M-Payment System for Service Delivery in a Wireless Village Context

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Abstract- Poverty, poor infrastructure and insufficient skills development in rural regions present a stumbling block in improving the socio-economic conditions of the marginalised regions. Identifying opportunities to introduce Information and Communication Technology (ICT) has seen researchers emerge with solutions to help alleviate poverty and create employment for the inhabitants in the rural regions. With the cellular networks in South Africa covering approximately 90% of the country, mobile phones have opened an opportunity for researchers to offer mobile based solutions. This paper presents a mobile payment system called M-Payment which consists of two user-driven mobile services for marginalised regions. The M-Payment system allows rural users to buy electricity and transfer airtime money using available service infrastructure and their mobile phones.

Keywords: M-Payment, Information and Communication Technology (ICT), ICT for Development (ICT4D).

I. Introduction

Developing regions have focused on piloting ICT projects with individuals as the direct beneficiaries of the technology solutions, for example the one laptop per child project [1]. The key to introducing ICT to the rural community is to understand the community's view in transferring the technology to them. Overlooking this will result in ICT solutions that fail to ease the burdens faced by rural people as they will not be entirely adopted. Low adoption is also due to insufficient research on the rural user-behaviour to such information and knowledge exchange technologies [2].
Wireless technology has made it possible for people in both rural and urban areas to stay connected. Mobile phones, using Global System for Mobile communications (GSM) technology, have been used to run developed applications that present different outputs or results in a portable platform. The decreasing cost and improving capabilities of these devices offers a desirable computing platform for data collection, supporting kinship, social and business networks [1].
With mobile phones successfully penetrating into the marginalised regions, researchers can take advantage of the wireless technology to use this device to deliver user-friendly and user-driven solutions. Apart from offering these solutions, the use of mobile devices opens a new revenue source for entrepreneurs living in the rural communities, a solution proposed in this paper. With over 30 million cell phone subscribers in South Africa, there has been an increase in opportunities for innovation in use of cell phones for communication, data and information exchange as well as service delivery [3].
The rural environment presents an untapped source of revenue in the form of agricultural land, natural resources and a market for other services that are not available in marginalised areas. These resources may include facilities like banks, hospitals, government structures and vendors of day to day necessities like prepaid airtime and electricity.

Service provision is poor in the rural areas, with inhabitants having to travel to nearby towns or business centres for most services, e.g. banking. This project focuses on developing and implementing mobile applications for a completely rural community to make better their standard of living and enhance the business prospect of the community entrepreneurs. The M-payment system offers two mobile applications that are used to deliver services to the rural community for transferring airtime money and buying electricity.

II. Description of the Dwesa Community

Dwesa is a rural marginalised area in the Transkei region, Eastern Cape, South Africa. It consists of several villages that are isolated from the main developed towns in the vicinity. The region has high unemployment and illiteracy levels. It has no proper infrastructure and has underutilised business resources. The only shops in the villages are backyard shops owned by entrepreneurs in the region and they generally offer basic commodities (e.g. food). In order to attend to business that requires government offices, service providers (e.g. Eskom and banks), competitive retail and grocery shops (e.g. Spar, Shoprite), Dwesa people have to spend minimum 60 Rand (R60) on transport only. The location of Dwesa and the situation thereof has driven researchers from the University of Fort Hare and Rhodes University, sponsored by different industry partners, to come up with ideas and solutions on how to decrease poverty in Dwesa using ICT innovations and by working with the local community.

III. M-payment System as a Solution

This paper proposes an M-payment system that does the following:

- Facilitates transfer of airtime money from a person in any developed town with banking infrastructure to a person in Dwesa without the banking facility.
- Buying of electricity from an entrepreneur in a developed town by a person situated in Dwesa.

The system not only thrives to serve regions without banks and the electricity users, but also boosts the business

prospects of the local entrepreneurs and eases travelling costs.

Currently only the schools, clinic and a few households have electricity, but this system comes at a time when Eskom rural electrification project is on the pipeline [4]. The rise in demand for electricity and money transfer will see the M-payment system uptake on the increase.

IV. ICT4D Strategies

ICT4D is a socio-economic development initiative meant to enhance social and economic growth in the underdeveloped societies. Many ICT4D strategies have either been implemented or suggested for solving some technological adoption of various ICTs to curb the digital divide. For example Gary Marsden proposes an approach, called Empowered Design, which suggests the creation of a technology that will allow people in Africa to develop their own applications without having researchers dictate over the interface or functionality of it [5].

The primary challenge in ICT4D is to harness the full potential of ICT to eradicate extensive poverty, hunger, promote development of universal primary education, gender equality and women empowerment [6]. The government, entrepreneurs, business structures and non-governmental organisations all play an important role in the achievement of this, although government policies and legislative framework can either boost the development or suppress it. According to Batho Pele's principle the following is the list of the measurement matrix for the use of ICT by the government [7]:

- Service standards: how is ICT improving in delivering services?
- Increasing access: What ICT initiatives are implemented to increase accessibility of this ICT?
- Provisioning of information: How does ICT improve provisioning of information on services?
- Value for money: Is ICT supporting users in getting better services at low cost?

The idea of this project is to utilise the capabilities of mobile phones in generating income for rural community entrepreneurs, at the same time improving the communities' socio-economic well-being. This approach is aligned to what is known as the Wireless Village Connection concept [9].

A. Wireless Village

The Wireless Village connection provides a cost efficient addition to existing GSM networks, extending coverage beyond where convectional network roll-out would be too expensive [9]. The concept opens opportunities for local entrepreneurs to own and run a franchised GSM network within the rural community. The entrepreneur and various microfinance entities combine resources to acquire a network access point and establish a GSM access Point (GAP) within a village. The access point is a plug and play module hence no technical knowledge or training is required to be able to use it [13]. Once a GAP has been established, the various user-based mobile applications are developed and deployed.

B. Examples of Deployed Mobile Applications

A variety of mobile applications have been developed and deployed around the globe. Some of these applications can fall under social, micro-finance and business applications. Most of the applications developed are traditional and meant to address the needs of both the urban and marginalised regions.

First National Bank (FNB) in South Africa offers a solution for account holders to purchase tokens to use on their electricity meters [8]. The application is SIM-based, meaning it is encrypted on the SIM card. The mobile application requires you to provide a valid prepaid electricity meter number and you select from which existing account in the system you want to transact your purchase. After a series of steps in purchasing an SMS token number is received by the user to load into the meter [8]. This system is dependant on the bank (cell phone banking) so it requires you to be a registered FNB client, with the minimum and maximum purchases for tokens being R30 and R1000 respectively.

In the Philippines users of a deployed mobile application can send or transfer money to a person without a bank account. The recipient is only required to fill in a bank form and send an SMS to the bank line dedicated to such a service. The transaction is then approved and the teller gives the recipient the money minus one percent service charge [9].

In 2007, Kenya's giant mobile operators Safaricom and Vodafone launched a mobile application called M-PESA. M-PESA stands for mobile money [10, 11]. It is designed for the mobile subscribers without bank accounts and can be used to transfer cash and make payment for anything. It is a SIM-based application that allows a user to first register their details in order to create a virtual wallet for them on the SIM. Once activated, the wallet can be loaded with cash from the more than 1200 retail shops in Kenya [10]. M-PESA can be used to transfer money, buy airtime, pay bills and withdrawals [10. 11].

Mobil-e-Com is a SIM-based application that supports the mobile seller who uploads his goods for sell using a mobile phone [12]. It has a micro-payment facility that allows subscribers to sell or buy products using mobile phones and also perform money transfer between registered micro-payment accounts [12]. This system does not use the bank but has the potential to in cooperate money transfer from micro-payment accounts to commercial bank accounts [12].

The M-payment System not only offers a solution related to the above mentioned projects but also has the advantage of having transparency, i.e. in cases where transaction disputes surface evidence of transactions can be retrieved to support the claims. This is further discussed in section VII.

V. Electricity Buying System

This system involves four key players, namely the rural entrepreneur, rural electricity consumer, urban entrepreneur and Eskom (the electricity supplier in South Africa) or any electricity vendor in an urban area. In this system an electricity consumer buys electricity by sending airtime voucher digits, using an SMS, to the system database and to an urban entrepreneur running a pay phone container. The

urban entrepreneur then SMSes the electricity voucher back into the database and to the electricity consumer.

Figure 1 below shows the architecture for the electricity buying system. The bidirectional arrows represent two separate operations in the direction of the arrows, one numbered in red and another in black.

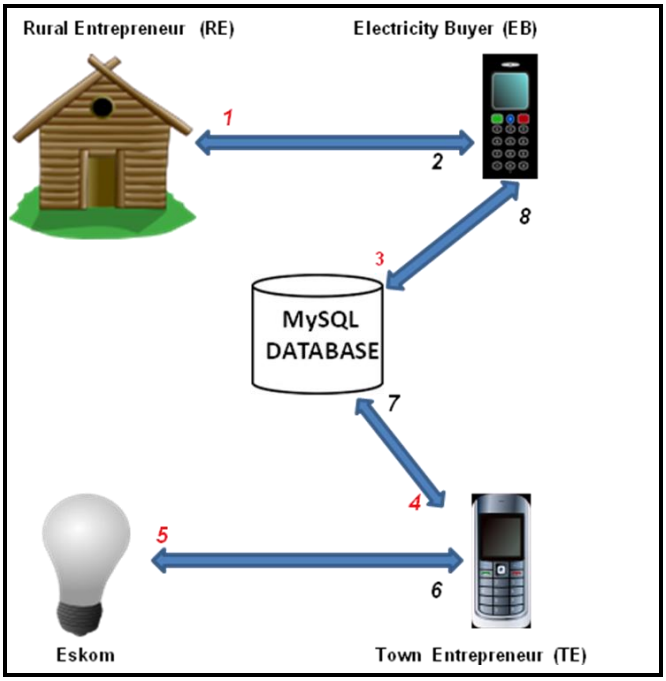

Figure 1: Electricity Buying System Architecture

The four players in the system are defined below:

- **Rural entrepreneur (RE):** this is the shop owner in Dwesa who sells airtime vouchers to community members.
- **Electricity buyer (EB):** this is the person in Dwesa who wants to buy electricity in town. This person buys the airtime voucher from the shop owner to use it to purchase electricity from an urban entrepreneur.
- **Town entrepreneur (TE):** this is an entrepreneur in nearby town who runs a pay phone container and is responsible for purchasing electricity form Eskom on receiving airtime vouchers from the rural electricity consumers.
- **Eskom:** this is where the urban entrepreneur purchases the electricity vouchers for the different electricity account holders in Dwesa.

The system application consists of the following components:

- **MySQL Database:** contains details of the rural electricity account holders that include the phone number, electricity meter number, airtime voucher number, electricity voucher number and respective equivalent voucher amounts**.**
- **Middle tier component:** this is a servlet application that queries the database for the voucher digits
- **Mobile application:** this is the GSM client application used to register users, send SMS with the voucher digits to update electricity consumer accounts in the database and is also used by the consumer and urban entrepreneur to query the database for voucher digits.

To use this application, the electricity consumers must first register and have their details stored in the database. The details in the database represent unique electricity accounts that use either the phone number or the electricity meter number to identify different user accounts. The details include the cell phone number, electricity meter number, airtime voucher digits, value in Rands of the airtime voucher digits, electricity voucher digits and its equivalent value in Rands. Once registered the following lists the steps to buying electricity, numbered according to their occurrence as indicated in Figure 1:

1. EB buys airtime voucher worth ***x*** Rands (***Rx)*** from the RE
2. RE gives EB the airtime voucher digits.
3. EB uses the mobile application to login and update his electricity account in the database. He SMSes the airtime voucher digits and its equivalent amount ***Rx*** into the database.
4. An account update notification is sent to the TE who is the pay phone container owner. The TE then attempts to load the airtime voucher into his pay phones.
5. If it is a valid voucher he then purchases electricity worth ***Rx-Ry*** using the EB's electricity meter number**,** where ***Ry*** represents the service fee charged, ***y*** Rand, by the TE for his services rendered. This means that if EB requests electricity worth R100, which represents Rx, the TE will buy electricity worth R (100 – y) for the account holder from Eskom or any shop selling electricity.
6. An electricity voucher is given to TE that contains the account holder details and the voucher digits for loading electricity to the account holder.
7. The TE updates the database using the mobile application. The fields to be updated are the electricity voucher digits field and its equivalent amount field.
8. Update notification is sent to the EB, who then queries the database for the electricity voucher to load electricity to his premises.

The above system enhances the business prospect for the shop owner in Dwesa as airtime demand and its equivalent voucher amount increases. The urban entrepreneur makes profit through the service charges ***(Ry***) incurred when a rural electricity buyer requests for electricity voucher from him. As for the electricity buyer, travelling costs are reduced and in this way the buyer saves money that can be used for something else.

VI. Airtime Money Transfer System

This system uses a bank in a developed town to transfer money to a recipient in the Dwesa rural community where there is no banking infrastructure. It takes advantage of the traditional bank's SMS transaction notification system and uses part of the deposit slip details to link the various targeted people in the system.

The bank account used should be activated to use the bank's automatic SMS notification system. This means that every time a bank transaction is made an SMS will be automatically sent from the internal bank system to the account holder's mobile phone.

Figure 2 below shows the architecture for the airtime money transfer system.

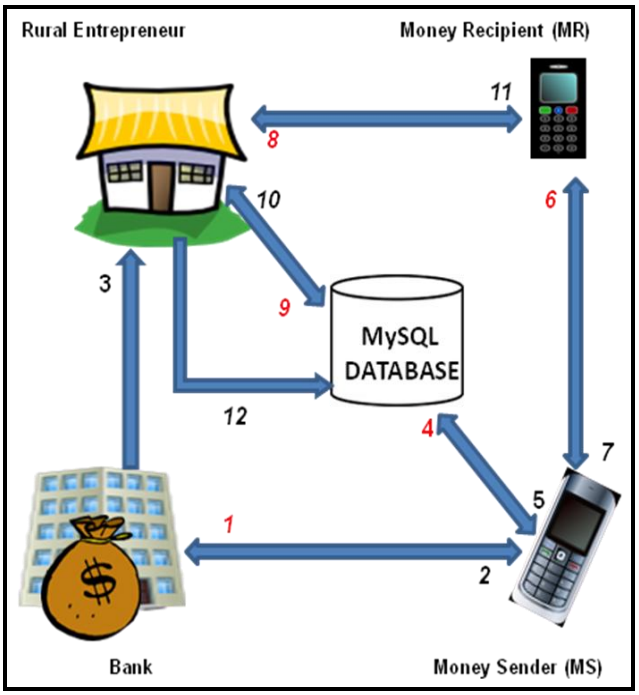

Figure 2: Airtime Money Transfer Architecture.

The system is made up of the following players:

- **Money recipient (MR):** this is the person in Dwesa to whom the money is being sent or deposited to. The person does not possess a bank account, but has a mobile phone and is subscribed to the network.
- **Money sender (MS):** this is the person from outside Dwesa where there is access to banking infrastructure. The person may or may not possess a bank account but is sending money to the **MR** in Dwesa.
- **Entrepreneur:** this is the shop owner in Dwesa who also possesses a bank account where the money for the **MR** is deposited by the MS.

The system application has the following and components:

- **Bank account:** this is the bank account where the **MS** deposits the amount to send to the **MR**
- **Database:** this contains user account details that include cell phone number and the reference digits sent by the MS to the MR for use when claiming money from the entrepreneur whose account was used to deposit the money.
- **Middle tier component:** this is a servlet application that queries the database for the reference digits.
- **Mobile application:** this is the GSM client application used to register users, send SMS with the reference digits from the **MS** to the **MR** and also used by the entrepreneur to query the database, through use of servlet, for the reference digits**.**

To be able to use the application the **MR**, **MS** and the entrepreneur first have to register and have their username and passwords stored in the database that also stores the reference digits. The mobile interface will offer a form for user details, and procedure for registering requires the following details: **Unique username** in the form of the cell phone as it is unique for every subscriber in the network, and the **password** that could be any string of text.

After registration the user can then be able to access the M-Payment system and choose the appropriate action of concern to them. Assuming registration done, the following lists the sequential steps to sending money from **MS** to **MR**, with the steps numbered according to their occurrence as indicated in figure 2**:**

1. **MS** fills deposit slip in a bank and specifies on it a combination of six random characters **ASDFGH** as reference for the deposit. A deposit of **R*y*** (y Rands) is then made.
2. Bank receipt processed that shows a deposit and has the **reference digits** on it.
3. An automatic SMS transaction notification is sent to the shop owner, who is also the account holder, which confirms the **R*y*** deposit and the deposit reference digits.
4. The **MS** adds the **reference digits**, **R*y*** and the **username** to the database using the M-payment system.
5. Response is sent to the **MS's** mobile phone confirming the data set has been added to the database.
6. **MS** then sends an SMS with the **reference digits, R*y*** and **username** to **MR's** mobile device in Dwesa.
7. If MR receives the SMS from MS an SMS alert is sent to MS to indicate message has been sent.
8. **MR** produces the details of the SMS sent to him by **MS** to the shop owner in Dwesa in order to claim the sent money **R*y***
9. The shop owner can validate the details of the claim in two ways:
   - by comparing the **reference digits** and **R*y*** sent to him automatically by the bank with the one's produced by the **MR** in the SMS, or
   - by using the mobile application to query the database using the **reference digits** produced by **MR ,**and check for the presence of the concerned entries in **MR's** account in the database.
10. A response is sent back to the shop owner's mobile phone confirming the presence or absence of the entries in the database
11. If claim entries do not correspond a null transaction is declared, otherwise payment of **R*y*** minus **R*j*** is done to **MS**. **R*j*** represents the service charge by the shop owner as the service provider through letting his resources (bank account and shop) be used for the transfer. That way the shop owner makes profit through M-payment and is able to save and secure his money through banking.
12. After payment to the **MR** the shop owner deletes the transaction entries from the database.

VII. Transaction Conflicts and Security

Transaction conflicts can arise in cases whereby the recipient or the entrepreneurs claim not to have received any SMS request or notification of a transaction by either party. The money transfer system involves a bank, and after a deposit has been made a deposit slip is printed for the depositor or money sender. In case there is a dispute over the transfer the deposit slip and the SMSes sent to both parties can be used to rectify the conflict.

As for disputes in the electricity system, the airtime voucher digits can be used to contact the traditional GSM operator to find out who loaded the airtime, and the advantage with the use of the electricity voucher is that it can only be loaded to the specified meter number of an account holder as indicated by the buyer and the urban entrepreneur.

Security at user level is ensured through use of unique login details. These are to be kept away from possible system attackers and should be used for validation when accessing the system. These user login details are kept secure in a MySQL database. The use of the bank in the money transfer ensures a secure transaction, a trusted service with proof of deposit whilst the authenticity of the airtime voucher in the electricity system is tested when the town entrepreneur tries to load the voucher into the pay phones.

VIII. Conclusion

A framework for developing mobile payment system for a rural region has been discussed in this paper. ICT4D represent the driving force behind the framework, as researchers attempt to penetrate new market in regions where traditional solutions have not been adopted or have not met the needs of the rural people. The M-payment system has an airtime money transfer application and an electricity buying application. The architectures for these two applications are meant to lessen the burdens faced by the people living in a completely rural region in Dwesa, Eastern Cape. The applications require users to be registered, after which the SMS-based applications can be used for buying electricity or transferring airtime money. Apart from the buying or transferring processes, the framework also enhances the businesses levels of the concerned entrepreneurs hence increasing their profits.

The implementation of the M-payment system is still underway. Once fully implemented the system will be field tested through deployment on a few mobile devices and performing the designated transactions. A questionnaire will be used to assess the users' attitude towards the system to help improve it to suit their needs. Through the use of the questionnaire and the initial deployment, an ideal system can then be finalised for the Dwesa community.

With the rapid adoption of mobile phone use in developing regions, the mobile devices are slowly giving remedy to ICT developers as they try out novel ideas in improving the socio-economic well being of the marginalised regions.

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