Modelling an Offline Electronic Cash Transfer Capability to the Existing Mobile Money Platform: Case of Social Cash Transfer Programs

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Abstract

The Productive Safety Net Programme (PSNP) is Ethiopia's rural safety net for chronically and transitorily food insecure households by providing cash and/or food transfers. These interventions aim to strengthen resilience, improve nutrition, and help households become food enough and, eventually, food-secure [1]. The cash transfer program has evolved through various stages from manual cash disbursement by the government agencies to the electronic cash transfer which is facilitated by mobile money platforms.

The electronic cash transfer method played an important role in the disbursement of cash to the beneficiaries as it provides timely, convenient, and secure service. But, due to the cellular network coverage and consistency problem, it is not possible to address all beneficiaries in the program by the electronic cash transfer system within the mobile money ecosystem in Ethiopia.

This paper comes up with an operational process and a technological solution by designing a software system in which offline areas can be addressed by the existing mobile money platforms. This is realized by modelling a software system that can be integrated into existing mobile money platforms. The system has two main parts: the desktop application which can be used by users who have online access to the mobile money platform, and the POS (Point of Sale) terminal application which can be used by an offline agent. The offline and the online systems are integrated by sharing a cryptographic file/key and offline capability and the existing systems are integrated via a database.

Keywords: Social Cash Transfer; Mobile Money; Advanced Encryption Standard (AES*)*

1. Introduction

During the past two decades, much social cash transfer (SCT) programs have emerged in developing countries as a promising means for social protection. Since their introduction as pilots in Latin America in the early 1990s, the popularity and support of SCTs among national governments as well as the international development community have increased considerably. SCTs have, therefore, moved "from the margins of development policy towards the mainstream in several global regions" [2]. In general, the term 'social cash transfer' describes "regular non-contributory payments of money provided by government or non-governmental organizations to individuals and households" [3]. SCTs can be both conditional and unconditional and they are commonly targeted at households or persons fulfilling certain eligibility criteria such as income poverty or malnutrition. As the largest SCT programs are carried out in middle-income countries such as Brazil, South Africa, and Mexico, only a minority of beneficiaries originate from states with a low average income. However, recently, several SCT pilot programs and nationwide initiatives have also been implemented in Sub-Saharan Africa and other low-income regions [4] demonstrating that SCTs are now considered as adequate instruments of social protection for the least developed countries.

The main goal of a delivery mechanism (or payment system) within an SCT program can be described as "successfully distributing the correct amount of benefits to the right people at the right time and frequency while minimizing costs to both the program and the beneficiary" [5]. The available delivery mechanisms can be broadly divided into 'pull' and 'push' methods. Traditionally, most SCT

initiatives applied a manual 'pull' system, which requires beneficiaries to collect their regular cash transfer at a specified date and location. These pay points are oftentimes local government offices, mobile offices administered by local authorities or NGOs, or post offices [6]. It is due to these substantial weaknesses that many development agencies have recently abandoned manual 'pull' methods and started using innovative 'push' systems, which 'push down' delivery to the individual beneficiaries [7]. In this respect, particularly electronic delivery methods have gained currency, as they outperform manual methods in multiple aspects. Almost 50% of all SCT programs implemented in the past decade use this type of delivery mechanism [8].

Any electronic delivery method consists of two steps. First, governments or international donor organizations electronically transfer cash to a bank which deposits the benefits impersonalized accounts that can be conventional bank accounts or limited-purpose instruments such as e-money accounts. The second step consists of beneficiaries withdrawing cash from these accounts at a network of pay points. Several electronic delivery methods exist that differ in the network of pay points they use. Pay points can be bank branches or post offices, Automated Teller Machines (ATMs), contracted shopkeepers with POS devices, or mobile money agents [9].

The inability of mobile money platforms of Ethiopia to provide electronic cash transfer to the beneficiaries located at non-cellular areas is the motivational factor for this research to study the existing systems and design an operational process and a software system that can enable existing mobile money systems to support social cash transfer and disbursement with an offline context.

The designed software system has two parts: online and offline. The online one is the main system that is integrated with the existing mobile money system. It is accountable to access an account and transaction history of account holders from the existing system and creating an encrypted file as an offline payment order which will be later used at the offline spot. Moreover, the online system is accountable for online account reconciliation by importing offline disbursement file. The online account reconciliation involves the debit and credit transactions on the online mobile money platform via the database integration channel.

The offline software system is a POS terminal system that can be installed on personal computers, mobile phones, or specialized hardware which can be accessed by the payer cashiers. This system is integrated with the online part with an encrypted file. The software system is capable of importing offline payment order files and disbursing the cash and exporting the transaction history as a withdrawal synchronization request, which is reconciled with the online system.

2. Literature Review

Mobile money constitutes an alternative electronic delivery method for smart cards or magnetic stripe cards. Governments set up mobile accounts for beneficiaries at Mobile Network Operators (MNOs). Accounts are linked to phone numbers and the government provides the MNO with a list of recipients including their Personal Identification Number (PIN) and phone number. A text message informs beneficiaries that a payment was transferred, and funds are debited from the government's account. Beneficiaries can then cash out their transfers at mobile money agents by inserting their personal Subscriber Identification Module (SIM) card in any mobile phone and entering their PIN. Having received a confirming text message, the mobile money agent cashes out the desired amount. Mobile money agents are independent entrepreneurs charging beneficiaries a service fee for withdrawing money out of their mobile wallets. Beneficiaries cannot only cash out their benefits but also store and transfer money between different accounts (e.g., paying bills) or buy airtime and goods at participating vendors. Whereas some countries allow MNOs to store money on behalf of their customers, in other countries formal banks need to be involved [8]. Although mobile money has not yet been applied in large scale SCTs, successful pilots exist.

The 'Post Election Violence Recovery' program in Kenya used M-PESA to deliver cash to 37,000 individuals [10] and in Haiti, several NGOs relied on

mobile money tools for their emergency relief work in the aftermath of the earthquake in 2010 [8].

As governments can leverage existing mobile money agent networks, initial set-up costs for electronic delivery solutions using mobile money tend to be lower than for smart card-based systems. Governments do not need to provide contracted agents with POS devices or set up ATMs, yet they may need to provide beneficiaries access to a mobile phone if they do not possess one. In addition to financial transactions, mobile phones provide an opportunity for communication between the government and beneficiaries. They allow beneficiaries to provide feedback by sending text messages and facilitate governments to respond to complaints or to inform about changing conditions of transfers. Such two-way communication is likely to reduce leakage and improve accountability. Governments may also use text messages to influence beneficiaries' behavior. For example, beneficiaries could be encouraged to use transfers for school fees [8]. One disadvantage of mobile money systems is that they require constant network coverage, which is likely to pose a barrier in remote areas. Moreover, unlike smart cards, which only require beneficiaries to provide a fingerprint, mobile money solutions demand them to operate a mobile phone. Unless training and guidance are provided, this might constitute a barrier to access especially for illiterate individuals [11].

Like mobile money, mobile vouchers also work with MNOs. Yet, mobile vouchers require less hardware than a mobile money solution since only contracted shopkeepers need to be equipped with a mobile phone. Beneficiaries receive a PIN and a voucher number on two separate scratch cards and approach a contracted shopkeeper to redeem their voucher. They do not need to redeem the full amount at once and can usually only receive in-kind benefits [11]. To verify the transaction, shopkeepers enter the voucher ID and the redeemed value into their mobile phone and ask beneficiaries to enter their PIN. Upon successful verification, shopkeepers receive a text message and are then allowed to provide beneficiaries with goods and services. The redeemed value is credited to the shopkeeper's account. Alternatively, with electronic vouchers, shopkeepers verify transactions via the Internet. Therefore, they need to possess a smartphone or computer and access to a data connection to process this type of voucher [11].

Mobile vouchers are easy to set up, which makes them useful delivery methods for emergencies. For example, in response to the humanitarian crisis in Siri, the World Food Programme implemented an electronic voucher program in 2013, which allowed 800,000 refugees to buy food at local shops in Lebanon and Jordan [12]. Since vouchers usually only entitle beneficiaries to receive in-kind benefits, voucher redemption is not constrained by shopkeepers' cash flow. In contrast to paper vouchers, with mobile or electronic vouchers, shopkeepers can be reimbursed more quickly and governments receive more detailed data on beneficiaries' voucher redemption patterns. One main downside of mobile or electronic vouchers is that shopkeepers need network connectivity in order to verify transactions [11]. Moreover, vouchers are more suitable for short-term cash transfer projects since periodically new vouchers need to be issued.

Another alternative is a smart card. Smart cards are plastic cards with an embedded chip containing information on the beneficiary and transfer values. Recipients identify themselves at pay points (e.g., ATMs, post offices, agents with POS device) with a PIN and/or biometric identifiers and can then withdraw cash. Fingerprints and iris scans are mostly used for identification purposes. Which biometrics is most suitable depends on the beneficiary's occupation and age. Some jobs may cause damage to either hands or eyes and, in contrast to irises, fingerprints only stabilize around the age of fourteen. Moreover, cultural preferences should be considered. For instance, in Muslim populations, iris scans might be more culturally acceptable since no physical contact is required [13]. Smart cards have recently been introduced to large-scale SCT initiatives in several countries including South Africa's 'Child Care' and 'Old Age Pension' programmes as well as Mexico's 'Oportunidades' programme [14]. Furthermore, following successful pilots, Deutsche Gesellschaft für Internationale Zusammenarbeit

(GIZ) supported the Indian Government in the application of this technology in the national safety net program [15].

One of the three key advantages of a smart card is that no constant network connectivity is required, which makes smart cards particularly useful in remote areas. Since transaction information is stored both on the POS devices and the smart card chip, it is enough for agents to connect the device to the network at times to reconcile the accounts [8]. The second key advantage of smart cards is that information stored on the cards can be updated after the cards have been issued [9]. This allows governments to eventually streamline a range of services to citizens. For example, governments can easily add another 'wallet' to the smart card containing information on beneficiaries' eligibility to access other social protection programs, which deliver commodities (e.g., fertilizer) or services (e.g., subsidized education, health care) thereby convergence between different programmes targeted at similar population groups may be improved. Smart cards can also be used to store information on medical history or voting records [6]. Third, if smart cards rely on biometric identifiers, they are very easy to use even for illiterate individuals, as they do not require to memorize and enter a PIN or to own a mobile phone [10].

In addition to the above three alternatives, magnetic strip cards can be used for social cash transfer system. Magnetic stripe cards store data on magnetic stripes using iron-based magnetic particles on a band on the card. Beneficiaries identify themselves with a PIN or a signature, which makes magnetic stripe cards less secure and slightly more complicated to use than smart cards employing biometric identifiers. Beneficiaries can cash out their transfers at ATMs or contracted agents with POS devices. Magnetic stripe cards are used in some of the world's largest SCT programmes such as 'Bolsa Familia', which delivers cash to more than 12 million Brazilian households regularly [14]. Besides, they have occasionally been employed in emergencies, for example, in the aftermath of devastating floods in Pakistan in 2010 [8].

In contrast to smart cards, magnetic stripe cards need constant network connectivity, as transactions are performed in real-time. Another weakness of the magnetic stripe card is that no new information can be added once the card has been programmed. While these features make magnetic stripe cards an inferior solution compared to smart cards, the latter cause considerably higher set-up costs [11]. Smart cards are up to five times more expensive than magnetic stripe cards and chip-reading POS devices cost twice as much as those for magnetic stripe cards. Given these high initial investments for smart cards, governments should carefully consider whether the additional costs compared to magnetic stripe technology are justified. In particular, the offline capability of smart cards might become less relevant to increasing mobile network coverage [16].

This work is fundamentally different from other works. First, since it proposes a solution that will not require new full system development, rather it can be integrated into the existing mobile money platforms, no need for a mobile phone, SIM card, or cellular network to make a cash withdrawal. From the payer side, only an encrypted file and POS terminal device will be used without any cellular or Internet connection. Second, the reviewed systems work for developed countries with heavy bank and telecom infrastructures like ATMs, POS, and smart mobiles with high Internet and cellular network coverage. Beyond this, the proposed systems are mainly designed to facilitate merchant payments in highly banked and financially included society without concern of social cash transfer to support the livelihood of the people.

3. The Proposed Solution

The research revolves around developing a system that enables existing mobile money platforms to perform offline electronic payment or disbursement of social cash transfer. The system targets two main platforms. The first is adding offline transaction capability to the existing mobile money platform and the second is a POS terminal application that runs on a cashier's or agent's mobile phone to disburse the cash to the beneficiaries. The POS terminal application is served by an encrypted

payment disbursement file and encryption key generated from the central mobile money platform.

A. Process Design

The process starts with sending a request for offline activation of a certain location with the custodian of a certain cashier near to the offline group by a branch or donor to the central payment unit or disbursement unit. The request will be delivered or asked via modalities like e-mail, formal letter request, phone call, or SMS upon the agreement reached between stakeholders in the offline payment process. The stakeholders are branches, donors, government bodies, etc.

Upon the request of offline activation, the central disbursement unit, the one responsible to make a bulk electronic cash disbursement to specific beneficiaries at specific woreda or kebele, starts to group offline located beneficiaries in one offline group and generates an encrypted payment order file as an offline group and share the encrypted file to the requesting branch or cashier for offline cash redemption. In the meantime, the central disbursement unit also shares the decryption key for specific offline file with the payer cashier. The file and the key will be shared on any communication channel upon the consent of stakeholders in the process. It can be an e-mail, SMS, or delivery persons who can reach the location.

Then the offline payment process will follow. The cashier will import the offline payment order file to the POS system by providing the decryption key. The successful import will result in saving all necessary account information of a beneficiary and enable him/her to make cash withdrawal from the nearby cashier. Then the cashier will disburse cash in return for the deduction of a certain electronic amount from the beneficiary's account number. The beneficiary must visit the cashier nearby and provide the account number, PIN and amount to be withdrawn. A successful traverse on the system by entering the credentials, the cashier will give the reverse cash to beneficiaries as long as the credentials are correct and the amount to be withdrawn is less than or equal to the account balance on the system.

After finishing the offline cash disbursement or withdrawal from the offline cashier's POS terminal to the beneficiary, the cashier must export the withdrawal history of user accounts at his/her post and send the encrypted file to the central disbursement unit for online account reconciliation, getting all his/her money paid at the offline post to the real online account of the payer cashier and debiting or deducting the amount from all beneficiary accounts with the same amount withdrawn by the beneficiary at the offline post.

B. High-Level Design

The main mobile money system will have an additional module to support the offline electronic money transfer and development of a new POS terminal application that enables cashiers to make actual cash withdrawal with the beneficiaries based on the encrypted file generated by the main mobile money system/software.

The application needs to first cache data dictionaries and decrypt the crypto file before making the offline cash withdrawal. The POS terminal application, therefore, has its own data storage. The local database keeps track of all transactions that a beneficiary has withdrawn with the respective amount of transaction. The POS terminal application not only serves as a cashier station but also offers an interface to the beneficiaries to verify and authenticate their account and transaction.

As shown in Figure 1 [18], the centralised database also serves as a store for all configurations and data dictionaries. The main database is interfaced with a web-based or desktop application that enables system administrators and other console users to administer users, to make a transaction, to generate encrypted offline transaction files, and to reconcile offline transactions.

C. Algorithm Design

Algorithms are designed for critical operations of the system. The critical tasks are *account validation*, *user authentication*, *account import*, *account* export, *withdrawal export*, and *account reconciliation*.

Account Validation: The account validation engine deals with beneficiary authentication at withdrawal stage. The system will check the account number first and will proceed to PIN code checking if the provided account number is valid. If the

account number and PIN don't match, the system will not allow the beneficiary to withdraw the cash from the POS terminal.

User Authentication: The User Authentication engine deals with the payment specialist authentication or login process on the desktop application. The user must provide username and password to the system. Then the system checks the password and username combination against the credentials saved in the database. If one or two of the password or usernames failed to match with the settled values, the system will not guarantee access to the user interface.

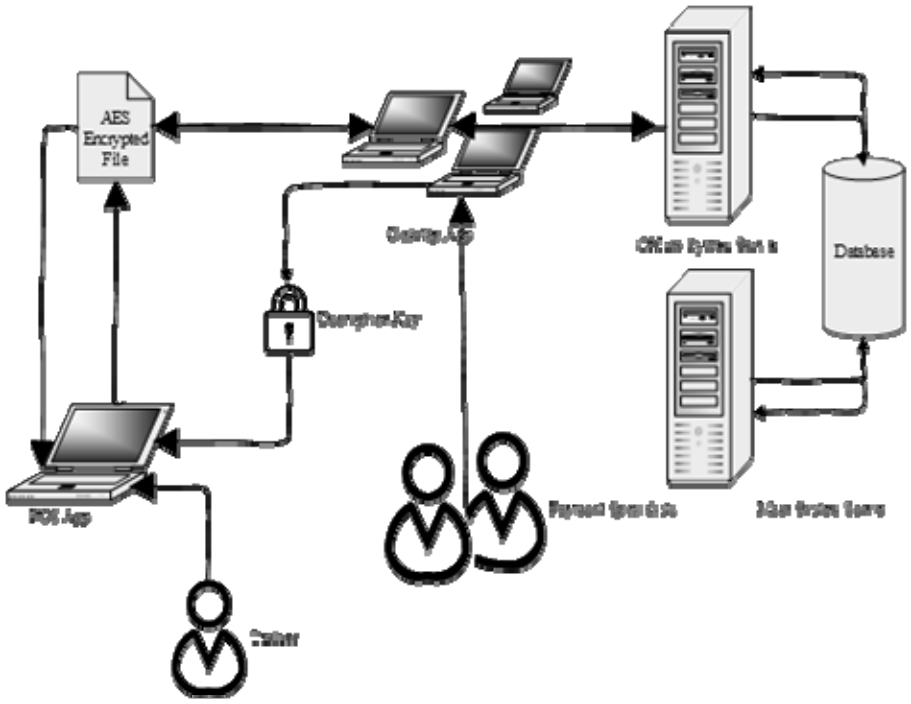

Figure 1: High-Level Design of the Proposed System

Account Import: The account import engine is about importing account information on the POS terminal application for the offline withdrawal process. The account information is imported from an encrypted file that is shared from the online system. The cashier must select the file and the decryption key. If the decryption key matches the key stored in the encrypted file, the account import process will continue, and the information will be stored in a local database on the POS application

Account Export: The account export engine is about exporting account information from the desktop application and encrypting the exported file. For user accounts to be exported for offline withdrawal, a cashier number must be provided to the system.

Withdrawal Export: The withdrawal export engine performs exporting user account information from the POS terminal application, writing the information to the file and encrypting it. The file will be used later for account reconciliation at the online system.

Account Reconciliation: The reconciliation engine is accountable for importing user accounts from the encrypted file, decrypting it, and updating the account information on the database system. This process is handled by the payment specialist on the desktop application with an online connection to the mobile money platform.

4. Prototype

To realize the feasibility and validity of the proposed solution, classes and methods are converted to source code. The prototype has two main parts.

A. Desktop Application

The desktop application is implemented using Java in NetBeans IDE. It follows object-oriented design patterns to structure the low-level functions. The software can run on an Operating System independent compiler and on a Java Virtual Machine.

As shown in Figure 2, the system offers capabilities that enable

- User Authentication,
- Offline group creation,
- Encrypted Payment order file creation and export,
- Withdrawal sync file selection and import,
- Financial transaction reconciliation, and
- Reporting.

Figure 2: Home Page of the Desktop System

B. POS Terminal Application

The POS terminal application is also developed using Java on NetBeans IDE. As shown in Figure 3, it provides an interface that enables cashiers to disburse electronic cash to the beneficiaries. The application offers capabilities that enable

- File selection and import,
- File decryption,
- File encryption and export,
- Beneficiary authentication,
- Electronic financial transaction, and Reporting.

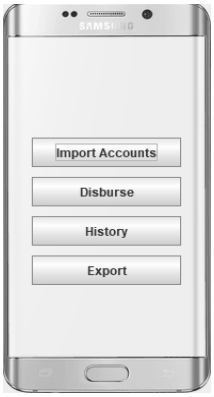

Figure 3: Home Page of the POS System

5. Conclusion

The electronic cash transfer on social cash transfer programs through mobile money platforms plays an important role in the disbursement of cash to the beneficiaries as it provides timely, convenient, and secure service. Beyond that, it calls for financial inclusion for the unbanked society.

The current mobile money technology does not serve social cash transfer beneficiaries living in offline locations due to cellular network coverage and consistency problem and a technology gap within the service providers in Ethiopia.

To alleviate the above gap, first, this research comes up with an operational process in which the non-mobile network areas can be addressed with the existing branch and agent networks of the mobile money service providers. Second, this research proposes a technolog by developing a software system model (a desktop system which serves users with direct access to the mobile money platform and the offline POS application which is used by agent and branch networks without direct online access to the existing system) that can be integrated with the existing mobile money platform. The offline and the online systems are integrated by sharing a cryptographic file.

The model is a new concept that also has several implementation challenges like the provision of training for stakeholders and integration with the existing system. The paper has identified operational procedure that can greatly enhance the social cash transfer program specifically to the non-cellular network areas and at the same time modeling and designing a software system which can be used for this purpose.

The algorithms and models used in the development of the system are not limited to the use case of social cash transfer programs. The same model can also apply in other tasks such as door to door revenue collection, shipping, and delivery.

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