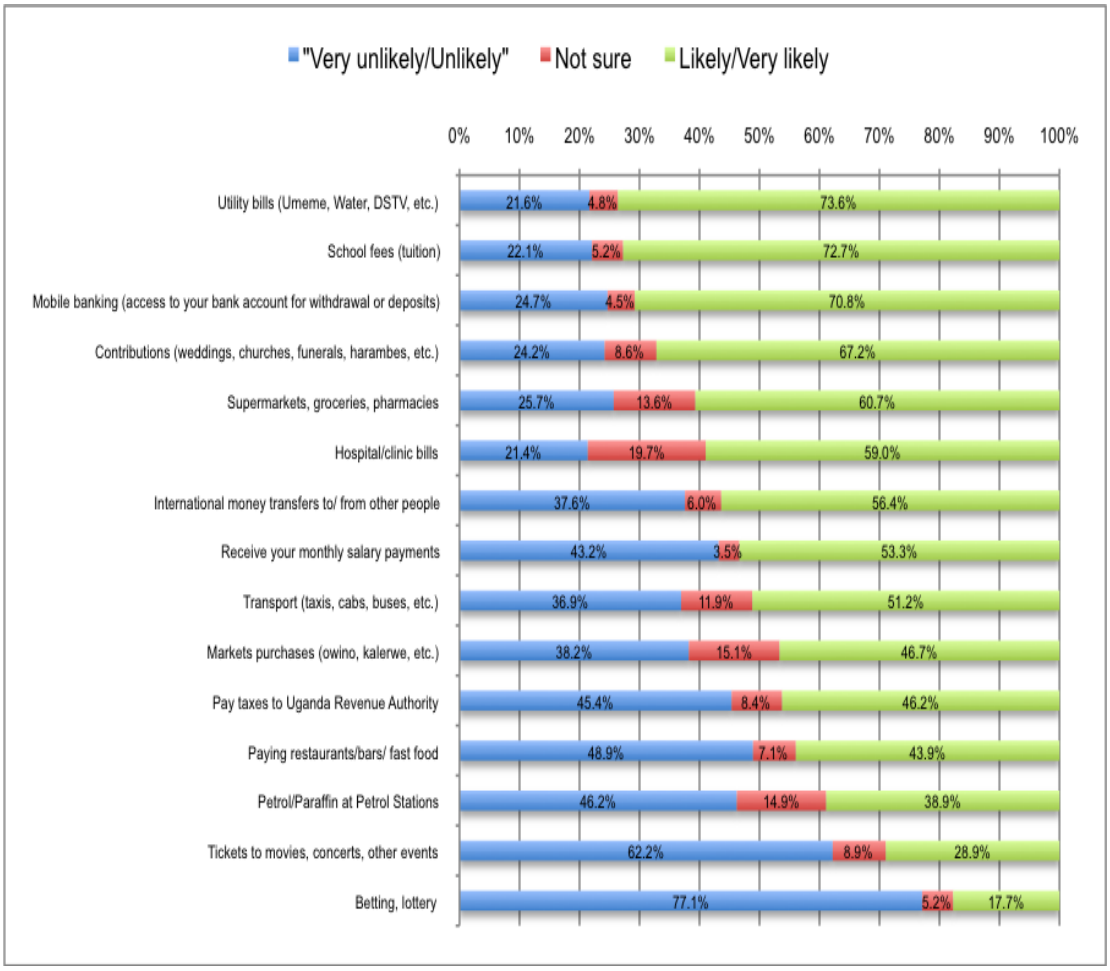

Figure 7: Intention to use mobile money for various transactions if made available at roughly the cost of an SMS (ranked by likelihood of mobile money use) across whole sample

6. Discussion

Shared ownership and use of mobile phones in the developing world has been noted to contribute towards improving access to communications (Chipchase and Tulusan 2006). On the contrary, there is not much on what this means for the success of mobile money. In this survey, 69.6% of respondents reported shared ownership verses 30.2% sole owners. Even if shared ownership was construed to mean shared usage, its prevalence does underscore need for attention as one of many peculiarities of phone usage with the potential to influence widespread usage of mobile money. What implication does use of mobile money have for the embodiment of the mobile phone, as we currently know it and consequently the way people use them? Conversely, how will mobile money adoption change the way people think about money? Would they spend more amounts, more easily because mobile money is intangible?

The demographics indicate that the sample was more educated and had much better access to formal financial services than the national average (Uganda Government 2007). This corroborates finding that M-Pesa early adopters were more educated and richer than non-users (Leishman 2010). While these early adopters can help bring on board other users, to leverage mobile money to improve and extend the reach of the formal financial sector on a national level presents a number of challenges. In rural areas, where formal financial services have least penetrated, literacy levels are still very low. Given that all mobile money services are currently text driven, this may necessitate new mobile phone interfaces that help bridge

the literacy inadequacies of our population (Donner and Tellez 2008; Medhi, Ratan et al. 2009). While dealing with airtime has helped equip users with concepts of using notational value, many reportedly also lack the mental models necessary to work with virtual currency to navigate this new landscape (Hinman and Matovu 2010).

Many potential usage scenarios are embedded within sectors that are still developing. Consider the public transport sector in Uganda today. A taxi (or matatu) can originate and end anywhere. Passengers can get on and off as well as pay anywhere in-between the start and end of their journey. In addition, the fare is not always fixed as different passengers can pay different fares even when they start and end in the same place depending on their negotiation skill. How does the matatu conductor ensure that all passengers do pay in all of this confusion? Application of near field communications (NFC) in mobile phones, thanks to the GSMA's Pay-Buy-Mobile initiative (Fischer 2009) can help address some of the obstacles inherent in such usage scenarios or other point-of-sale scenarios like paying in the supermarkets, groceries or petrol stations. Despite its progress, we are not aware of any pilots of mobile NFC technology in Africa. In addition, we should not take for granted that merchants and other small businesses that dominate African economies will jump at the opportunity of investing in new contactless infrastructure that is a prerequisite for the success of such technology. So there is need to be more innovative within the constraints of what we currently have and push it to the limits as usage and adoption become more mainstream.

The survey also confirms use of multiple SIMs as a strategy to minimise communication costs across networks (Tusubira, Kaggwa et al. 2007). 43.6% indicated having multiple SIMs to get cheapest rates on each network, while 38.8% indicated that friends and family were on different networks hence the need for multiple SIMs. While such fragmentation maybe accommodated for voice and SMS services, it is not quite clear what impact this has for mainstreaming mobile money. Should we compel MNOs to make their mobile money services interoperable to enable users to transfer money to others on different networks to create better economies of scale? Would it be helpful to plug the mobile money ecosystem into the existing national payments system? Or would this just stifle continuing innovation? (Bellis and Nagel 2010).

While mobile money might still be a new phenomenon in Uganda, with the first service launched only in March 2009, respondents described a positive experience of using it. More than half of the respondents indicated strong intention to use it for other frequent transactions like paying at the supermarkets, groceries and pharmacies as well as transport (taxis, cabs, buses, etc.) as highlighted in Figure 7. 70.8% of respondents wanted a linkage between mobile money and their bank account to facilitate withdrawals and deposits, given that 73.3% already had a personal account. This alludes to the potential that mobile money could play in inculcating and enhancing people's saving culture (Morawczynski 2009; Morawczynski and Pickens 2009).

The ability to transcend temporal and spatial constraints differentiates mobile money from other payment methods currently available in the developing world today. Coupled with this is the notion that a mobile phone can be a "smart wallet" capable of leveraging environmental cues like a user's location for their benefit. While mobile money is operational in Uganda today, we have barely "scratched the surface" in terms of its ability to consummate different types of financial transactions. While on one hand the possibilities are alluring, on the other hand they accentuate how little we know about this new world.

7. Conclusions

In this paper, we explored the current usage of mobile money in Uganda using a questionnaire and interview survey of respondents drawn from Kampala, the capital. In addition, we investigated the relative importance of different financial transactions amongst respondents, the frequency of those transactions and methods of payment used to settle them. Satisfaction with current payment methods and strength of intention to use mobile money if

offered for these transactions were also captured in a bid to identify gaps and new opportunities to leverage mobile money in Uganda.

Mobile money has the potential to extend the limited nature and reach of the formal financial sector. Besides helping to organise the hitherto chaotic scene of domestic money transfers, mobile money can improve the national payments system by providing innovative ways to meet the transaction needs of ordinary people. Success at this calls for a better understanding of people's needs, current adoption and usage patterns of mobile money along with accompanying motivations and perceptions (Donner and Tellez 2008). Perhaps with the exception of M-Pesa (Morawczynski 2008; Mas and Morawczynski 2009; Morawczynski 2009; Morawczynski and Pickens 2009), our knowledge of mobile money usage is still limited. When you factor in contextual differences that arise with each deployment, then the knowledge gap becomes glaring (Donner and Tellez 2008; Duncombe and Boateng 2009).

Europe has been a breeding ground for various business models and mobile money equivalents that have not been successful at scaling during the last few years (Dahlberg, Mallat et al. 2008). This failure has been attributed to lack of collaboration amongst different stakeholders in the various business models as one of the main reasons (Pousttchi, Schiessler et al. 2009). While Uganda's context might be different with no serious mobile money competitors besides cash and indications that telecommunications and finance sectors are starting to work together, one key lesson does emerge—access to mobile money will not automatically translate into usage. Rather, usage is something that needs nurturing and by many players. What is the role for progressive policy and regulation? Should MNOs, banks and other potential players in the ecosystem be mandated to work more closely together to help speed up the process or continue laissez-faire?

The regulatory environment in Uganda has spawned a variety of business models whose nuances we are yet to appreciate. As an example, what impact has an implementation like MTN mobile money where transaction charges are rigidly defined and automatically deducted by the system compared to Zain's approach where charges are only recommended and the agent has the power to modify and collect them as they interact with the customer at their location? As we seek to transform mobile money into a vehicle that can truly serve the financial needs of poor people, answers to such questions will be helpful in formulating progressive regulatory policy and more user studies can provide a useful source for some of the answers.

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Information Needs and Communication Patterns of Rural Uganda: Implications for Mobile Applications

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Abstract: In light of the growing ubiquity of mobile phones within the context of developing countries, there is a gap in understanding the information and communication needs of rural users. Using the backdrop of Uganda, this work reports on a detailed study, of rural users of various information and communications technologies (ICTs). It explores how rural users prioritise various information needs, identifies their current methods of information access, their frequency of information access as well as their satisfaction level with the information that they do receive. The study discusses priorities and gaps in current access to information that may highlight opportunities for mobile applications. The study sample includes an urban component that is used for purposes of contrasting differences between rural and urban information practices as well as exploring the communication linkages that do exist between the two sides.

1. Introduction

There is growing enthusiasm about the potential of leveraging the mobile phone as a tool for social and economic development. This is motivated by the rapid expansion of networks in the developing world coupled with the growing number of subscribers. To date, the mobile has been exploited primarily as a communication device—to talk, contributing to tremendous profitability of mobile operators in sub-Saharan Africa. As competition intensifies thanks to deregulation and new entrants seeking for ways to benefit from the mobile boom emerge, operators are looking to diversify their revenue base. One potential avenue is offered by mobile applications that can be used by a wide range of subscribers in a variety of ways to compliment the voice side of the business. Promising progress is being made towards leveraging mobiles as a platform for addressing financial needs of the poor (Hughes and Lonie 2007; Mendes, Alampay et al. 2007; Mas and Kumar 2008; Duncombe and Boateng 2009). The catch is that current models tend to lock-in customers, while excluding other potential players in the sector (Ndiwalana and Popov 2008). The donor community on the other hand, has funded a variety of forays exploring socially related aspects of leveraging mobiles, ranging from agriculture, education to health.

Despite all these initiatives, there has not been a documented effort to study the general information needs and priorities of rural communities coupled with their current use and attitudes towards different communication media as an avenue to explore potential mismatches and hence new mobile application opportunities. It is towards this gap in the literature that this study seeks to contribute. To set the stage, the next section provides a background, which encompasses an

overview of prior work related to the study and presents its methodology. Section three explores how rural users prioritise their information needs and how they seek information to satisfy them. Finally, the conclusion summarises the study findings, and highlights some of the critical issues that we need to keep in mind as we strive to develop new mobile phone applications.

2. Background

In Uganda, there are now over 9.9 million mobile phone subscribers spread across 5 networks (MTN, Orange, UTL, Warid and Zain) and the percentage of the population covered by mobile phone networks has increased to over 90%. While the number of mobile subscribers is soaring, fixed line subscribers are merely 244,455 coupled with 96,890 payphones countrywide, bringing the national tele-density to 32.2 only. As expected the traffic is largely dominated by voice, logging about 2 billion voice minutes in the first quarter of 2010, of which 89% is in-network traffic, thanks to discounted in-network tariffs, which help explain multiple-SIM ownership strategies adopted by many subscribers. About 175 million SMSs were sent in the same period, a growth of 28% (Uganda Government 2010).

Internet is still largely a luxury for an insignificant few. Initially only available in a few urban locations (Mwesige 2004), it can now be accessed via a large portion of the GSM infrastructure. In fact with over 460,000 active accounts, more users access the Internet using mobile connectivity compared to any other means of access. This has been primarily the result of many operators adopting 3G in upgrading their networks as competition intensifies in the data segment as well as the arrival of cheaper bandwidth from undersea cables that have become operational on the eastern coast of Africa (Uganda Government 2010).

2.1 Related Work

Understanding the role of information and communication within the context of a rural community is a big challenge. Information needs tend to be explored through a sectoral approach. For example, in health we might want to identify information requirements to help people avoid contracting some disease, while from an agricultural view the concern might be to equip farmers with information about pesticides to increase yields or fishermen with accurate weather information to facilitate better catches (Ikoja-Odongo and Ocholla 2003). Research on the use of mobiles has also tended to follow a similar approach with a particular bias towards economic sub groups like informal urban entrepreneurs (Donner 2006; Esselaar, Stork et al. 2007), fishermen (Njoku 2004; Jensen 2007), and craftsmen (Molony 2006). The recognition that development (and the strategies that people adopt to cope with poverty) depends on a range of interrelated factors has resulted in more holistic approaches, such as the sustainable livelihoods approach. Only relatively recently, with the advent of development communications as a field of study in its own right have people started to advocate for the role of information and communication in a more integrated context (Donner 2008).

Based on household surveys in three countries (India, Tanzania and Mozambique), Souter, Scott et al. (2005) identified priority types of information and ranked them according to perceived importance. They showed that people leverage different media channels to access different types of information. Zainudeen, Sivapragasam et al. (2007) conducted larger surveys in Asia (Pakistan, India, Sri Lanka, the Philippines and Thailand), but with limited set of indicators. Besides highlighting the latent demand from potential users and issues of affordability, current phone owners indicated that their greatest benefit from owning phones was perceived ability to be able to act in an emergency.

Donner (2008) decries the lack of studies focussing on rural users compared to their urban counterparts. While he justifies this trend from the point of view that services usually start in urban and spread to rural areas as connectivity improves, he contends that ignoring rural areas

might result in researchers overlooking emerging usage patterns given the difference in contexts. He makes the case for appreciating and capturing the needs and motivations that influence rural people and understanding how these differ, are influenced and interrelate with those of urban people.

In our study the focus is on the individual, because we assume that as mobile phone ownership rapidly increases, phone usage will tend to be more individualised. One weakness of a user-centric approach is the focus on information "pull", where a user seeks information or a service to meet a perceived need. This may overlook the inherent potential offered by a shared platform used by a growing proportion of rural users in developing countries. Mobile phones now offer the ability to engage with large proportions of the public, and may be of value in information "push" issues (Heeks 2008).

2.2 Methodology

This study draws on extensive desk research on information needs and communication patterns across the developing world (Ikoja-Odongo and Ocholla 2003; Donner 2004; Njoku 2004; Souter, Scott et al. 2005; Molony 2006; Skuse and Cousins 2007; Zainudeen, Sivapragasam et al. 2007; Dutta 2009) and a range of discussions with different stakeholders in the communications industry in Uganda. These shaped a questionnaire and interview survey of 406 individuals from across the country, selected for having experience with using telecommunications services. Most survey questions were structured and included both single-option and multi-option variables. The 5-point likert scale was used for questions that required responses on an interval level. The survey instrument was in English, but definitions and translations into local languages were agreed upon during enumerator training. Actual data collection occurred between January and February 2008.

"Information" is a concept that respondents have difficulty in dealing with, so the survey explored the relative importance of a range of development issues in 3 categories—business and financial, health and education, as well as those related to social and civic endeavours. For each issue respondents also indicated means of access to related information—to identify current information sources and existing gaps; frequency of access—that impacts on sustainability and business models of any potential application ideas; and level of satisfaction—as a way to gauge respondents' willingness to seek alternative sources.

Besides information needs, the survey explored current use of communication channels, looking beyond the mobile to capture interaction with radio, TV as well as newspapers. How people accessed phones and used them beyond making calls was given special emphasis. Intention to use a range of potential mobile-based applications was captured using a list of potential applications drawn from literature, focus group discussions as well as brain storming sessions within the project team.

The focus of our interest was on the rural part of the sample, although an urban component was included for juxtaposition because earlier research hints at differences in information needs and information seeking behaviour between rural and urban dwellers (Donner 2008; Dutta 2009) and the fact that from earlier focus group discussions in the rural area, it emerged that most communication in rural areas generally has some link to urban areas. Please note that the selected sample is not nationally representative.

2.3 Description of Sample

The survey covered 406 respondents from different parts of the country to provide a mix of livelihoods. Respondents were randomly selected from Kampala (central), Mbarara (west), Lira (north), and Mbale (east). The sample had a 290:116 rural:urban split, where urban refers to Kampala city centre and district capitals, with the rest of the areas classified as rural. The bulk of

our subsequent discussion revolves around the 290 rural respondents, with the urban portion of the sample used only for comparisons.

The rural sample of 290 respondents had a gender balance of 56:44 (male: female ratio) with a mean age of 31.1 years old. Roughly one third of respondents claimed to be the head of household. The sample had a good balance of educational levels as illustrated in Table 1. Based on claimed literacy in own or other language, literacy is 95.5% among the rural sample, and 97.4% among the urban sample. This is much higher than national levels (overall literacy rate of 69% among persons aged 10 years and above for 2005/06 (Uganda Government 2008)), reflecting the relatively high status of the sample. The importance of English as a national language is reflected in the high levels of English literacy—72% amongst the rural sample, and 90% among the urban sample.

Table 1: Demographic characteristics of survey respondents

		Rural		**Urban**	
		Frequency	%-share	Frequency	%-share
Gender	Female	127	43.8	37	31.9
	Male	160	55.2	78	67.2
	Missing data	3	1.0	1	0.9
	Cumulatively	290	100.0	116	100
Age	16 - 23 years	87	30.0	16	13.8
	24 - 29 years	80	27.6	44	37.9
	30 - 49 years	96	33.1	52	44.8
	50 years and over	26	9.0	3	2.6
	Missing data	1	0.3	1	0.9
	Cumulatively	290	100.0	116	100.0
Education	No formal schooling	21	7.2	3	2.6
	Incomplete primary school	37	12.8	5	4.3
	Complete primary school (P7)	41	14.1	4	3.4
	Incomplete secondary school	74	25.5	20	17.2
	Complete secondary school (S6)	45	15.5	18	15.5
	Post secondary e.g. certificate, diploma	53	18.3	50	43.1
	Degree and above	19	6.6	16	13.8
	Cumulatively	290	100.0	116	100.0

The average household size is 7.2 people with an average of 3.3 children. Interestingly, 78.6% of respondents reported members of their immediate family living in other cities in Uganda and 24.8% of respondents with members of their immediate family living abroad. Urban demographics amongst the sample indicated a male bias with gender balance of 68:32 (male:female ratio), higher educational status, smaller households (average of 5.7 people) and more-dispersed households with 82.8% reporting members of their immediate family living elsewhere in Uganda and 46.6% living abroad. This dispersion across both rural and urban families has implications for familial communication patterns as they attempt to stay in touch with each other.

3. Information Needs and Access Channels

Information and communications technologies (ICTs) within the context of this study refer to the various ways people use to organise and disseminate information in the developing world. Thus technologies like radio, TVs, newspapers, etc. are unconventionally considered within the realm of ICTs. In this section, we provide an analysis of the results. It begins by looking at the current access to various information and communications technologies (ICTs) by respondents. We then

explore the importance that respondents attach to various types of information, the means and frequency with which they access this information, and their level of satisfaction with the current modalities at their disposal.

3.1 Patterns of ICT use

Radio is still the most dominant form of ICT used to access information in rural areas, followed by the mobile phone as highlighted in Figure 1. TV as a broadcast media is growing as more private broadcasters get licensed and coverage expands to rural areas. 39% of respondents owned a mobile phone, with an additional 5.9% owning only a SIM card. 9.6% of all respondents own more than one SIM card and prepaid plans are ubiquitous, with only 2 respondents claiming to own post-paid contracts. In comparison, 83.6% of urban respondents own a mobile phone and an additional 4.3% own only a SIM card.

Phones are primarily used for making calls, with incoming calls accounting for about 35% of all calls. About 50% of survey respondents report using SMS, although many do so infrequently. As with calls, most SMS are outgoing messages, with incoming messages accounting for about 31% of all messages. In contrast, for the urban sample both voice and SMS traffic is roughly balanced—54% of voice calls incoming and 46% of SMS messages are incoming.

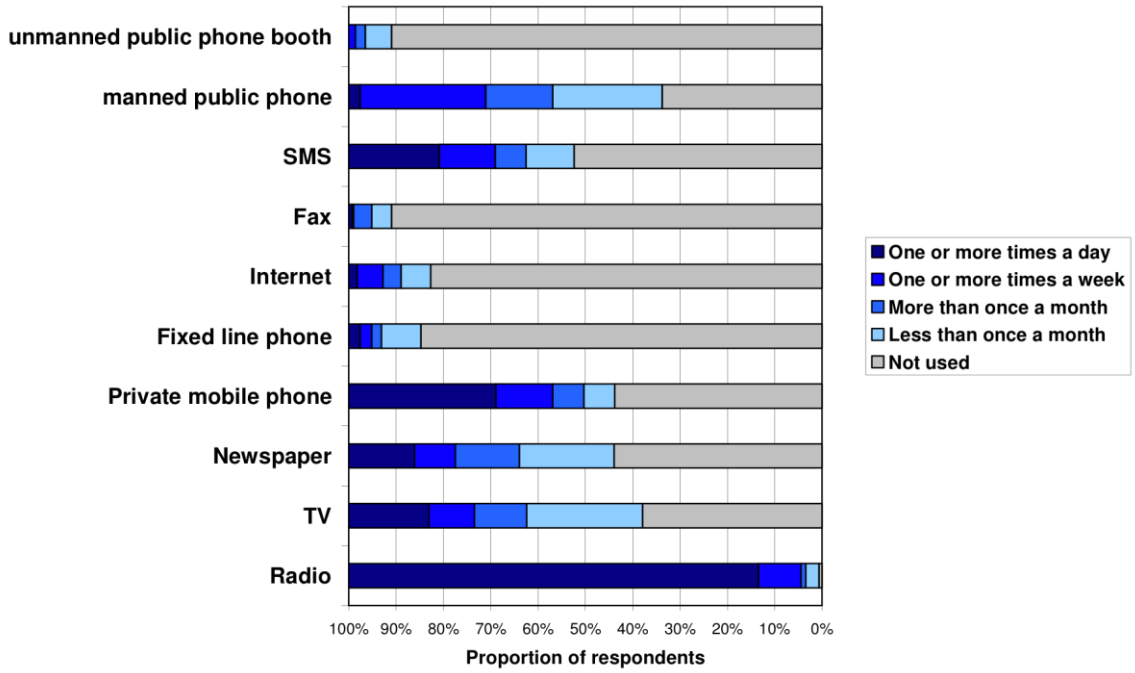

Figure 1: Breakdown of frequency of use of different ICTs in rural areas (N=290).

Although a slightly higher number of people make use of manned public phones (with an operator) compared to private mobile phones, private mobile users appear to be more intensive users. In reality, more mobile phone owners (74%) use manned phones compared to those without a mobile phone (54%). The high cost of across-network tariffs is given as the most common reason for this, making use of manned public phones cheaper for occasional calls. Other reasons included lower denominations or call cost compared to top-up credit and call management features provided by phone operators like timing calls for users to ensure they spend a specified amount of money. As a result, mobile phone owners tend to spend more on communication than non-phone owners who rely exclusively on public phones.

3.2 Importance of Issues

Issues related to health (HIV/AIDS, family planning, finding a medical expert, finding drugs, first aid) and social wellbeing (keeping in touch with family and friends) are ranked as most important. Interestingly, issues related to agricultural production (e.g. agricultural advice, modern farming ideas, weather information) are ranked higher than those relating to finance (e.g. credit, cash transfers). This might imply that respondents regard their lack of knowledge of good practice as more of a problem than infrastructural issues. Amongst infrastructural issues though, transport is ranked as most important and this appears not to be restricted to transporting only agricultural products, reflecting the importance that respondents attach to transport infrastructure.

Governance issues are ranked with low importance (e.g. learning about local government, awareness of human rights, compliance with legal requirements, participation in political debate). While this contrasts with the current importance attached to governance issues by the donor community, it might reflect respondents' perception of the minimal influence they have on political issues. Ranking local governance as highest amongst governance related issues seems back up this view, as people tend to participate more in local governance.

Preliminary fieldwork seemed to indicate that making cash transfers was important, but remittances were not ranked as highly as expected. Most of the agriculture and business related issues are given higher importance by economically active age groups (24 – 49); this is also the case for some political issues e.g. engaging in political debate, awareness of human rights.

Amongst health issues, importance attributed to knowledge on health matters tends to be consistent across age groups with the exception of the oldest (over 50 years), who regard many issues as less important e.g. HIV/AIDS, family planning, diseases. However, there are no differences in issues relating to health treatment e.g. finding a doctor or drugs.

Table 2: Information needs ranked according to importance.

Rank	Heading level	Rural Mean score (N=290)	Urban Mean score (N=116)
1	Understanding HIV/AIDS	2.73	2.74
2	Contacting people in an emergency	2.71	2.80
3	Keeping in touch with family & friends	2.64	2.82
4	News	2.58	2.70
5	Understanding family planning	2.40	2.24
6	Finding a medical expert	2.38	2.69
7	Finding drugs and what they cost	2.35	2.49
8	Learning about first aid, disease prevention & treatment	2.32	2.53
9	Transport	2.24	2.60
10	Entertainment	2.23	2.15
11	Crime & insecurity	2.18	2.46
12	Getting agricultural advice	2.18	1.63
13	Getting market information	2.17	2.47
14	Introducing modern agricultural ideas	2.16	1.78
15	Job opportunities	2.13	2.47
16	Remittances to/from family	2.12	2.24
17	Weather	2.10	2.14
18	Fake drugs	2.08	2.42
19	Expanding markets	2.06	2.23
20	Finding the right school	2.04	2.39
21	Learning more about my local government	1.98	2.10
22	Sport	1.92	2.27
23	Availability of savings, credit & other financial services	1.88	2.30
24	Raising awareness of human rights	1.87	2.15
25	Compliance with government & legal requirements	1.80	2.20
26	Adult education	1.66	1.59
27	Having your say in political debates	1.65	1.57
28	Making cash transfers remotely	1.45	1.95
29	Finding a boy/girlfriend (dating)	1.36	1.35

(Scale: 0 = n/a; 1 = not important; 2 = important; 3 = very important)

3.3 Level of Satisfaction

Generally, urban respondents expressed higher levels of satisfaction with information they receive than their rural counterparts, which is expected given the wider choice and quality of sources. Despite radio's dominance, it is not clear that satisfaction ratings are higher overall wherever more people use radio to access information. It is apparent though that, satisfaction ratings are lower where a large proportion of people claim not to get information. This latent demand for information might portend opportunities to serve them. Figure 2 shows a weak correlation between importance attributed to information on one hand verses satisfaction with current sources used to access this information. Some highly ranked information needs for which satisfaction levels are low are indicated in Figure 2. They include:

1. Introducing modern agricultural ideas;
2. Fake drugs;
3. Getting agricultural advice;
4. Learning about first aid, disease prevention & treatment;
5. Raising awareness of human rights;
6. Expanding markets;
7. Job opportunities.

These indicate issues for which people might be inclined to consider alternative means of accessing information.

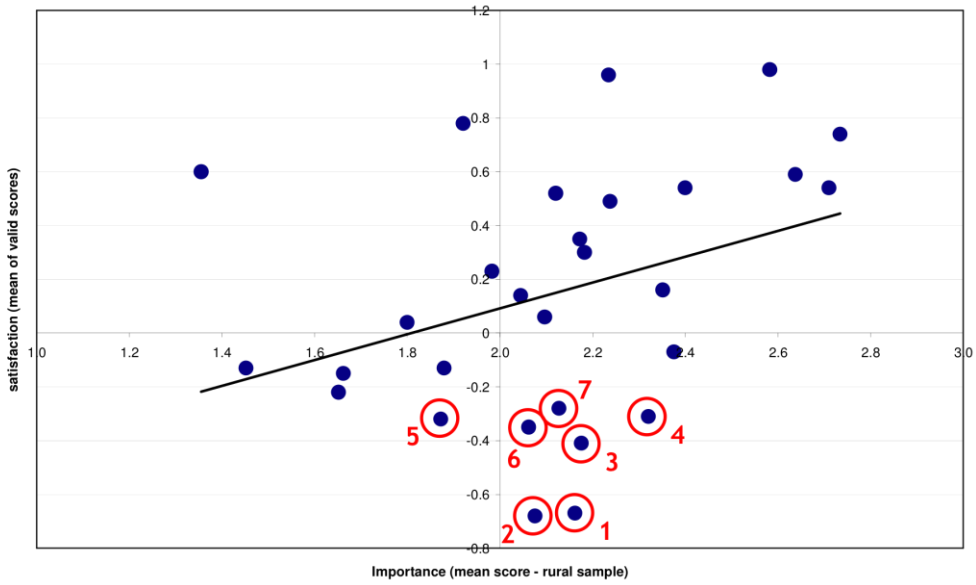

Figure 2: Correlation of Satisfaction scores with importance of issue (N=290).

3.4 Frequency of Information Access

The frequency with which respondents' access information tends to reflect the importance attributed to those issues. Figure 3 shows a distinct relationship between importance and access that compounds the potential value of being able to provide information services related to important issues, particularly for top-ranked issues like understanding HIV/AIDS, keeping in touch with family and friends, news as well as contacting people in emergencies.

The high frequency with which respondents claim to access HIV/AIDS related information begs the question of whether this information is "pushed" (e.g. radio and TV programmes) or

"pulled." The answer lies in the main channel for accessing this type of information, which is radio, reflecting the high profile of HIV/AIDS issues in radio broadcast scheduling.

There are some issues rated as important, but for which respondents access information only infrequently. Highlighted below the line in Figure 3, some of these issues include:

1. Contacting people in emergencies
2. Finding a medical expert
3. Expanding markets
4. Fake drugs

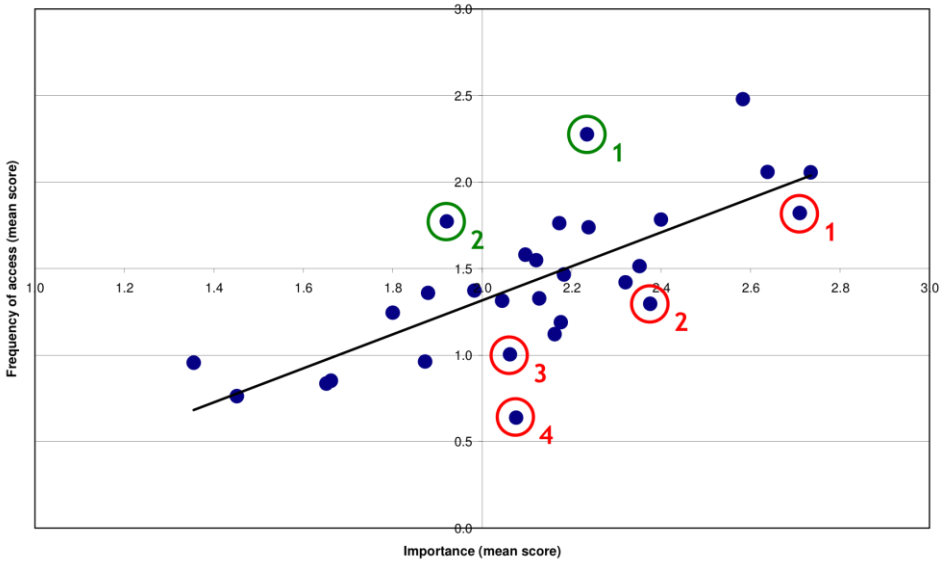

Figure 3: Correlation of frequency of accessing information with importance of issue (rural; N=290).

Other types of information people access regularly that might not be regarded as particularly important are also highlighted above the line in Figure 3. These include:

1. Entertainment
2. Sport

While urban respondents claim to access information more frequently than their rural counterparts, issues for which differences in frequency of access are not significant mirror those for which there is no difference in importance. Getting agricultural advice is the only issue for which rural respondents access information more frequently than their urban counterparts.

3.5 Means of Information Access

Radio and Face-to-face are still the dominant means through which people access information. Radio is particularly used for information relating to News and HIV/AIDS information, two of the most important issues while Face-to-face contact is commonly used to access information relating to many other issues. The phone also accounts for two of the other highly ranked issues—contacting people in emergencies and keeping in touch with friends and family. Newspapers on the other hand play an important role in urban areas, where they are most common sources for information on job opportunities as well as government and legal issues.

Although over 60% of respondents watch TV (Figure 1), only a modest proportion of the respondents—around 15% (note that this corresponds to the number of respondents watching TV frequently) regard it as the most important means of accessing information. TV is primarily used as a source of information on entertainment, sports, news, and the weather.

Taking into account the dominance of radio and face-to-face, *location of the information source* tends to play an important role. Information that originates locally tends to be accessed via face-to-face, while that which originates remotely (nationally or globally) tends to be accessed via radio. *Information urgency and its shelf life* also tend to play a role with face-to-face better suited for information needed with a given *timeframe*. Although learning about HIV/AIDS is recognised as important, it tends not to be a matter of immediate urgency, unlike, for example, the need to find a doctor.

Where an issue involves a *personal transaction* (even as an outcome of the issue itself) face-to-face tends to be best suited e.g. finding a medical expert, job opportunities (employers will generally want to meet the person they employ); finding schools (similarly, parents will probably want to visit school and meet staff before committing to a school). On the other hand, information suited to the radio tends to be "impersonal" information e.g. weather, information on disease, etc.

Some information needs do require multiple pieces of information that are related that may require interpretation and sorting, which introduces two related challenges—*complexity* and *interaction*. Consider a job opportunity, it will include start date, duration, tasks, skills and experience required, and wage—all of which tend to be negotiable. Interaction relates to the ability to drill down through large amounts of information to find what you are looking for while getting feedback throughout the process. Face-to-face might be expected to lend itself best to complexity and interaction, although radio, augmented with say mobile phones can be used to communicate complex ideas and provide opportunity for users to give feedback. It is over such issues that the Internet has a clear advantage, but its use is currently almost non-existent. For most issues that involve actively seeking specific information (e.g. finding the right school, job opportunities, getting market information, finding drugs) it is face-to-face that is the dominant means of access.

There is a good deal of similarity between the predominant means of information access between rural and urban respondents. Differences highlight a preference for TV as a means of entertainment among the rural population, wider availability of newspapers, and more widespread use of phones for personal contacts.

4. Discussion

There are a number of expressed information needs for which people seem unable to get the desired information. Issues for which 10% or more respondents claim not to get information include health (finding a medical expert, learning about first aid, fake drugs), agricultural matters (advice, weather), and economic matters (job opportunities, markets). For many of these issues, people tend to seek information (information-pull) and face-to-face contact is currently the predominant way to access this information.

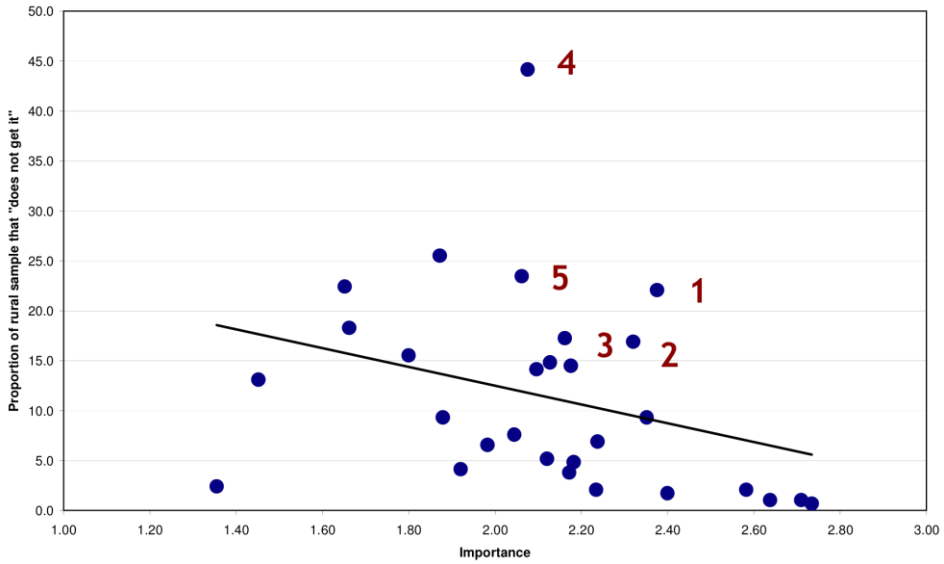

Figure 4: Proportion of sample not getting information against importance of issue (N=290)

The relationship between importance attributed to an issue or information need and proportion of respondents that report it as unmet is illustrated in Figure 4. Given that respondents try to find sources of information relating to issues that they regard important, this does indicate latent demand for information that could be filled by potential services. Some of the emerging information gaps highlighted in Figure 4 include:

1. Finding a medical expert
2. Learning about first aid, diseases etc
3. Introducing modern agricultural ideas
4. Fake drugs
5. Expanding markets

Compared to other means of accessing information, one advantage of the phone is its interactivity—communication (using voice or data) is two-way. In this respect, it's an obvious substitute for face-to-face communications. However mobile phone applications need to take into consideration other aspects that can influence channel selection, some of which may include:

- *Content origin*—allowing users to easily access information generated remotely (nationally or globally), which currently needs to be broadcast. The challenge then becomes one of cost as most broadcast media are currently free
- *Content publication*—empowering mobile phone owners (and public phone users) to publish information, particularly about their local context, whether explicit (such as voting on different TV programmes) or implicit (such as tracking the spread of disease through enquiries about the disease)
- *Content timeliness*—enabling users to access information whenever and wherever they might require it. Some situations might require on-demand responses, while time-lags between requests and responses might be acceptable for others
- *Specificity*—relevance of information is often related to geographical location and context. For example face-to-face discussions are a great way for farmers to share agriculture tips and experience that are local in nature. Thus to capture such information for later dissemination would require accompanying context. Phones can make it easier to target a user with content using a range of criteria (e.g. location and language) much more easily than other channels

- *Navigation*—databases are good for organising and sifting through large amounts of data or complex information, but how do you provide an interface that allows users to easily navigate such information with a good user experience within the constraints of mobile phone while minimising operator intervention at the backend?
- *Personal interaction*—some transactions like visiting the doctor sometimes require face-to-face communication and contact during interaction to facilitate examination and diagnosis. How can we emulate or compliment such personal interactions? Or better support transactions that require discussion or dialogue before a solution can be identified

5. Conclusions

As a communication medium, mobile phones now have a wide reach into rural communities in Uganda. The rapid increase in phone penetration thanks to falling handset costs coupled with the good coverage across the country, indicates that handset ownership is likely to increase within poorer sections of society. TV audiences are also increasing and, as coverage increases, this is likely to emerge as a viable alternative to radio, which is still currently the only medium with universal coverage. Complimentary interaction between mobile phones with both radio and TV is an aspect that we did not cover in this study, but one that warrants further investigation (Donner 2008). As mobile handsets acquire more processing and beget open source operating systems like Android and Symbian, they are spawning application development efforts that are more responsive to local needs.

One of the implications of public phone use is the difficulty of receiving calls—in rural areas only about one third of calls and SMS messages are incoming or received. This implies that the poor are bearing a bigger burden of the costs of communication. Given that phones are primarily used for calls to family and friends, this has implications for the development of social types of applications. It would be attractive to explore ways to support shared use of devices as well as the cost of services (much like a collect call, or reverse charge call). This will require some ingenuity, as the concept of collect call services has not been widely adopted in Africa and we have not encountered research in this area.

Phone applications as a source of information might tend to be more accurate and less susceptible to distortions for example compared to face-to-face. While face-to-face communication is common and plays an important role in building social capital, people have to use more judgement to assess the accuracy and relevance of information they pick up. A good deal of this also depends on the recipient's relationship with the information bearer and perception of their credibility. All of this implies that preliminary effort has to be invested to create credibility and trust for any mobile application amongst its potential users.

Literature has indicated that mobile phones tend to result in cost reductions rather than increased income for small business operators (Souter, Scott et al. 2005; Donner 2007). It is likely that mobile applications will in the same way enable people to access information more cheaply. Mobile applications that provide information may also reduce vulnerability, especially where they facilitate access to services (e.g. finding medical experts). They can also build the capacity of the individual to cope by providing access to education materials (e.g. family planning).

There is still need for more research to explore viable business models for mobile applications. For starters, some of the most important information needs that also align with developmental themes like health services tend to correlate with less frequency of access (see Figure 3), complicating normal commercial avenues to provide such information. Where there is a tangible benefit, it is likely that the poor will pay for a service as the mobile market has demonstrated. Although there is some reluctance to pay for services offering potential or future

benefit (e.g. introducing new crop varieties) as they tend to be risk averse. It is difficult to assess willingness to pay for services, but it would be useful to gain an understanding of how users make decisions to use or not use services.

A related challenge emanates from the tension between accessing information for private gain verses for public good. Rural communities tend to work collaboratively together on certain matters and certain types of information may fall into this category or people tend to share—one household member will pay and then share information with rest. How such characteristics influence the success of some mobile applications is not entirely clear. Conversely, NGOs have a track record of paying for media programmes in line with their work (e.g. health awareness campaigns) and might be interested in subsidising some of these applications. Government institutions might also subsidise services that provide an element of public good (e.g. tracking spread of the disease, monitoring insecurity, detecting fake drugs). This raises the possibility of interesting public-private partnerships that fulfil the interests of various stakeholders.

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Blacknoise: Low-fi Lightweight Steganography in Service of Free Speech

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Abstract: Censorship of communications is a widespread, current practice in various countries with repressive governments in order to prevent or restrict speech; political speech in particular. In many cases state-run telecommunications agencies including those providing internet and phone service, actively filter content or disconnect users in defense of incumbents in the face of widespread criticism by citizens.
In this paper I present Blacknoise, a system which uses commodity low-cost mobile telephones equipped with cameras, and takes advantage of their low-fidelity, noisy sensors in order to enable embedding of arbitrary text payloads into the images they produce. These images can then be disseminated via MMS, Bluetooth, or posting on the Internet, without requiring a separate digital camera or computer to perform processing.

1. Introduction

Regimes such as China [1,2] are actively censoring content across various communications channels used by their citizens under the auspices of an effort to curb "offensive" materials, often with full cooperation from state-run agencies such as China Mobile [3]. However, reports in [4] indicate that this censorship also cracks down on political speech including satire, and is triggered by, for instance, any mention of the names of political figures.

In addition, nations as varied as France and India [5] prevent encryption of SMS by regulation, ostensibly in order to ease monitoring of communications along this channel, while Iran [6] disabled the transmission of SMS entirely in the hours leading up to its 2009 presidential election in response to SMS' role in organizing protests and mass rallies as well as transmitting news outside of the country via channels such as Twitter [7].

A litany of other nations conduct routine censorship of internet traffic, including but not limited to Turkey [8], Saudi Arabia [9], Pakistan [10], and many others, which follow the pattern of limiting speech and consumption of speech on the grounds that they are protecting their citizens from harm.

2. Steganography

The aim of steganography (from the Greek *στεγανός*, for 'covered' and *γράφειν*, 'to write') as a technique is to conceal a message within some 'cover medium' in such a way that the fact that a message is being sent at all is difficult to detect and harder to prove, and recovery of any such message is harder still.

A popular historical example of such a technique is noted in Herodotus' account of Histiaeus, who shaved the head of a trusted slave and tattooed a message on his scalp, sending the slave to deliver the message once his hair had grown back in, obscuring the message. The modern interpretation of this technique involves embedding message bits into some digital cover (most typically in images, although embedding in video, audio, and text are also practiced.) One of the most basic steganographic techniques is known as Least

Significant Bit (LSB) replacement, wherein the message bits are written over the least significant bits of the carrier medium, e.g. the lowest intensity bit in each pixel in a raster image. These bits were initially assumed to contain random Gaussian noise.

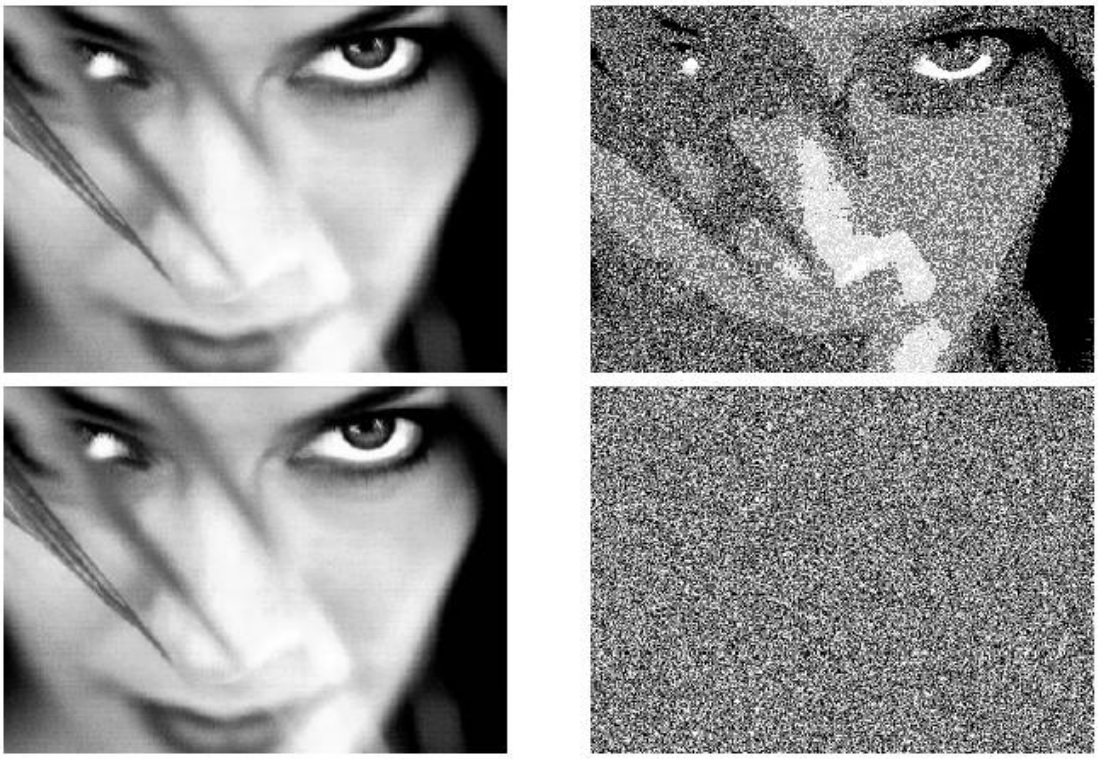

Figure 1: LSB plane example using two images. Upper left image is the original photograph, and upper right is its least significant bit plane with 0 set to black and 1 set to white. The lower left image is a message embedding with S-Tools and the lower right is its LSB plane. Images from [11].

Subsequent analysis [11] indicated that the LSBs of cover images were not, in fact, random, but statistically correlated. The outworking of this was that naive embedding of message bits was easily detectable using straightforward χ^2 analysis and, depending on embedding style, could also be detected using a "Visual Attack" [11] in which the bit plane assumed to contain the image was extracted from the cover image and visually inspected.

A somewhat more advanced technique than LSB replacement is called LSB matching [12], wherein the pixel values are modified at random by ±1 if the bit of the cover does not match the bit of the embedded image, which preserves image statistics better than the earlier method.

3. System Overview

We make the observation that low-cost embedded imaging sensors of the type typically found in early or inexpensive cameraphones exhibit high noise floors in both luminance and chrominance due to their small size, artificially increased sensitivity/ISO, and typically the lack of a flash.

Using 150 samples of images taken with a Nokia 3110c, a Chinese-made Amoi E72, and an Indian-made Micromax X280 at the default resolution for MMS (120x160 pixels), it was observed that the LSB plane did, in fact, more closely resemble random noise than image content illustrated in Section 4). Significantly, this also held true for each of the four least significant bit planes of each color channel, leading to significant visible noise in the resultant images.

The design of Blacknoise makes use of this fact and makes the novel contribution of extending the LSB matching technique across all three color channels of a PNG bitmap image taken with mobile phone cameras, across the four least significant bits. The result is that the embedding rate on any given bit plane is 1/12 what it would be on an equivalent grayscale bitmap image using conventional LSB matching.

Blacknoise operates, at a high level, as follows: Users Alice and Bob each have a cameraphone handset with the Blacknoise software installed. In a face-to-face encounter, the software establishes a symmetric key for communication between the two parties over Bluetooth or some other near-field communication method, e.g. Infrared, NFC. This key is used until the two parties meet face-to-face again and optionally establish a new key.

After the two parties separate, if Alice wants to send Bob a message, she takes an arbitrary, innocuous snapshot using her cameraphone, and enters the message. This message is encrypted appropriately with the symmetric key and a stream cipher, and the message is embedded into the image in a pseudorandom manner, using a pseudo-random number generator (PRNG) seeded with the last *n* bits of the key. When embedding the message, the system makes use, as noted above, of the four least significant bit planes of each color channel. The alpha, or transparency, channel is left untouched as it is unlikely that a mobile phone will produce an image with variable alpha, and as such images with alpha channel noise would immediately become suspect. The encoded image is then sent as a PNG bitmap using some carrier medium (MMS, Bluetooth, email, Internet posting, etc.) to Bob.

Upon receipt of the message, Bob opens the application and uses the established key to seed his own PRNG, selecting the correct bits to read values from, and uses the key to decrypt the ciphertext, recovering the message.

Eve, a party at the telecom or Internet provider observing the MMS message or image, may perform statistical analysis on messages passed between parties, and ideally should not be able to detect the presence of a message in the cover.

4. Implementation

A proof-of-concept implementation of Blacknoise was created on a pair of Nokia 3110c handsets in J2ME. The 3110c has the requisite J2ME APIs: JSR 205 [13] for MMS, JSR 82 [14] for Bluetooth connectivity, JSR 177 [15] for cryptographic APIs, and JSR 135 [16] for access to multimedia devices, including onboard cameras. In addition, as noted previously, the 3110c has a poor-quality image sensor which produces a high noise floor.

The software creates an RFCOMM Bluetooth connection between the two handsets using a custom UUID to distinguish the application. It subsequently establishes a symmetric key for the Salsa20 stream cipher. The implementation of this cipher is provided by the BouncyCastle [17] cryptographic library for J2ME.

A file selector is provided to load images which have been saved to the phone, allowing images to be received via any of the various communication methods the phone supports, including MMS, Internet, Bluetooth, and Infrared.

As the 3110c unfortunately does not support capture of images into a bitmap format (despite specifications indicating otherwise) a custom PNG encoder using the open source JZlib [18] library was implemented.

Once a key between two parties is established using the J2ME PRNG, the application allows capture of images via the 3110c's onboard camera, at the 120x160 pixel resolution standard for minimal MMS. After the image is captured, the user specifies a message to embed, with the same 160 character, 140 byte payload limit as an SMS message. This limit is artificial but is designed as a sensible first-cut payload size and will increase as further evaluation about the embedding capacity of these images is performed. Larger captured images also clearly offer greater embedding capacity.

The input message is encrypted using the Salsa20 cipher and the established key (with a static, predefined 64-bit initialization vector for the purpose of this proof of concept) and embedded at random using LSB matching to preserve statistical properties. The resulting

image is then either saved for transmission using WAP/GPRS/EDGE/UMTS or Bluetooth, or is embedded into an MMS/SMIL message. In the latter case the user is prompted to enter any additional descriptive text, such as a caption, and the message is transmitted using JSR 205 APIs.

The message is appropriately extracted and decrypted upon receipt when the user selects the received file in the file browser and selects the symmetric key he has established with the sender, and the decrypted message is displayed to the user.

5. Dissemination Methods

5.1 – MMS

The Multimedia Messaging Service (MMS) is a service which works analogously to the better-known SMS, but can carry multimedia content (e.g. images, video, and audio) as well as text. As a result, the payload size of MMS can be much higher, albeit at a somewhat higher cost to the subscriber.

The popularity of MMS is on the increase in areas with limited data connectivity, with China Mobile, for instance, reporting a volume increase of 130% to 33.1 billion messages, representing an 83.7% increase in revenue to approximately $421 million USD in its 2008 earnings report [19].

MMS is supported on every modern cameraphone handset and has widespread API support via J2ME JSR205 [13] and lower-level phone operating systems.

This widespread and growing acceptance of MMS, its larger payload as well as its own and well-understood specification make it one of the natural choices as an obfuscated data carrier.

The use of Blacknoise over an MMS carrier is straightforward. Once the shared key is established and an appropriate message is encoded in an image shot by the cameraphone, the image is then embedded in an MMS message and conveyed to a target user, and the message extracted and decrypted on the other end using the shared key.

5.1.1 – MMS Caveats

While MMS is a natural channel for information such as this, there are certain drawbacks which must be considered.

Firstly, MMS, depending on the country, can carry a significant cost, often three to ten times that of SMS or data via GPRS, EDGE, or UMTS, which can represent a major cost burden in developing nations.

Secondly, MMS messages are routed from handsets to servers controlled by the mobile service provider known as MMSCs, or Multimedia Messaging Service Centers, which then route the messages onward to their destinations. Because this carrier-controlled bottleneck exists, carriers can put filters in place which either resample or compress images in bitmapped formats, destroying the data contained within. While techniques exist to embed bits in similar ways into audio and video rather than images, these media are also susceptible to the same type of resampling or compression and offer no advantage against this bottleneck, while offering significantly increased complexity to encode on a computationally restricted mobile handset.

Finally, as in the Iranian example, during periods of dissent, mobile carriers can simply be instructed to turn off communications entirely, completely blocking this channel of communication.

5.2 – Bluetooth/Infrared

Bluetooth or Infrared file transfer, also known as OBEX, or Object Exchange, offers another channel through which Blacknoise images can be conveyed. This technique requires the communicating parties to be in very close proximity to one another - 30 meters in the case of

Bluetooth, and mere centimeters in the case of Infrared. In order to perform the exchange, the properly encoded Blacknoise image merely needs to be sent, as any other image file, to the recipient which is set to receive it.

This proximity makes widespread interception and analysis difficult, as the information exchanged never spreads beyond the immediate vicinity of the sender and receiver. In addition, there is no cost associated with this transfer mechanism, as there is with MMS.

Finally, Bluetooth supports a technology called 'Piconets' in which one master can communicate with up to 7 other devices, and 'Scatternets' which are bridged Piconets, which have no effective size limit. While the exact implementation of a communication channel using these techniques is outside the scope of this paper, it's clear that in some cases, particularly where many people are massed together, (e.g. a protest) this represents an economical and secure method for dissemination of information.

5.2.1 – Bluetooth/Infrared Caveats

Again, certain drawbacks apply to this communication channel, aside from the distance restriction inherent to the technology.

Bluetooth, as a standard wireless communications medium, is susceptible to jamming on its standard frequencies. While Bluetooth uses channel hopping in order to counteract narrowband interference, a sufficiently powerful broadcaster could energize the entire Bluetooth band and prevent any communications from occurring.

Additionally, only certain payloads and scenarios make sense for Blacknoise communication with those who are already nearby vis-a-vis passing a piece of paper or having a conversation in person. However, in these specific scenarios (e.g. where the parties communicating are under direct visual observation), Blacknoise can prove indispensible in, for instance, providing plausible deniability that any communication occurred.

Finally, in the case of Piconets and Scatternets, the problem of key dissemination and control adds a significant degree of complexity to 'broadcast' type messages. While these challenges are straightforward to overcome, they do require careful redesign of certain elements of the protocol, as well as potentially imposing a larger infrastructure burden compared to the current lightweight implementation of Blacknoise.

5.3 – Internet

The Internet, for those who have access to it, is easily the most robust and simplest method of conveying Blacknoise images. While nations which carry on censorship can and do selectively block sites, it is nigh well impossible to block every site on which a Blacknoise user might post an image, and even more difficult to resample every candidate image to make it unusable, given the sheer volume of images transmitted through the Internet.

Aside from dedicated photo-sharing sites such as Flickr [20], Blacknoise images can be posted anywhere in innocuous forms from personal blogs (though Blogger [21], Tumblr [22], Livejournal [23] and Wordpress [24] are all blocked in China, myriad other services exist), and the nearly limitless number of discussion forums on the internet which support .PNG images in 'Avatar' icons or user signatures.

Use of the Internet as the medium for conveying these messages carries with it all of the advantages entailed in other Internet use, including (relative) anonymity, encryption when using TLS and, typically, low cost.

Finally, unlike either the MMS channel or Bluetooth, it is impossible for a regime to completely cut off Internet access without both incurring significant negative global publicity and crippling elements of its business mix which rely on the information economy.

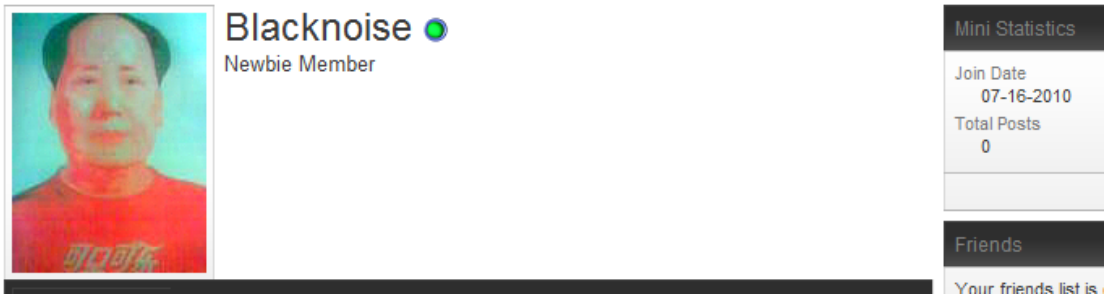

Figure 2: A Blacknoise image used as an avatar on an arbitrary web discussion forum.

5.3.1 – Internet Caveats

The Internet may be a preferred medium for dissemination of Blacknoise images, but there are obvious drawbacks to using it for this purpose. Countries which have an interest in controlling the flow of information have developed extremely sophisticated methods for tracking and tracing these flows and, while Blacknoise offers a significant degree of deniability, the burden of proof in such regimes typically lies with the accused. Thus, should an image be suspected of carrying hidden information, it is possible that the poster could be tracked and prosecuted.

In addition, it is important to note that Blacknoise images posted on the Internet as opposed to shared directly on handsets have the property that they can be accessed by anyone, a negative property if the goal is information control and a positive one if the goal is broad dissemination.

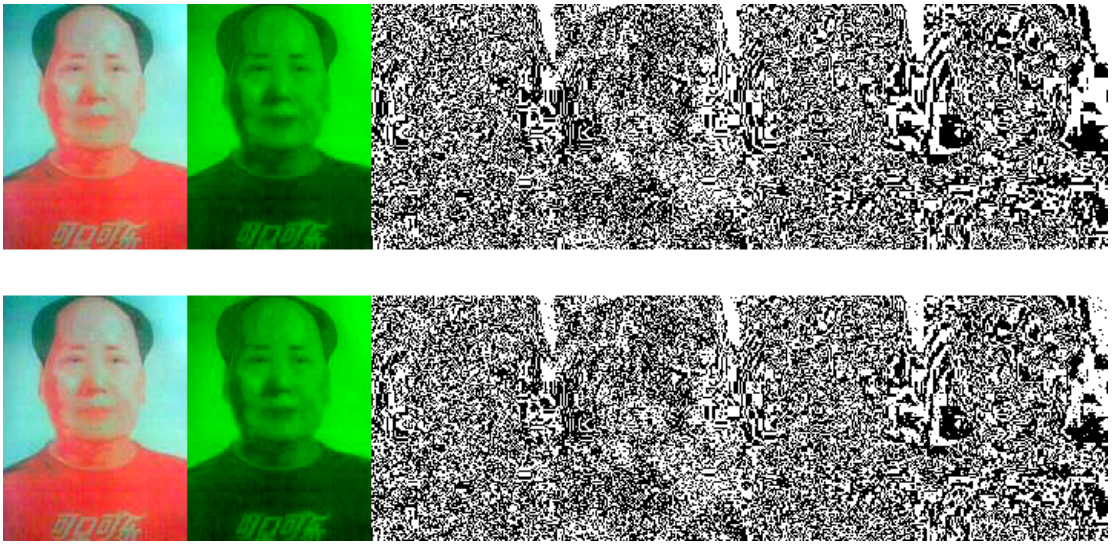

Figure 3: Examples of an image captured with the 3110c camera. The top row from left to right consists of the full color image, the green channel (selected as representative and containing the least visible noise) and the bit planes of the four least significant bits of the channel (1,2,4,8) before encoding. The bottom row contains the same images after encoding 1 message bit per pixel, a total of 19200 bits, or 2400 bytes. This represents more than 17 times the data payload of an SMS, and was selected as a reference only.

6. Analysis

We examine the results of embedding a message at a rate of 1 bit per pixel; in other words, an average of 1/3 bit per pixel per channel, or 1/12 bit per pixel per channel per bit plane. The resultant images of the bit planes can be seen in Figure 3.

It is clear to see that visual attacks will be difficult to execute without access to the original, unembedded cover image, as the qualitative noise pattern in the embedded and unembedded images on each of the four bit planes is very similar due to the high noise floor of the sensor masking the embedding. While differences are perceptible, particularly in fields of high intensity such as that in the upper right of the image, even these would be difficult to pick up in the absence of the original image for comparison. In addition, measures can be taken to avoid embedding 0 bits in such saturated areas during the embedding phase, or additional procedural noise can be introduced to mask saturation.

Initial attempts to classify stego and cover images using standard χ^2 techniques as well as Westfeld and Pfitzmann's sliding window [11] technique have failed to provide significantly better than random detection due to the low effective embedding rate per channel per bit plane. Histogram analysis to detect greater-than-normal symmetry in least bits due to LSB replacement is defeated by using LSB matching instead. The small image size (and therefore the small number of pixel samples) and high noise floor also contribute to creating high degrees of statistical variance between images and a difficulty in accurately characterizing a given image.

Because existing techniques for bitmap images rely upon the assumption that all bits are embedded in the LSB plane, effectiveness is reduced. It is currently unclear whether there is a simple augmentation that could be performed on these tools which would allow more robust detection of LSB matching among the 12 different bit planes used.

While there exist commercial tools to detect embedding in bitmap images, (e.g. [25]), their effectiveness is unclear as it is unknown what principles they work on. There are free and open source steganalysis tools available, but the best among them, StegDetect [26], only operates on JPEG coefficients, not bitmaps. StegSecret [27], an open-source contribution which detects various LSB schemes on bitmap images, failed to identify a single embedded image.

7. Related Work

There is a great deal of work surrounding the topic of steganography. Jessica Fridrich at Binghamton University leads a group that has produced several important papers on steganography and steganalysis [28-33].

Andreas Westfeld and Andreas Pfitzmann [11] contributed some early seminal work on steganalysis including some of the first statistical attacks on contemporary steganographic systems. Westfeld also contributed one of the first LSB encoding systems resistant to basic statistical attacks, F5 [34] for JPEG images.

Niels Provos created OutGuess [35], which used selective pseudo-random number generator seeding to deterministically offset statistical aberrations caused by steganographic embedding in JPEG images, and also created StegDetect [26], an application which detects various steganography schemes in JPEG with a high degree of reliability.

While there has been research into steganography on mobile platforms, notably by Agaian et al [36], most of the corpus consists either of implementations of 'naive' LSB or orthogonal research on algorithms which work well with constrained image sizes and low-powered processors without taking the advantages of naturally occurring noise into account.

Blacknoise builds upon various facets of the existing work, particularly making use of LSB matching and pitted against several of the published statistical steganalytic methods while contributing the underutilized principle of high-noise sources and using multiple bit planes to limit statistical perturbation of any given bit plane. In addition, the fact that Blacknoise operates preferentially on low-cost phone handsets brings steganography within

practical reach for many in the developing world who own such phones but have little or no access to computers of their own.

8. Future Work

Future work on the Blacknoise system will proceed in several directions. Of primary importance is more robust analysis of the statistical properties of the cover images produced by small sensors, and how they differ from images which have been embedded. This analysis will help ascertain tight bounds for embedding capacity, allowing greater freedom in embedding text.

Orthogonal to this but of similar importance is research into generating procedural noise which carries similar statistical and visual properties for use with phones with better cameras, including smartphones.

Finally, more rigorous steganalytic tools will be brought to bear upon the images which result from Blacknoise, including RS [28] and Difference Image Histogram [37]. The standard statistical tools used in the analysis performed to date will also be examined for ways in which to augment them to detect the multiple bit plane embedding used in BlackNoise.

9. Conclusion

In this paper I have presented Blacknoise, a simple, lightweight steganographic system which takes advantage of the significant noise present in image sensors in typical inexpensive cameraphone handsets. The properties of the images produced by these cameraphones combined with contemporary embedding techniques defeat known existing first-line detection of message embedding in bitmaps.

Properly implemented, the system should allow the transmission of arbitrary text within and outside the borders of nations governed by restrictive regimes while maintaining plausible deniability and making both detection of message transmission and the recovery of messages difficult for parties not in possession of the appropriate keys.

The advantages of the Blacknoise system are clear, but significantly include a vast reduction in the amount of infrastructure required to send a hidden message: one $30 USD cameraphone as compared to a digital camera, memory card reader, computer, image editing software, etc. It is my hope that this will democratize the sending of truly private communications and increase free speech in otherwise repressive environments.

While this implementation is academic and stills a work in progress, it is my hope that future development will allow for both more definitive security guarantees and practical use in China and elsewhere around the world.

10. Acknowledgments

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"Ten Seeds": How mobiles have contributed to growth and development of women-led farming cooperatives in Lesotho.

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Abstract: The potential for mobiles to contribute to development has been widely heralded, but evaluations tend to be technically-oriented and not framed by development theories, and thus empirical evidence on their actual developmental impact is limited. This paper attempts to address this gap by building on 4 follow-up evaluations over the 4 years since mobiles were provided to women-led farming cooperatives in Lesotho. Using theories of development as economic growth, empowerment and choice, the paper highlights how, in these women-led farming cooperatives, development has certainly been achieved against all of these elements.

1. Introduction

Information and Communications Technologies (ICTs) have widely been heralded as a mechanism for promoting development (UNDP, 2001; Saunders et al, 1983). This is particularly the case in Africa, where there has been a rapid growth in both mobile ownership and signal coverage in recent years. A number of academic communities have turned their attention to the developmental impacts of ICTs, resulting in such terms as M4D (mobiles for development) and ICT4D (ICTs for development), and the growth of a development informatics discipline. However, the dominance of technical specialisms in development informatics, relative to development studies, means that impact assessments have been poorly informed by conceptual frameworks on which to truly assess the effects of mobiles on development. By association, it also raises the question of how to define development. This paper presents a qualitative and longitudinal examination of the impact of ten mobiles ("ten seeds"), provided by a development programme to women-led farming cooperatives.

2. Growth in the availability and uptake of mobiles in Africa

In 2008 58.5% of the population of Africa was covered by a mobile signal, with some countries, including South Africa, Botswana, Mauritius and the Seychelles, approaching 100% coverage of inhabited areas (ITU, 2009). A number of African governments, such as South Africa, Kenya and Uganda, have obliged mobile operators to provide certain population coverage as part of their license conditions and/or require them to install community service telephones, thus ensuring that coverage is not solely restricted to urban areas (Gray, 2006). By the end of 2008 there were over 246 million mobile subscriptions in Africa (out of a population of just under 700 million), and between 2003 and 2008 the rate of growth was more than double that in the rest of the world. Estimates suggest that actual

usage might be twice the subscription rates, due to the shared usage of mobiles (Heeks, 2009). Even vulnerable groups that are typically targeted for development interventions, such as the elderly and women, are embracing the technology and learning how to use mobiles (Vincent et al, 2009; Vincent and Freeland, 2008).

3. Theories on the linkages between mobiles and development

Whilst the increased diffusion of ICTs is undisputed, more questions have been raised about the actual impact of these on development. In a recent policy arena of the Journal of International Development Studies, Richard Heeks argues that the development informatics community has been informed much more by academics with a technical bias (for example those from the information sciences, information systems, communication studies and computer science disciplines) than those with a development studies focus (Heeks, 2010). The consequence has been that the impact assessments of ICT4D have typically been descriptive rather than analytical, lacking in methodological rigour and, crucially, not linked to development studies-informed conceptual frameworks around which to structure and analyse findings. Perhaps even more fundamentally, undertaking impact assessments around ICTs requires epistemological questions to be asked concerning what development actually is?

The policy arena presents three papers in which different perspectives on mobiles and development are shown. Donner and Escobari (2010) use models of enterprise value chains first proposed by Porter (1985) to define how mobiles contribute to development. They find that mobiles improve the quality and depth of existing trading relations, by allowing small and micro-entrepreneurs to build trust by keeping in closer contact with their suppliers and customers, and also to reduce their costs by removing the need for physical journeys. This is defined as progressive change, but not transformational. Donner and Escobari (2010) find less evidence of transformational change, with few signs that mobiles alter the market structures, or create new livelihoods but they cite other studies which found that found evidence of the "digital provide", namely that the existence of mobiles tends to change the operating environment to the benefit of all in it, whether or not they themselves have direct access to mobiles (the reverse of the argument proposed in the 1990s and 2000s on how a "digital divide" would arise between those with access to ICTs, and those without it (van Dijk and Hacker, 2003; Norris, 2001).

A study on fisheries in India showed that, after the introduction of mobiles, profits for small-scale fishermen in Kerala increased, whether or not those fishermen owned mobiles. For those that did, profits rose by an average of US$4.50 per day, more than offsetting the costs of phoe ownership and use; but even the profits of those fishermen without phones increased by US$2 per day, as market efficiency improved for everyone, meaning fishermen were able to sell more of their catch, and thus reduce wastage. The actual price per kilogram for fish dropped, as less wastage meant the market was better supplied – but this, of course, provided benefits to all consumers (Jensen, 2007).

Whilst economic growth is undoubtedly one aspect of development, there are other, less tangible, elements that are equally important. The second element addressed in the policy arena is a sense of empowerment, arguably something which is particularly the case for vulnerable groups in society, whose economic position may have consequences for their social standing. Khan and Ghadially (2010) take the example of Mumbai – second only to Bangalore as a centre for ICTs in India – and show that, despite the widespread availability of ICTs, uptake shows gendered differences, with women far less likely to use computers and the internet outside of their college time. However, those women that have benefited from training in ICTs report higher indicators of empowerment than their male counterparts, thus suggesting that if women are enabled to cross the digital divide, ICTs do have a potential to reduce inequality. Psychological perceptions of well-being thus also form a critical component of development.

Staying with the more qualitative definitions of development, a sense of empowerment can also be brought about by the availability of increasing choices available to individuals. In the third policy arena paper, Kleine (2010) zeroes in at the individual level, looking at the impact ICT plays on the life of a single female micro-entrepreneur living in Chile. Underlying the fact that development involves so much more than economic growth, she finds that the choices now open to this woman might be overlooked by quantitative indicators. However, to the woman herself, the ability to "visit" online a German city in which she once had a pen friend was just one example of how ICTs offered her a choice that was of significant value to her life.

The following chapter applies the various conceptions of development to women-led farming cooperatives in Lesotho. The Thulare Dairy Farmers Cooperative (established in 1997) comprises a number of member groups based in different agro-ecological zones in Lesotho – the lowlands, foothills, and highlands. The cooperative was provided with 10 mobiles in 2006, and subsequent follow-up visits for evaluation took place in July 2007, January 2009 and July 2010. The frequency of visits and length of time that has elapsed since the initial provision of mobiles exceeds that which might be expected as part of a typical monitoring and evaluation framework attached to development funding. The qualitative nature of the evaluations also provides an extra dimension that is typically overlooked in quantitative studies. Thus this case study is ideal to critically assess the role of mobiles in promoting development over the long term.

4. "Ten seeds": background to the provision of mobiles to the cooperative

As part of its remit to build evidence on innovative approaches to develop better, more dynamic, ways of tackling both acute hunger and chronic, predictable vulnerability, the Regional Hunger and Vulnerability Programme (RHVP) undertook a pilot project to see how vulnerable people benefit from mobiles. Ten mobiles were provided to the Thulare Dairy Farmers Cooperative in Lesotho in August 2006, five of which stayed in the lowlands groups, 1 of which went to the foothills groups, and 4 of which went to the highlands group (see figure 1).

The Regional Hunger and Vulnerability Programme (www.wahenga.net) is a UKAid by the Department for International Development and AusAID-funded programme in southern Africa. It advocates for long term social protection to at-risk groups in order to reduce their vulnerability and hence reduce the likelihood that episodic events such as drought plunge such groups of people into crises. Cash transfers are a popular example of social protection in southern Africa, taking the form of non-contributory social pensions, child support grants, and disability grants. Effective and efficient delivery of cash transfers is, however, an important policy question (Devereux and Vincent, 2010). Electronic delivery systems, using smart cards, debit cards, and mobiles, have been proposed and trialled but, initially, opponents cited an obstacle to their use: the inability of vulnerable groups (such as those targeted by cash transfers) to handle ICTs. RHVP provided these mobiles to the cooperatives on the basis that cooperative members had similar demographic profiles to the target beneficiaries of cash transfers, and thus was interested to see how they would be used.

Evaluations subsequently took place in July 2007 and January 2009 (for further information, see Vincent et al, 2009; Vincent and Freeland, 2008). The results showed that, contrary to the arguments against using mobiles to deliver cash transfer, even illiterate vulnerable people are actively able to embrace ICTs. Moreover, these women-led cooperative groups had greatly benefited from improved communications, both in terms of their farming activities and the reduced time and cost of staying in touch with each other. Furthermore, they had even been able to use their mobiles as effective income-generating tools through selling airtime by SMS, thus raising revenue to enable further development of their cooperative.

4.1 Background to the Thulare Dairy Farmers Cooperative

The Thulare Dairy Farmers Cooperative has its headquarters at the Bishop Allard Vocational School in Roma, and benefits from skill sharing and training from the school. Indeed, the cooperative was initially formed by a number of agriculture teachers at the school who had benefited from overseas training on the management of cooperatives. The cooperative was formed in 1997 and formally registered with the Ministry of Trade and Industry, Cooperatives and Marketing in Maseru. In order to be registered, the cooperative had to have a formal structure, including an Executive Committee comprising 1 representative from each of the member groups. Figure 1 shows the six member groups that belong to Thulare. Three of these (Itjareng Manonyane, Maliele Progressive, and Tsoelang Pele/Makanyane/Raohang) are based in the lowlands; two are based in the foothills (Machache and Kopananang Matiama), and one is based in the highlands (Haesise Basotho). Reflecting the different agro-ecological zones, as well as group preferences and priorities, each group concentrates on, and specializes in different crops and livestock.

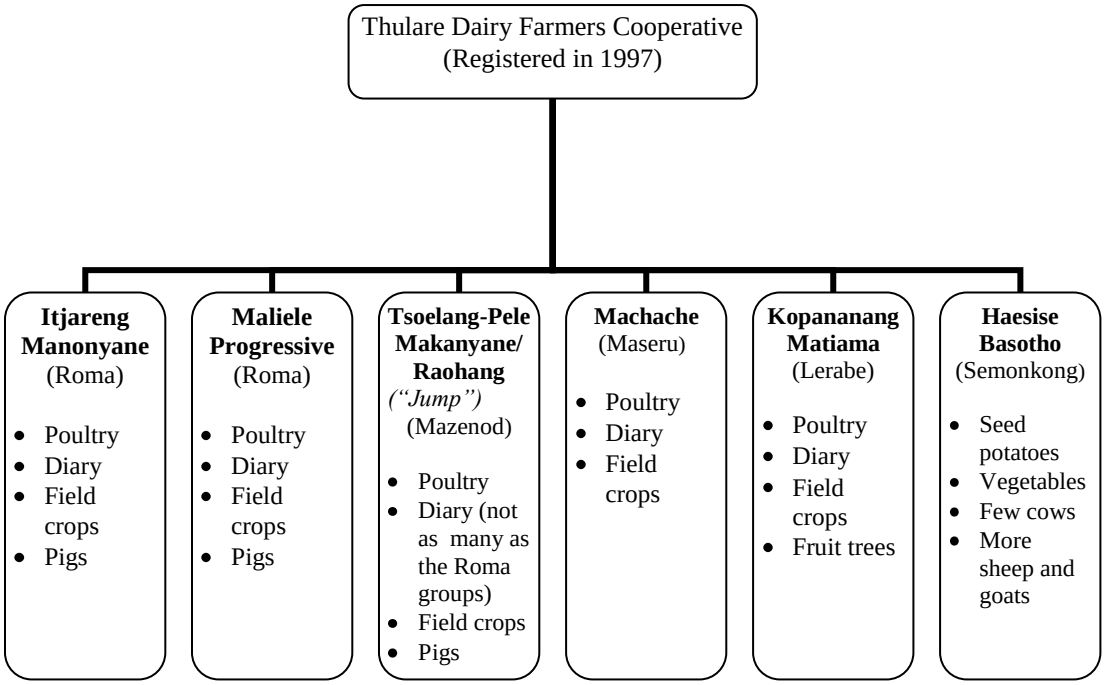

Figure 1: Structure of the Thulare Dairy Farmers Cooperative, highlighting the location and primary agricultural activities of the member groups.

4.2 Provision of mobiles to the Thulare Dairy Farmers Cooperative

The mobiles provided to the Thulare Dairy Farmers Cooperative were Siemens handsets and training was provided by the Maseru-based service provider (Vodacom Lesotho). Recognising the lack of exposure to mobile telephony amongst the target users, joint monitoring committees comprising a teacher in the community and a young student, together with the members of each farming group, were established. As it was beyond the scope of RHVP to provide a regular cash transfer, each handset was preloaded with ZAR500 (approx $50) of airtime, with the intention that the recipients would use ZAR100 of this for group communication, and then sell the remaining ZAR400 (as airtime or SMS) to other community members, such that the enterprise becomes self sustaining. Follow-up evaluations were conducted in July 2007, January 2009 and July 2010.

5. Impacts of mobiles within the Thulare Dairy Farmers Cooperative

5.1 Mobiles and economic growth

Perhaps the most immediate impact of mobiles on the farmers was the way in which the improved ability to communicate contributed to economic growth. Economic growth is brought about in two interlinked ways: by reduced transactional costs, and by increased sales. Lesotho's terrain is mountainous and outside of the capital, Maseru, transport infrastructure can be poor, meaning that disproportionately long times are often spent travelling short distances. This meant that, even within the cooperative, internal communications were arduous. Often letters detailing monthly meetings had to be personally delivered and in the lowlands groups, for instance, the distance between groups can be up to 200km which meant an 16 hour round trip by taxi costing ZAR130 (approx $13) and necessitating an overnight stay. This situation is compounded in the winter, when inclement weather in the mountains can impede physical transport. At the time of the third evaluation, for example, in July 2010, the group based in Semonkong (in the highlands) was unable to travel to Roma for the meeting at the last minute due to the forecast of imminent snow. Now that groups are connected by mobile, internal communications are far easier, and costly physical meetings are only arranged when there is a need, which of course can be ascertained by calling ahead.

As well as being more economical through reducing transport costs, the availability of mobiles has also improved the productivity and marketing successes of the cooperative groups. Marketing their produce is one of the focal areas of the cooperative. A lot of trade takes place between the members of the different groups within the cooperative, with goods typically available more cheaply than through the market. In the highland location of Semonkong, for example, women would typically have to make a long and difficult journey to the Bishop Allard Vocational School where ad hoc meetings were held concerning the marketing of produce. After mobiles had been distributed, it was possible for the women to call ahead to the market and obtain pricing information, and then to communicate with each other, removing the need for physical travel. The different groups have also been able to make better use of product exchange, building on their geographical advantages: such that in the last year those in the lowlands could swap maize for wheat from the highlands.

Similarly, external trade (outside the cooperative) has improved through the availability of mobiles. In one case, reported in January 2009, those in Nyakosoba had a surplus of beans, and were able to successfully market them by using their mobiles to contact potential markets. In 2010, as a result of financial pressures, the government has reduced the number of agricultural shows it hosts, thus limiting a traditional product marketing opportunity. Thulare Dairy Farmers Cooperative thus plans to hold regular open markets at the Bishop Allard Vocational School, as well as in other key centres, where group members will be able to sell their produce. Before instant communication was available through mobiles, such open markets would have been impossible due to the time taken to communicate, both internally (with members on what products to bring) and externally (with potential buyers).

Thus mobiles have clearly enabled economic growth within the Thulare Dairy Farmers Cooperative. Findings correspond with those noted by Donner and Escobari (2010) and Jensen (2007), that mobiles increase the depth and quality of trading relations, both within and outside the cooperative. However, economic growth benefits are not limited to progression in existing activities – there is also evidence for transformation, in terms of new and expanded activities.

Discussions with the cooperative member groups on all three occasions highlighted the role that mobiles had played in creating new income-generating activities which had, in turn expanded the roles of the cooperative. Trading airtime vouchers is undertaken by all the groups. They purchase discounted airtime vouchers from town-based outlets, and sell these

on within their communities at the list price, thus making a very small profits on each sale. The exact modality of this varies from group to group: at Bishop Allard Vocational School a small stall has been set up, which sells vouchers to pupils at the school and community members who particularly appreciate the flexibility of being able to purchase airtime outside of formal shop opening hours. In the highlands, where the distance from shops is greater, group members based in the city may purchase airtime and use Vodacom Lesotho's network facility to transfer that airtime to the highlands. From there it can be purchased and transferred (again via network facility) to other mobile owners.

Despite the very small margins on each sale, the cooperative has been able to capitalise on the greater diffusion of mobile technology and tap into the resultant market for airtime for prepaid subscriptions. Within the whole of Thulare Dairy Farmers Cooperative, for example, they began with ten mobiles but this has now grown to 27 handsets. Thus 17 have been purchased using income generated through the sale of airtime over the last 4 years. In January 2009, the Maliele group explained how they had initially saved up ZAR1000 from airtime sales, and then used that to purchase 4 additional mobiles. Now the greater availability (and thus distribution) means it is easier for those group members not charged with holding a mobile to access one, thus further benefiting the groups, as well as the individual members.

Some member groups have furthered their agricultural activities with the profits from airtime sales, leading to economic growth. Two of the lowlands cooperative groups purchased two piglets which they fattened up and slaughtered, thus further generating income through the sale of the meat. This money was invested in a stokvel (savings wheel) for the farming groups, the profits of which enabled a further member group to be formed. The lowlands groups' next plan is to buy a breeding pair of Duroc pigs, from which they intend to distribute piglets so that eventually each group has a breeding pair of Duroc pigs. Having breeding pairs, in turn, increases the availability of income through the sale of piglets.

Other groups have expanded their activities beyond the agricultural sector. One of the groups in the foothills has embraced trade in second hand clothes, which it sources in bulk from Maseru and then sells locally. Generating income from airtime sales gave them the initial capital required to commence this business, which has become so successful that other member groups in the lowlands are considering following suit. The highlands group put the first ZAR1000 generated from airtime sales to another use. Due to its location in the mountains, Semonkong is a popular tourist destination. The group loaned the first profit to a community member who was setting up a guesthouse, to enable her to purchase linen. She will pay this money back to the group with 5% interest. It is intended that further profits will also be invested in tourist-related small businesses.

5.2 Mobiles and empowerment

In addition to communication and income generation advantages, the availability of mobiles has had some other important, and perhaps unanticipated, benefits for the farming groups. These benefits relate to empowerment. As already explained, Thulare Dairy Farmers Cooperative was targeted to receive the mobiles from RHVP primarily because the members have demographic profiles similar to those typically targeted by cash transfers. On the whole, members are women, elderly, and with generally poor levels of education. As noted by Heeks (2010), measuring empowerment is arguably more difficult than economic growth as it requires more qualitative indicators, but on all three follow-up evaluation visits, comments from various group members verified that empowerment certainly was a consequence of having access to mobiles.

The mobiles had been presented to the Thulare Dairy Farmers Cooperative on Women's Day (9th August) in 2006, and one female chicken farmer from the Maliele Progressive group recounted in the July 2007 how she had felt so proud as a woman to have been chosen to benefit from technology, which is arguably typically a male-led phenomenon. Similarly in

January 2009 the head teacher at the Bishop Allard Vocational School explained how farmers now have much more confidence, both personally and in their farming ability – "mobiles have enlightened us". In July 2010 a spokesperson from one of the foothills groups said that before his group had had access to mobiles and the income generation opportunities that they brought, he was not as well-presented (i.e. dressed) as he is now.

The empowerment advantages of having mobiles extend beyond individual feelings of self-esteem and confidence. In Semonkong, which is much more remote from urban areas and has high levels of illiteracy, the chieftainess reported in January 2009 that members of her community have learned basic English and mathematical literacy through using the phones – they know how to do sums (to work out how much airtime they have used) and understand the instructions on the phone.

Empowerment has also resulted from a better sense of cohesion and belonging that is felt by group members within the cooperative. There is a Basotho saying that translates as "If you walk alone, you are doomed", which reiterates the importance of collective action in Basotho society. In July 2010 one lowlands group said that "we want to buy more mobiles in order to stay united" and the manager of Thulare Dairy Farmers Cooperative also explained that "we are vulnerable – to be strong we need to be able to communicate". The headquarters of the cooperative at the Bishop Allard Vocational School is now home to a number of trophies and awards that they have won at past agricultural shows and exhibitions, all of which have helped to instil pride and confidence, which is vested not only in individuals, but in the groups as a whole.

Similarly empowerment has resulted from the way mobiles have facilitated access to networks and relevant expertise. The Thulare Dairy Farmers Cooperative is now able to collaborate more effectively with relevant government structures, including the Ministry of Agriculture, and the Ministry of Trade and Industry, Cooperatives and Marketing. In fact on the day of the July 2010 follow up evaluation visit, the cooperative had arranged for both the local extension office and their official liaison person from the Department of Cooperatives to be present, to capitalise on the fact that the majority of the cooperative members were having a physical meeting. Representatives from UNESCO were also in attendance to document the cooperative's activities as a case study of best practice for a development publication. Similarly the cooperative is also a member of the Participatory Ecological Land Use Management (PELUM) network, "a civil society network that aims to build the capacity of farming and rural community groups to enable them to accumulate skills, stimulate farmer learning and inspire experimentation and innovation in their quest to achieve food security" (www.pelumrd.org).

As well as improving access to relevant networks and social capital, mobiles have also brought about empowerment through facilitating access to formal education. By the time of the January 2009 follow up evaluation, income from the mobiles had enabled 4 group members to attend formal training arranged by the Department of Cooperatives in Maseru. Similarly cross-border training has occurred, with visits to South Africa. In early 2009 the lowlands dairy farmers visited a Jersey cow farmer in Ladybrand, South Africa, with a view to learning about, and potentially purchasing, breeding stock. In July 2010, the cooperative reported that a number of South African farmers have assisted with the participation of group members in informal training opportunities. One, in particular, had offered free training in artificial insemination, enabling further participation by the cooperative since they only needed to contribute travel costs. Clearly without mobiles finding out about such training opportunities would have been much more difficult, and would have impeded the increase in skills amongst group members.

The provision of a valuable commodity to vulnerable groups has raised concerns that it would inadvertently increase the vulnerability of the recipients. Although there had been no incidents of mobile theft amongst the recipients, the women were all familiar with incidences of mobile theft within their social circles, with one lady explaining how her daughter's phone had been stolen at a party attended only by family and friends. Electricity availability for

battery charging was problematic, particularly for the highlands groups, where mainline electricity is only available in Semonkong town. Farmers in this community have to travel 20km to get here – but tend to send their phones for recharging (at nominal cost) with anyone who is going to town. However, solar chargers are now very inexpensive (available for US$30), and would be an ideal solution to this problem for each community as well as providing a further income-generating opportunity for small businesses.

5.3 Mobiles and choice

To a certain extent, it is already evident from the preceding sections on economic growth and empowerment that, in the four years since first having access to mobiles, members of the Thulare Dairy Farmers Cooperative has had increasing access to choice. Furthermore, arguably the choices they have made have contributed to the extent of economic growth and empowerment they have experienced over the past four years. This is perhaps best summarised by a quotation from the manager of the Thulare cooperative, that "we turned the mobiles into a business."

The most recent follow up evaluation visit, in July 2010, shows that the range of choices available to group members has grown exponentially with time. A fairly universal wish for the future among groups is for the installation of wireless landline telephones. Like mobiles, these wireless landlines do not require fixed telephone infrastructure, although they do need to be connected to a power supply (which can be provided by a solar charger or car battery in non-electrified areas). Airtime is prepaid and purchased in vouchers, similar to mobiles, but the advantage is that call rates are much cheaper, thus facilitating the level of communication to which they have become accustomed at lower costs. The main office of the Thulare cooperative has already purchased one of these, at a cost of ZAR330, and is making a profit of between ZAR150-200 per month through selling call time to community members.

Even greater availability of communications, through mobile and wireless landline services, will also act to facilitate the cooperative's latest development, the creation of a Savings and Credit Association. The majority of cooperative group members do not fit the profile of typical bank clients, and most are unbanked. This inhibits their access to credit and ability to take the risks necessary to further their growth and development. However, the capital which are being raised through the mobiles have facilitated the cooperative acting as a *de facto* bank, where both individual members and groups collectively are able to save money and access loans.

The savings and credit scheme is financed by each of the six member groups paying ZAR200 per annum to the cooperative (which is added to the account which holds their ZAR500 once off membership fee). The policy is that 20% of the total funds must remain in the bank while 80% of the funds should be loaned out to members of member groups at a rate of 2.5% per month. At the same time, each member of a member group is entitled to use the cooperative as a savings scheme for their own personal funds. Savings lodged with the cooperative earn interest of 1.5% per month. Furthermore, the Thulare cooperative is undertaking training around banking for its members. At the July 2010 follow up evaluation meeting ZAR680 was invested by individual members, highlighting the trust in, and support for, the initiative. The cooperative foresees employing a permanent "teller" to handle transactions in the future.

6. Conclusion

Criticisms have been raised that impact assessments of the role of mobiles in development have been lacking in analytical rigour and restricted to considering only certain elements of development. This chapter has added empirical weight to the argument that mobiles do indeed promote development, as defined in broad terms to include economic growth, empowerment and choice, using a qualitative and longitudinal case study of women-led farming cooperatives in Lesotho. In this case access to mobiles has been both progressive, in

terms of improving the ease and efficiency of existing operations, as well as transformational, in extending the range of activities as chosen by the cooperative themselves, as opposed to being externally-led. Arguably one of the reasons for this is that the initial provision of ten mobiles to the cooperative was part of a small intervention by RHVP, who imposed no conditions whatsoever, including no demands for reporting back on progress. As a result, all the progress observed and development that has taken place has been driven entirely by the enthusiasm and capacity of the cooperative leadership, together with the commitment of its various members. It is thus fair to say that, in this case, from ten seeds the Thulare Dairy Farmers Cooperative has grown and even blossomed.

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The "ሀለሐ" Virtual Ethiopic Keyboard for Smart Phones

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Abstract: The need for effective text input methods on smart phones has increased with the advent of virtual keyboard being one of the major methods. The nature of the Ethiopic characters that are used for writing of several languages such as Amharic, Tigrigna, Geez, etc. needs special considerations in its design. Though it is UNICODE supported, the large quantity of the characters brings a challenge for designing a virtual Ethiopic keyboard for smart phones. We designed the layout for the virtual keyboard considering these inherent challenges. We then developed a working virtual Ethiopic keyboard system. The developed virtual keyboard is implemented and tested on the emulator and the real Android based smart phones. The system is also designed in such a way that users can switch between our virtual Ethiopic keyboard and the default virtual English keyboards for multi-script text entry in the different applications that can exist on smart phones.

Keywords: virtual keyboard, virtual Ethiopic keyboard, multi-script text entry, localization of smart phones, virtual Ethiopic keyboard layout design

1. Introduction

The most popular input method for transferring ideas from human mind into the memory of the computers is the keyboard. The common two types of keyboards are the physical and the virtual keyboards. The virtual keyboard is a software component that allows a user to enter characters by tapping graphical keys displayed on touch screens. Where as the physical keyboard is commonly used with desktop computers and has set of physical keys where hardware assigns a binary scan code value to each key [1].

These days, many applications such as: email, web browsing, intranets access via WiFi, word processing, address recording, spreadsheet processing, scanning bar codes, computer games, data collections, recording survey responses, and location based systems are being developed on mobile computing devices, and the need for having smaller size keyboards is increasing [3]. Particularly, for many mobile devices, the need to have a keyboard design that fits on their small screen size. As a result, text entry on mobile devices is moving to virtual keyboards. Of all possible text input methods for mobile devices such as smart phones, virtual keyboards seem to be the best choice in many situations [2].

Smart phone manufacturers such as Apple, blackberry and the Palm Pilot featured touch screens for user interaction for frequently used programs. Touch screen smart phones and PDAs usually have a detachable stylus that can be used on the touch screen. Interaction is then done by tapping the screen to activate buttons or menu choices, and dragging the stylus to, for example, highlight. For many reasons such as simplicity, efficient use of screen space and when no text entry occurs it will disappear (they are displayed on demand rather than continuously appearing on the screen); the virtual keyboard is by far the best alternative for text entry on smart phones [4].

Having the advantage of this keyboard, several types of virtual keyboard with optimized layout are developed and applied for English, French, Arabic, Japanese, etc. text entry. However, in our knowledge, no virtual keyboard is readily available for use for the dozens of languages that use Ethiopic script based texts on smart phones. Among the languages that use Ethiopic script are Amharic[1] and Tigrigna[2], Guragegna, Agewigna, and many other languages in the southern region of Ethiopia.

This work thus facilitates the use of Ethiopic text entry on smart phone and PDA based applications, in turn it paves the way to provide input for Ethiopic based software application development on handheld devices and as a result Ethiopic software development for handheld devices can be accelerated. Since smart phones with different Ethiopic based applications can be used in the areas of schools, hospitals, and in the field of data collection etc. using a localized virtual keyboard will enhance the usage of the device in the countries where the languages are used. Thus, the general objective of this work is to design and implement a virtual Ethiopic keyboard for smart phones and PDA.

The remaining parts of this paper are organized as follows. Section 2 presents related work on the design of virtual keyboard layout. Section 3 describes the property of Ethiopic characters. Section 4 presents the layout design of the proposed virtual Ethiopic keyboard. Implementation of the design is discussed in Section 5. Finally conclusions are given in Section 6.

2. Related Work

The criterion for a good virtual keyboard is different from the design of the popular physical keyboards such as QWERTY. The major criteria in physical keyboard is that higher entry rates can be obtained if common digraphs are entered by fingers on opposing hands instead of on the same hand [5]; where as in virtual keyboard layout design, common digraph letters should be close to each other in order to minimize the hand travel with the stylus. Performance modeling of virtual keyboards focuses on minimizing finger movement on a virtual keyboard, and two factors must be taken into account for this purpose. One is the transitional frequencies from one letter to another in a given language (digraph statistics), and the other is the relative distances between keys. The goal should be to arrange the letters so that the statistical total travel distance is the shortest when tapping on such a keyboard. This means, the most frequent keys should be located in the center of the keyboard and the frequently connected letters, for example in English T and H, should be closer to each other than the less frequently connected letters [6].

In addition, text input requires primary evaluation metrics: speed and accuracy. The simplest way to measure and report speed is to measure the number of characters entered per second during a trial, perhaps averaged over blocks of trials. Accuracy is more problematic. For a simple treatment of accuracy, a metric that captures the number of characters in error during a trial and report these as a percentage of all characters in the presented text can be used [4]. By taking the

[1] Amharic is the working language of the federal government of Ethiopia (a country with a population of about 78 million) and is spoken and written as a first or second language in many parts of the country [7].

[2] Tigrigna is a language for about nine million people particularly in Tigrai region of Ethiopia and in Eretria.

above virtual keyboard requirement into account, a lot of methods for text entry on a PDA application were developed. The input system design problem for PDA device is to determine the layout that provides the highest text input speed by rendering optimized finger movement for expert users who have memorized the locations of the key. In short, the problem is to find the layout associated with the highest peak expert input rate. However, this criterion is not applicable for novice users as the dominant factor for them is the visual scan time, rather than the movement time [8].

The different virtual keyboard layout designs including the ABC virtual keyboard layout [9], the QWERTY virtual keyboard layout [10], the Fitaly Keyboard layout [11], the Hooke's Keyboard and Metropolis I & II Keyboards [12, 10] are reviewed on [13]. All these works are performed on English character set, but no endeavor is made to design a virtual keyboard layout for Amharic text entry except the first attempt to design an Amharic virtual keyboard for Android operating system based smart phones by Gedion Tamene [13]. The Ethiopian ICT development Agency (EICTDA) had developed a key-board standard for the standard PC based Ethiopic keyboard layout [14]. However, virtual keyboards for smart phones differ from PC keyboards. Thus, no design and no standard are developed for smart phones based physical or virtual keyboard.

3. Challenges of Virtual Keyboard Design for Ethiopic Character Set

In designing of the virtual keyboard, the character sets and the languages that use the character sets for which the virtual keyboard is designed has to be studied. Especially when it comes to character sets like Ethiopic, that has many characters, the need for analyzing the usage of the characters, their natural order, the specificities of the languages that use the character sets will be important. In this section, the overview of the Ethiopic script and its associated challenges for the design of a virtual keyboard is explained.

Ethiopic is the only ancient writing system in Africa. The Ethiopic script is used as a writing system to the majority of the languages in Ethiopia and Eritrea. For example, Amharic, a language that uses Ethiopic script for its writing system is the working language of the Federal Government of Ethiopia and is spoken and written as a first or second language in many parts of the country. It is the language that uses characters derived mainly from Ge'ez which was the language of literature in Ethiopia until the middle of the 19th century [15]. Tigrigna, which also uses Ethiopic for its writing system, is a working language in Tigrai region of Ethiopia and also the major working language in Eritrea.

As Amharic has borrowed most of its characters from Ge'ez, it uses characters created by consonant vowel fusion (the second version of Ge'ez script representation) and seven vowels are used in Amharic each of which comes in seven different forms (orders) reflecting the seven vowel sounds (ኧ, ኡ, ኢ, ኧ, ኤ, ኧ, ኦ) [16]. Because of this, Amharic script is categorized under a syllabic type. For example the symbolic representation of the seven forms of the Amharic characters በ, ገ, ደ can be seen in [17].

The Ethiopic character system consists of a core of 34 characters where each of which occurs in a basic form and six or more other forms. This representation of each core characters in seven or more different forms raises the number of core characters to more than 238 (34x7). In addition, there are 44 other symbols which contain a special feature usually representing labialization (ሏ, ሟ, ሯ,...), where most of them can be categorized with the basic symbol tables. There are also punctuation marks which consist of a basic word-driver (:), a sentence-driver (::), and other marks like equivalent to the English comma (፣), semi-colon (፤), and borrowed symbols like: ?, !, ", (,). The numeration system consists of a basic single character for 1 to 10, for multiples of 10 (20, 30, 40, . . ., 90), for 100 and 1000. Generally, in the design of a virtual keyboard for Ethiopic deals with the arrangement of more than 340 character symbols.

Taking the above facts into account, designing virtual keyboard for Ethiopic text input method in smart phone environment is challenging. Smart phones are handheld devices that operate on limited resources such as small CPU cycle, limited memory, and small screen. In addition, the abundance of Ethiopic characters makes the design of virtual keyboard on the small screen more difficult. So in designing a virtual Ethiopic keyboard, these challenges should be considered.

4. System Layout Design

4.1 Requirements

Since the numbers of characters for English language are relatively small, all of the layout designs for virtual keyboard are concerned with the arrangement of the characters in such a way that their usability will be more comfortable to the user. However, for Ethiopic Character Set, which is composed of more than 340 characters, all can not appear on the front page. Thus, a systematic design of the keyboard layout will be necessary.

The layout of the virtual Ethiopic keyboard should be designed in such a way that front page design uses the minimum possible space on the small screen size of smart phones. The work flow design should also permit the minimum possible number of taps to input a character. Figure 4.1 shows the high level work flow representation of the system.

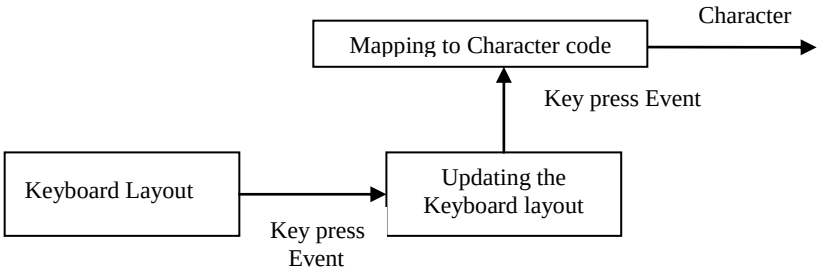

Figure 4.1: Work flow of the virtual Ethiopic keyboard system

As can be shown on Figure 4.1, the system will display the Ethiopic keyboard layout on the screen showing the basic character set which consist of keys (buttons) for the first order letters, the keys for Ethiopic numerals, Arabic numerals and the Ethiopic punctuation marks. When the user presses one of the basic characters set, the keyboard layout will be adjusted so that all the families of the pressed character will be shown in the top raw panel. Then, the user can press the key representing the required character in the editable panel; then this character will be displayed which can be used in any application to tap texts of languages that use Ethiopic characters. The layout appearance of the virtual keyboard should not be complicated in order to remember the keys pattern on it and must be easy to learn and use. Thus, what will appear on the front page is mainly the basic characters. The system should also allow switching to English virtual keyboard to allow multi-script (Ethiopic and Latin character scripts) text entry, if the user needs it.

The end user criteria include qualities that are desirable from a users' point of view. The system shall be developed so as to be easy for user understanding. By providing a layout that requires minimum learning curve for novice users, it is possible to enhance usability of the system.

4.2 Architecture of the System

The system is well suited to be implemented by a Model View Controller design pattern.

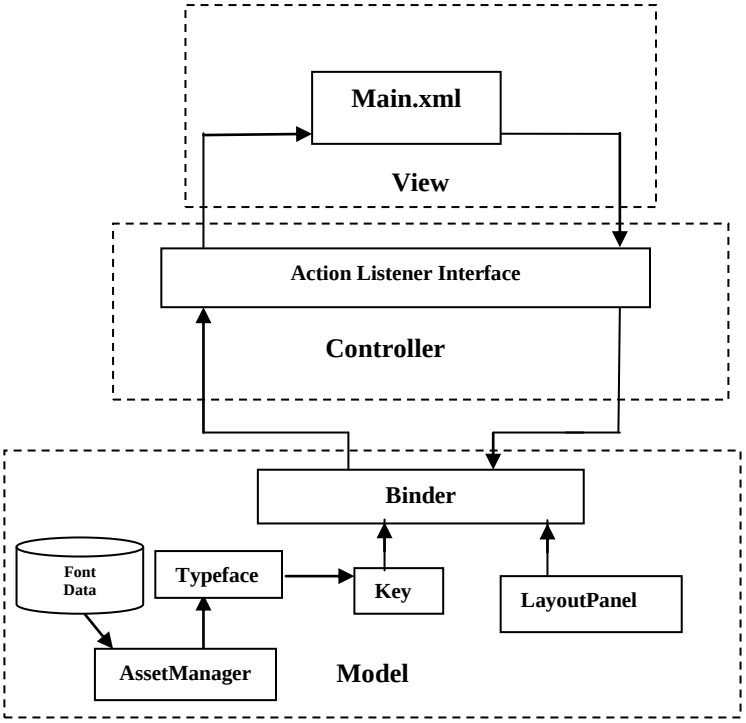

Figure 4.2: The general architecture of the Amharic virtual keyboard system

From the architecture of the system one can observe that the system has three layers: the view, the controller and the model. The view is responsible for the visualization of the state of the model, and for the mapping of graphics onto a device. A view typically has a one to one correspondence with a display surface and knows how to render to it. It also attaches to a model and renders its contents to the display surface. In other words, the view is capable of rendering the contents of the model to the display surface by managing the graphical and textual output portion of the bitmapped display allocated to the application. For our system there is an xml specification about the view of the user interface that is written in the main.xml.

The controller is the means by which the user interacts with the application. A controller accepts input from the user and instructs the model and view to perform actions based on that input. In effect, the controller is responsible for mapping end-user action to application response by interpreting the key press input from the user, and commanding the model and/or view to change as appropriate. The user interaction in this system is button click that contains the desired character font. Based on the user interactions and the outcome of the model actions, the controller responds by selecting an appropriate view.

The model manages the behavior and the data of the application domain, it responds to requests for information about its state and instructions to change its state. It is the layer that contains all the business rules and algorithm of the application to manage the state of the application and conduct all transformations. For this system the five classes Binder, Layout panel, Key, Typeface and AssetManager classes are part of the model for the virtual Ethiopic keyboard system. The font data is stored in the asset folder of the application.

Generally, the Model-View-Controller design pattern maintains links between model and views and notifies the views when the model changes state. The view is the piece that manages the visual display of the state represented by the model. A model can have more than one view. So the model part of the system is considered for subsystem decomposition. The layout subsystem provides the appropriate interface for the input method of the system. The display configuration of the virtual keyboard is determined by binder class using array of keys, and the layout panel manages the keyboard appearance. This subsystem packages the bind, key (button) and layout panel classes together. This subsystem is the major component of the project that incorporates the proposed layout design for the virtual Ethiopic keyboard and the description of the layout design. The proposed layout for Amharic virtual keyboard is composed of the two panels (Figure 4.3).

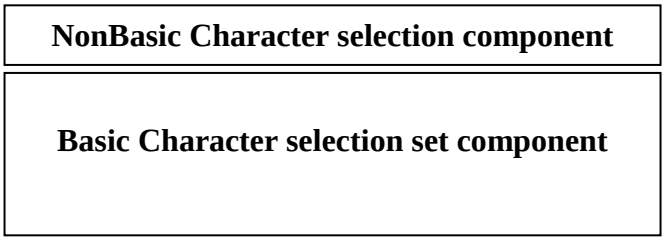

Figure 4.3: Proposed Layout for the virtual Ethiopic keyboard

5. Implementation

5.1 The System Development Environment

For the implementation of the virtual Ethiopic keyboard Android operating system based smart phones are selected. The basic reasons to choose Android platform are that:

- It uses Freetype, a free and open source bitmap and vector font engine, which supports Unicode text layout and glyph rendering. Ethiopic Unicode fonts, such as Microsoft's Nyala and GFZ's Geez Free Zemen, can be used to render text using Freetype on the Android platform. Other platforms such as the Palm OS lack the internationalization support required to fully meet the needs of Ethiopic software development.
- It is based on open source product, Linux kernel, which brings a big change from the current oligopoly of mobile OS makers that charge handset manufacturers various licensing fees.
- It comes with immediate availability to mobile versions of Google search, Google Maps, and Google Products that allow independent developers to create their own array of applications at a much less restrictive cost.

For the development, the Android SDK is used. The Android SDK includes custom tools that help to develop mobile applications on the Android platform. The most important of these are the *Android Emulator* and the *Android Development Tools plug-in for Eclipse*.

5.2 The Virtual Ethiopic Keyboard System (VEK)

Based on the proposed layout design, the "*'ሀሌሐ' Virtual Ethiopic Keyboard for Smart Phones"* system is implemented. *VEK* is implemented in such a way that Ethiopic characters, punctuations, Arabic numerals, Arithmetic operators and Ethiopic numerals to be incorporated in the layout systematically. Figure 5.1 shows an implementation of VEK Android smart phones emulator (A) and its installation on an HTC G1 Android phone (B). The system is also capable of

inputting language texts that use Latin characters and hence permits multi-script text entry. Initially, the system will display all the first order of the 34 Amharic characters, a key for Arabic numeral, Arithmetic operators and Ethiopic digits selection. The user has to tap the key of his interest from which the character family belongs. For example, if the user wants to input the character "ሂ", he has to press a key containing the first order form of the character which is the base character "ሀ"; then, all variants (Non-Basic families) of the character "ሀ" will be displayed on the top panel of the keyboard layout. Then, the user has to press the key labeled with "ሂ" (See Figure 5.2). This procedure will be applicable to all characters, digits, operators, punctuation and numbers of VEK. This permits to tap the Ethiopic characters with a maximum of two key taps.

Figure 5.1 VEK on Android Emulator (A) band on the Android based HTC G1 smart phone (B).

Figure 5.2: The input of the letter "ሐ" after taping the button for "ሀ".

Pressing the button “123” will display the panel for Ethiopic and Arabic numerals and the user can tap the Ethiopic or Arabic numbers or the mathematical symbols that he wants to input. This is displayed on Figure 5.3 (A).

Figure 5.3: (A)-The panel for Ethiopic and Amharic numerals and Mathematical symbols; (B)- the Virtual QWERTY keyboard.

If a user wants to insert English characters, then he can press the “ABC” button, then virtual QWERT keyboard which is linked with the VEK will appear to permit English texts or multi-script texts (Figure 5.3 (B)). Similarly if the user wants to switch to VEK, he needs to press the *‘ሀለሐ’* key. For evaluation purpose, the VEK installed on a real HTC Android smart phone was given to several people who speak the languages that use Ethiopic script and almost all responded with their opinion that VEK is an easy to learn and to use system.

6. Conclusions

On screen keyboard is one form of virtual keyboard which is frequently available in handheld devices with touch screen capability, especially on smart phones and PDA environments. The keys appearing on the screen are actually component of the software application that is programmed to map the corresponding character code based on the event triggered on key. In this work, a virtual Ethiopic keyboard is designed and implemented on Android OS based smart phones.

The layout design for languages having such an abundant amount of characters is challenging, so, judicious technique is mandatory. In this work, a virtual keyboard layout is designed for more than 340 Ethiopic characters. Ethiopic characters are used as a writing system for many languages in Ethiopia and Eritrea and the design of this VEK is very useful to design localized applications on mobile devices. The designed layout is composed of two panels: the top and the main panels. The main panel contains all the basic (or first order) Ethiopic characters, a

key for Amharic punctuation mark selection, the delete and space characters, a key for Ethiopic/Arabic digit and Arithmetic operators selection.

For the implementation purpose, the Android platform is used which is gaining popularity as an operating system for handheld devices. Since this is the first work in such environment, it is our belief that its output and the experience gained will pave the way for applications development on handheld devices using Ethiopic languages.

To accommodate the requirement of multi-script text writing, the system is designed and implemented in such a way that users can switch between our VEK and the Virtual QWERTY keyboard.

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