

Mobil-e-Com: A SIM-based Application to Support Second Economy Entrepreneurship

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Abstract— The e-commerce infrastructure in developing countries can greatly benefit from the implementation of SIM solutions that enable and facilitate second economy entrepreneurship. Our solution, Mobil-e-Com, is a micro-payment ecommerce platform that gives second economy entrepreneurs the ability to manage their virtual e-shops via their cell phone, placing products in e-shops, tracking orders and views, and also performing basic account management functions. The solution also allows for payments to be made between cell phones, i.e. inter-cell phone money transfer. The SIM card not only becomes an electronic wallet, but also allows the operators to actively participate in the facilitation of commercial transactions between subscribers.

Index Terms— ICT, Telecommunication Infrastructure, e-Commerce.

I. INTRODUCTION

Developing countries are required to deal with many significant issues, with poverty and the lack of access to job opportunities being key [1]. McNamara notes that community groups can escape poverty by a combination of economic growth, opportunities for the poor, and the removal of risks / vulnerabilities particularly faced by the poor [2]. In South Africa 42.5% of the population live in rural areas [3]. These communities, by sheer size and because of current political dynamics, represent a strategic emergent market.

Mwabu and Thorbecke note that rural based growth is essential on the route to development [4]. By harnessing both the human and natural potential of rural areas, rural development can be kick-started. Pade notes that rural development needs to be promoted as it equips rural populations with skills to help improve their community and economic activities [5].

The solution proposed in this paper is implemented to fill the gap where current e-commerce solutions for development do not exploit the proliferation of cell phones among the communities in developing countries. The entrepreneurship potential in these developing communities can be harnessed and enabled through SIM applications. The second economy (particularly in Southern Africa), represent a market potential that can be realized through focused Information and Communication Technology (ICT) solutions that enable and facilitate dormant entrepreneurship. This is the market that represents the majority of people in developing countries.

Mobil-e-Com targets a use for cell phones that hasn't been exploited: the facilitation of e-commerce transactions between sellers and buyers via cell phone. Existing e-commerce platforms require both sellers and buyers to have access to a networked computer. Instead, we support the truly mobile seller – a registered user who has access to a second generation (2G) cell phone, where they can upload details of their goods for sale. Using their phone, they can browse and update their goods already for sale. Buyers browse online via a web-portal and select items they wish to purchase by adding them to a virtual shopping basket. When the buyer checks out their purchases, Mobil-e-Com forwards the buyers details to the seller. It is then up to the seller to contact the buyer to arrange details such as delivery and payment.

Mobil-e-Com also includes a micro-payment infrastructure that can be used to provide an efficient, hassle-free payment facility between subscribers. Buyers are given the option of using this facility when making a purchase via the e-shops. The money accumulated in the micro-payment account can be transferred into commercial banking accounts, and vice-versa.

This paper describes a framework we designed, developed and implemented to prototype a SIM-based e-commerce and micro-payment infrastructure that can be deployed on any 2G cell phone. This paper first describes related work on ICT deployment in marginalized communities, in particular demonstrating the cell phone's acceptance and everyday usage in rural communities. It then goes on to describe the three components of Mobil-e-Com. Next it illustrates the tasks that network operators would be required to complete on the server back-end of the system. Finally it provides some concluding remarks on the use of SIM based applications for fostering second economy entrepreneurship.

II. RELATED WORK

When discussing technologies for deploying ICTs in developing communities, researchers and practitioners often think primarily of the use of computers with internet connectivity. The United States Agency for International Development (USAID) define two categories of ICTs, namely *traditional* and *modern* ICTs [6]. USAID define traditional ICTs as technologies that are engrained in most people's daily lives such as television, radio, and fixed line telephones. Modern ICTs are defined as computers and communication systems between computers such as the Internet, desktop computers, laptops, cell phones and PDAs. There is often great debate amongst researchers about the

compatibility of modern ICTs in rural communities [2]. Pade notes that it is assumed that traditional technologies are more suitable in meeting the needs of rural communities as they already face challenges such as poor education and illiteracy [2]. McNamara also warns against overlooking traditional ICTs which in most cases are more appropriate, affordable, and adaptable to local community needs than modern ICTs [1]. If the only pre-requisite of a technology to be seen as traditional is that it is engrained in most people's daily lives, we argue however, that due to the proliferation of cell phones in Southern Africa, they can now be seen as a viable technology. A report compiled by the Wireless World Forum states that 66 % of all South Africans own one or more mobile phone contracts [7]. Another study compiled by the Consultative Group to Assist the Poor (CGAP) and United Nations Foundation reports that in early 2006, the cell phone became the first ICT to have more users in developing countries than in developed ones [8]. In South Africa, a study completed by Finmark Trust found that one third of people who do not have a bank account (a system itself that is undoubtedly engrained into daily life), own or have access to a cell phone [9, 10]. These figures speak of the proliferation and acceptance of cell phones within Southern Africa.

With the decrease in prices of cell phones and other mobile devices due to market competition, there has been a recent "hyper growth of m-commerce" [11]. These m-commerce solutions however, can make great demands on the cell phone handset [11], and the wireless infrastructure [12]. Our solution is designed to provide similar functionality, but to target it for 2G cell phones in order to support the widest audience possible.

Cell phone banking itself is not a new concept, with hundreds of banks worldwide offering this service. Tailoring this service to marginalized communities is also not a new concept. A study carried out by World Wide Worx of cell phone banking within South Africa found that "the demand in rural areas for cell phone banking is far higher than in urban areas, and the need to access banking services is a more important determinant of the popularity of cell phone banking than being 'switched on' to technology" [13]. Again, what sets our solution apart from this however is that primarily, it is a lightweight e-commerce solution that also supports a micro-payment infrastructure.

III. MOBIL-E-COM OVERVIEW

In the previous two sections we have provided motivation for the development of our cell phone based e-commerce and micro-payment infrastructure. This section describes some initial requirements and design considerations for Mobil-e-Com.

The dominant motivating factor in the development of Mobil-e-Com has been the exploitation of the proliferation of cell phones in rural communities. To this end the solutions is implemented to be sufficiently deployable on entry-level 2G cell phones on the SIM card. An alternative implementation scenario would be developing Mobil-e-Com as a J2ME application, but this would necessitate JAVA support and capabilities on the handsets, which reduces

accessibility from the older generation of cell phones. Deploying the solution on the SIM makes it marginally independent of the handset, which ensures operational consistency. A SIM based solutions also means that it is implemented within the architectural framework of the mobile operators network, allowing for optimizations on data transport protocols used, and allowing access to operators' servers (messaging, authentication, etc). The other advantage is that Mobil-e-Com's footprint, as far as resource utilization on the cell phone is concerned, is minimal as it runs entirely from the SIM.

The usage context that Mobil-e-Com is developed for, is of rural, marginalized and isolated communities. In this context, deployment woes of installing applications on individual handsets, are alleviated by the OTA messaging infrastructure on mobile networks. OTA is a messaging infrastructure that enables a network operator to download applications or messages to a SIM card without being physically connected to it. Using OTA, the operator's back-end servers send requests through an OTA gateway, where the messages are restructured and sent to one or more SIM cards in the field. In this way, an "overnight" deployment of Mobil-e-Com is possible through a push transaction, and as a pull request from the subscribers.

The following three sections will now describe the three components of Mobil-e-Com separately: registration, trade and banking.

IV. REGISTRATION

Users must register for the Mobil-e-Com solution before being able to take advantage of the functionality it provides. We envisage that registration could take place either online or placing a call to a call-centre. The user can either choose to register by phone or using a computer. Regardless of the method used to register, the following details need to be provided: full name, cell phone number. If this system were to be able to transfer money to traditional bank accounts, details of an existing bank account would also need to be provided.

By design, we have strived to keep the Mobil-e-Com solution as lightweight as possible. The registration process has been designed to be as easy as possible to ensure that this principle is adhered to. On completion of the registration process, the user now owns a *micro-payment account*. As the user's cell phone number is already guaranteed to be unique, we use it as the account number for the micro-payment system. Once a user has registered with the system, they are able to perform trade and banking transactions.

V. TRADE

In the trade component of Mobil-e-Com, we separate users into two categories: buyers, and sellers. This is a logical separation rather than a physical separation, depending on the role the user is taking at any moment: any registered user can be a buyer or a seller. We define a *seller* as a user who wants to sell stock using Mobil-e-Com, and a *buyer* as a user who wants to buy goods using Mobil-e-Com.

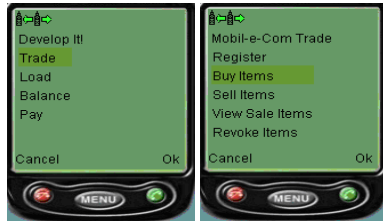


Figure 1: (a) Main menu and (b) trade menu respectively

Throughout all trade actions, cell phone users must navigate through one menu to find the options that are available to them, as shown in Figure 1 (a). As can be seen in these menus, users must first select the Trade menu option which will then display a list of actions that are available. From this menu, shown in Figure 1 (b), users can then select their desired action.

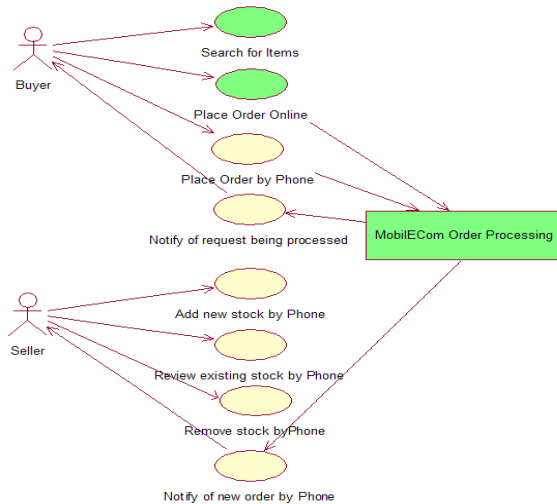


Figure 2: Mobil-e-Com trade process

Figure 2 is a use case diagram of Mobil-e-Com's trade process. In this figure and all proceeding use case diagrams, all shapes shaded in green denote that the action occurs online, using a computer connected to the Internet. All shapes shaded in yellow depict an action that occurs on a cell phone. The remainder of this section describes the buyer and seller actions separately.

A. Buyer actions for trade process

A buyer can perform three actions: *search* for items; *place order online*; or *place order by phone*. To search for items, a buyer must use a computer attached to the Internet to browse a website with a list of all stock that is available to be purchased. Stock is organised into nine categories: Accessories; Antiques; Arts and Craft; Books; Clothing; Electronics; Music; Unusual; and Other. It was envisaged that this action could be performed on the phone to support a mobile buyer, but this was changed because of the vast amounts of data that would be required to be transferred to the cell phone. Each stock item has an associated StockID that is used to uniquely identify it. This StockID is required in order to place order online or place order by phone, along with the quantity to be purchased. To place an order online, buyers would simply click on the item they wish to purchase and add it to their shopping cart, along with the quantity they

require. To place an order using their cell phone, the buyer must open their Mobil-e-Com application, and select the Trade menu options and then the Buy Items menu option. They must then quote the StockID from the online portal, along with the quantity they require. A message is displayed while the request is being processed, providing useful feedback to the buyer.

Regardless of the technique used to place the order (whether using a cell phone or a traditional workstation), the method used to process the request is the same. First the StockID is checked to see that it is valid. If this is successful, a check is performed to ensure there is enough stock to complete the order. If there is not enough stock, a message is sent back to the buyer (either online or by SMS) notifying them of the problem. If there is enough stock, the transaction is identified as successful, and the stock levels are decremented in order to stop multiple customers ordering the same goods. If the transaction is successful a message is sent to the buyer's cell phone, re-iterating what they have ordered and notifying that the request is being processed, and that the seller should be in contact with them soon. A similar message is sent to the seller informing them of the StockID, the quantity required and the buyer's cell phone number. This process will be described further from the seller's perspective in the next section

B. Seller actions for trade process

As is shown in Figure 2, the seller can perform three trade actions, each of which occurs on the cell phone: add new stock; review existing stock; and remove stock.

To add new stock, the seller must again navigate to the Trade menu, and then select the Sell Items menu option. Sellers are then prompted for five pieces of information: category that the stock falls under; short name; short description; unit price; and quantity available to be sold. This information is then all sent to the server, where it is stored in a database. While being processed on the server, the stock is assigned a StockID, depending on the category selected by the seller. This StockID takes the first three letters of the category name, concatenated with a three digit number, supporting up to 999 items in each category.

Sellers are able to review their existing stock that they have already sent to be sold on the Mobil-e-Com Trade application. To perform this action, sellers must first navigate to the Trade menu, and then select View sale items. This automatically sends a message to the server, where a query is made to the database for a list of items that have been placed for sale by the seller. An abbreviated version of this list is then returned to the seller's cell phone and displayed on their screen.

The final action available to sellers is to remove stock from the e-Shop using their cell phone. This action would be used in the event that seller's change their minds about selling goods. To complete this action, users must simply enter the StockID and the quantity to remove from the system. When processing this action, the server checks to see that the seller has authority to remove the stock from the e-Shop (seller's can only remove their own stock), then checks to see there are enough items to remove. If both of these conditions are met, stock is removed from the e-Shop.

As stated in the previous section, once a buyer has checked out the items they wish to purchase, an SMS is sent to the seller, notifying them of the potential sale. As well as including details on the stock required, it also provides them with the cell phone number of the buyer. It is then up to the seller to contact the buyer to arrange for the logistics of the sale. This process was designed to be as lightweight as possible, in order to provide buyers and sellers with flexibility in the marketplace. To enable the seller to maintain their mobility, we provide another component to the solution, Mobil-e-Com Banking, to support inter-cell phone money transfer. Users are not forced to utilize this banking infrastructure, but instead may choose to take advantage of it. This process is explained further in Section VI.

Type(1)	Send(10)	Tr(1)	StockID(6)	#	PL				
<i>Where PL equals</i>									
Tr=1	Cat	#	Name	#	Desc	#	Prc	#	Qty
Tr=2	Qty								
Tr=3									
Tr=4	Qty								

Table 1: Messages passed TO server during trade

Table 1 provides an overview of all messages passed to the server during the trade actions. Grey rows show the default message structure. As shown in Table 1, fields included in the default message are: the type of transaction (Type) which takes the value 1 for all trade transactions; the sender's cell number (Send); the transaction that took place (Tr, where the value of Tr ranges from 1 to 4 and signifies: *sale* transaction; *purchase* transaction; *view* transaction; and *revoke sale* transaction respectively); and the ID of the stock (StockID). The payload (PL) depends on the type of transaction, with the possible values listed under the default message structure. Field sizes of fixed message components are shown in brackets next to their respective names. Variable length fields are delimited by a '#' character. In the case where the message is passed to the server for a sale transaction (Tr=1), the following information is also required: category of goods (Cat); short name description for goods (Name); long description of goods (Desc); price per unit (Prc); and quantity for sale (Qty). In the cases where a *purchase* or *revoke sale* transaction is taking place, the only additional information required in the payload is the quantity of items to purchase or revoke (respectively). No additional information is sent in the payload when a view request is sent.

Tr(1)	RC(1)	Send(10)	#	PL				
<i>Where PL equals</i>								
Tr=3	Len	#	Name	#	Qty	...	#	#
Tr≠3	#	#						

Table 2: Messages passed FROM server during trade

Table 2 illustrates the messages sent from the server during the trade actions. Similarly to Table 1 grey rows in the table show the default message structure. Any additional information sent in the payload is outlined below the default

structure. By consulting this table it can be seen that the default fields are: the transaction that took place (Tr, values identical to those specified in the description for Table 1); the response code from the server (RC); and the senders cell number (Send). Response codes are used to provide feedback to the user, with their values indicating one of the following states: Insufficient funds; recipient does not exist; invalid stock code; invalid amount specified for transaction (less than R0.00); insufficient stock; an error occurred during processing of transaction; and OK. In the case where a view transaction takes place (Tr=3), the first message component of the payload in the message from the server depicts the number of hash-delimited, Name-Quantity pairs to expect in the remaining fields of the payload. In all other cases (Tr≠3), the payload simply contains two hash characters, to denote an end of message.

As previously stated, on successful completion of a *Purchase Items* transaction, a message is sent to the seller. The structure of this message is shown in Table 3. The fields contained in this message are: the transaction that took place (Tr); the sender's cell number (Send), the Stock ID (StockID); the number of items requested (Qty); and the total cost of the transaction (Total).

Tr(1)	Send(10)	StockID(6)	#	Qty	#	Total	#
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Table 3: Message passed to seller on successful completion of Buy Items action

VI. BANKING

The final part of the Mobil-e-Com solution is the banking component. This gives the users of Mobil-e-Com an efficient way of transferring money between registered users' micro-payment accounts. Not only can it be used to pay for goods from the trade component, but it can also be used for simple money transfers between parties. In this proof-of-concept application, security measures have not yet been implemented to ensure sensitive information is left intact during communication between the cell phone and the server. However, these extensions are planned for any future implementations of Mobil-e-Com.

As shown in Figure 3, users are able to perform three actions: balance enquiry; load money; or transfer money. To perform a balance enquiry, users must simply select Balance from the root menu in the Mobil-e-Com application (as shown in Figure 1 (a)). A message is then sent to the server, which in turn queries the database and returns the balance to the user's cell phone.

In theory, money should be able to be transferred between a user's micro-payment account and their bank account. As this is only a prototype of the solution, this action does not interface with existing banking structures. Instead, we provide the load money more as proof-of-concept. Again, when this is fully implemented, users will also be able to perform another action where they can transfer money from their micro-payment account to their bank account (currently, money can only be "transferred" from their existing bank account to the micro-payment account). To transfer money into their micro-payment account, users must select Load from the root menu in the Mobil-e-Com

application, as shown in the left hand screen capture of Figure 1. The user is then prompted for the amount that they wish to transfer to their micro-payment account. When the server receives this message it checks that two conditions are satisfied before completing the transaction: the amount is a non-negative integer; and there are sufficient funds in the bank account. The new balance is then returned to the user's cell phone.

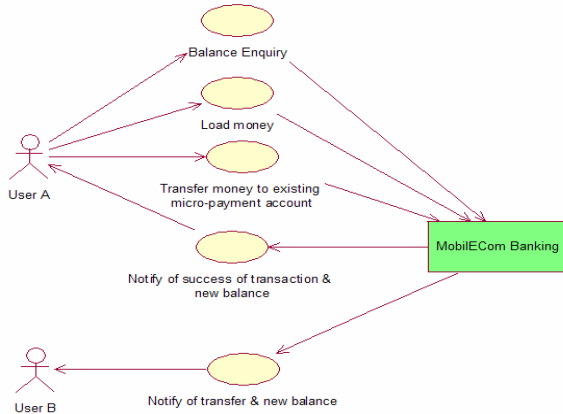


Figure 3: Mobil-e-Com banking process

The final action available to users is to transfer money to an existing micro-payment account. To transfer money into another user's micro-payment account, users must select Pay from the root menu in the Mobil-e-Com application. Users are then prompted for a cell phone number to transfer to, and an amount. It is envisaged that users would be able to browse their phone book to find a recipient's details, but in this proof-of-concept implementation, users are required to enter this number. When the server receives the request it checks that three conditions are satisfied before completing the transaction: the recipient number must correlate to an existing micro-payment account; the amount must be a non-negative integer; and there must be sufficient funds in the sender's micro-payment account. On successful completion of the transfer, the second user, illustrated as User B in Figure 3, receives a notification that money has been transferred into their micro-payment account, indicating their new balance. After all transactions, users receive a notification of the success of their transaction and are shown their current balance (after their transaction has occurred).

An overview of all messages passed to and from the server during the banking actions is presented below in Table 4 and Table 5 respectively. Similarly to Table 1, field sizes of fixed length message components are shown in brackets after their respective names. There are slight variations in the requirement for message components in the bank messages (for example the recipient field is only required for the Pay action), but instead of changing the message structure as was done with the trade messages, message components are filled with 0s. As shown in Table 4, all messages passed to the server during banking consist of the following fields: type of transaction (Type) which takes the value 2 for all banking transaction; sender's cell number (Send); transaction type (Tr, where the value of Tr ranges from 5 to 7 and signifies: balance transaction; load

transaction; and pay transaction respectively); recipient's cell number (Rcpt); and the amount of money involved in the transaction (Amt). Table 5 describes all messages passed from the server during banking actions. This message consists of four different components, all of which have now been defined in the descriptions of Tables 1, 2, and 4.

Type (1)	Send (10)	Tr (1)	Rcpt (10)	Amt
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Table 4: Message passed TO server during banking

Type (1)	RC (1)	Send (10)	Amt
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Table 5: Message passed FROM server during banking

Tr (1)	Send (10)	#	Amt	#	Bal	#
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Table 6: Message passed to recipient on successful completion of Pay action

As described above, a notification message is sent to the recipient when a Pay action is successfully completed. The structure of this message is shown in Table 6. As can be seen in this table, this message contains the following fields: type of transaction (as defined in previous paragraph); the sender's cell number (Send); the amount to be transferred (Amt); and the current account balance after the transaction has occurred. (Bal).

VII. MOBIL-E-COM SERVER

As there is comparatively limitless processing power, storage capacity, and power supply on the server, it has been designed to perform most of the computation in the Mobil-e-Com infrastructure. An overview of the architecture of the server is illustrated in Figure 4.

The server itself consists of three main classes: MOSMS Listener; e-Commerce Logic and Database Wrapper. These classes will now be described from the lowest level of abstraction upwards. The Database Wrapper connects to a SQL database using JDBC. It performs basic database methods such as inserting, deleting, and updating database rows. The e-Commerce logic abstracts away the implementation details of the database, performing methods such as adding customers and stock, loading money into accounts, and transferring money between accounts. The final class is the MOSMS Listener that listens on a TCP/IP port for SMSs from the users' cell phones. When it receives a message, the contents are extracted and parsed. The MOSMS Listener then calls methods in the e-Commerce Logic class to process the actions. Responses are received and then formatted into SMSs. These SMSs are then sent on a TCP/IP port to EasyOTA.

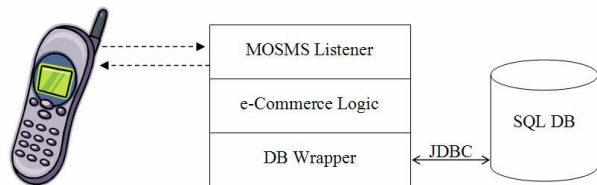


Figure 4: Mobil-e-Com back-end server architecture

VIII. CONCLUSION

This paper has described a novel SIM-based application to facilitate and support second economy entrepreneurship, in particular in rural areas in South Africa. In designing our framework for this particular audience, careful attention has been paid to ensure that the solution makes limited assumptions on the cell phone hardware available to rural communities.

From a technical perspective, this paper has provided a functional description of the four components that comprise the Mobil-e-Com system: registration; trade; banking; and back-end server. It has demonstrated the functionality that the components provide with respect to use case scenarios and screen captures of the deployed system.

In summary, the proliferation of cell phones is already extensive in both developing and developed nations. Mobil-e-Com is deployed in an OTA infrastructure which allows operators to provide the micro-payment infrastructure, and the cell phone facilitated e-Commerce platform “overnight” to the user’s SIM.

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