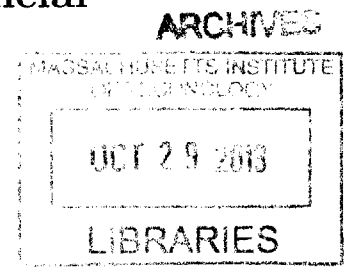
Information Accountability for Mobile Financial Applications



by

Arun Karthik Saigal

S.B., Massachusetts Institute of Technology (2013)

Submitted to the Department of Electrical Engineering and Computer Science
in partial fulfillment of the requirements for the degree of

Master of Engineering in Electrical Engineering and Computer Science

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Abstract

In this thesis, I designed and built three sets of applications for three different demographics - young people, elderly people, and people in the developing world - to enable them to be involved in their personal banking. Members of these demographics are not actively involved in their personal banking when compared to others. We believe that part of the discrepancy lies in the lack of convenience and accountability. Thus, we have developed applications, whereby the issues of convenience and accountability are addressed. The applications are built around mobile devices, which will likely make them accessible since members of these demographics are often on mobile devices. The applications are also built around rules that can be set by a responsible party, so that the users know exactly what can and cannot be done with their money (such as a father restricting the amount of money his son can withdraw, or what the money can be used for). Finally, we keep a history of every transaction, who initiated it, and an explanation given by the initiator so we can understand why it occurred. Using our applications, built around convenience and accountability, will allow banks to reach youth, elderly people, and people in the developing world in ways that they have not been able to previously.

Thesis Supervisor: Harold Abelson
Title: Class of 1922 Professor of Computer Science and Engineering

Acknowledgments

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Chapter 1

Introduction

1.1 Purpose

The goal of this thesis is to develop accountable systems that make personal banking more accessible for underserved demographics. According to a representative from CitiBank, as well as other banks, this includes young people, elderly people, and people in the developing world [7][14]. Traditional infrastructure has made serving these groups too expensive or impractical, but with new technologies emerging, we believe that this can change. We believe that banks have not made banking a convenient part of these people's every day lives, and thus they do not participate as actively as they could in the process. Part of the reason is because banks want to save costs by not devoting many resources to these groups in terms of infrastructure and support.

However, in discussions with bank executives, we have learned that they still want to reach out to these groups. And now, with costs dramatically decreasing, thanks in part to mobile devices and the infrastructure that accompanies it, banking in the developing world, including in rural areas, is becoming possible [14]. We believe that the solution lies in building convenient, accountable systems — systems that are built to encourage responsible use of data by following policies set by the parties who use it and parties who provide it [16][20]. As the International Monetary Fund points out in a report of *Economic Issues*, accountability is imperative to have in a banking system, as it ensures that banks comply with laws and expectations of the people they serve

[11]. Since these applications have user-defined rules of use, we must ensure that these application follows the rules defined by the users. If access to finances were built around convenience and accountability, these three demographics may be more involved in their personal banking.

1.2 Contributions

In this thesis, I have made the following contributions:

1. I have built a set of applications for young people and their parents to allow the young people decide when they get money transferred to their accounts by their parents, while giving the parents an easy way to see when and why their children need money. The application allows parents to set rules as to what transfers can be automatically approved and what must require their permission.

2. I have created a set of tools to allow the caretakers of elderly people to track their spending while allowing the elderly to maintain their purchasing freedom. The caretakers can set rules as to what transactions may be suspicious, that the bank may not catch, and receive notifications or approval requests if a strange-looking transactions made by the elderly person.

3. I have developed an application to allow banks to set up and control local branches in rural areas of the developing world with just a smartphone. This will allow people in these areas to set up accounts with the banks, deposit and withdraw money from the banks, and and transfer money to other parties via SMS. We set policies that will require the banks to know who money comes from and goes to in a transaction, and who initiated the transactions, so that the bankers will not be able to make a transfer on a customer's behalf with out them knowing, and so that other illegal transfers will not occur. I also discuss the concept of a *broadcast phone*, where a smartphone acts on behalf of a feature phone that interacts with it.

1.3 Outline

In chapter 2, I give some background on convenience and accountability, and describe what is currently happening in the market of banking applications. In chapter 3, I describe the applications I have built to help youth be in charge of their finances while allowing their parents to give them funds and monitor their spending. In chapter 4, I talk about tools I have developed to allow the elderly to be in charge of their finances, while allowing caretakers to monitor seemingly erratic spending. Chapter 5 talks about the personal banking applications I have built for people in the developing world, especially in rural areas. Chapter 6 discusses some of the technical choices I have made in building these tools. Finally, chapter 7 concludes the thesis.

Chapter 2

Background

Over the past few years, mobile devices have changed the way we approach our lives. Many phone calls and emails have now been replaced with SMS messages. Most activities that we once performed on gaming devices or computers, we now often perform on mobile devices. Multi-million dollar companies are formed around developing mobile applications [13].

While many industries have been entirely revolutionized by these mobile applications, personal banking has not completely changed. People still go to the ATM to withdraw money, transfer money, and deposit checks. Based on a conversation with a representative from CitiBank, I learned that CitiBank wants to reach out to three demographics that are not very actively involved in personal banking: young people, elderly people, and people in the developing world, as do many other banks [7][14]. We believe that by making applications that are built around convenience and accountability, people will be more likely to get involved in personal banking.

In the rest of this chapter, I explain what accountability is, and why convenience and accountability are important in regards to banking applications. I also give an overview of some banking mobile applications that exist now. I show how the applications from the banks do not leverage the mobile device by utilizing it more than the as a device connected to the internet, and how third party application aid the needs of those who maintain their own bank accounts, but not the needs of the elderly/caretaker or parent/youth relationship.

2.1 Convenience

If the members of aforementioned demographics had more convenient access to their bank accounts, i.e. through a mobile application, they would be more likely to be involved in personal banking, and the costs would be affordable for banks [14]. Mobile phones have become ubiquitous and many people in these demographics have mobile devices, even if they do not have access to other technologies, much less a personal bank account [12]. Young people and elderly people often have mobile phones so that they can easily contact family and friends. Many people in the developing world have mobile phones while they do not have computers, or even consistently running water.

In a recent trip to India, I visited a school in a village that farmed cotton in the Indian state of Haryana. In this village, I did not see any computers as I visited homes, but I did see that nearly all families, if not most family members, had a cell phone. People did not have televisions. There were no large malls or movie theaters. People went outside or played mobile games (like Snake) for entertainment. The people had no easy access to a bank, with the nearest physical bank location being over 100 km away in the city.

All transactions were made in cash. This was not generally a problem, but when large cotton buyers came to town to purchase the cotton that was produced by the villagers, they paid for the cotton in large sums of cash. This meant that the farmers had to keep large sums of cash in a cupboard at home. Another problem that they had was in buying communal goods. There were no specific village taxes that people paid, but everyone contributed when a communal purchase was being made by giving cash to one person and having them make the purchase. If they had access to a bank, they could keep their own funds as well as communal funds in an bank account rather than for in a cupboard.

A mobile application approach to improving a system has proven successful in other instances in rural communities. For example, many mobile applications developed for rural farmers have become widely used, like one that tells farmers weather patterns, or another that connects farmers with buyers in the market [6][9]. Even

then, there are still more innovations for using mobile devices people in rural area get important health care information both for themselves and for their animals. Similarly, there are banking applications, such as M-pesa, that have transformed rural banking in places like Tanzania and Kenya, giving basic banking abilities to locals who never before had an account [19].

2.2 Accountability

2.2.1 What is Information Accountability

In addition to convenience, accountability concerns are extremely important. When downloading a mobile application for a smartphone today, users give the application permission to take their data and make decisions as to what the data is used for. Users often do not know what all their data is being used for and in what contexts it is being used. This is troubling, since users often allow applications to use data that is sometimes personal, such as their email address, contacts, and phone number. Some applications even require more sensitive data such as their bank account or credit card information. Smartphone users are generally not informed exactly when and what for their data is used. If there was some accountability in place for the use of their information, they would better be able to understand how their information was being used, and potentially be more discriminative as to which apps they use and why.

Weitzner et. al. defined information accountability as "the use of information [being] transparent so it is possible to determine whether a particular use is appropriate under a given set of rules." They also claim that there should be a way to trace the use of all information so that those who misuse it can be held accountable [20]. Pato et. al. say that information accountability should "encourage responsible use of information by combining clearly expressed usage policies" [16]. Thus, we have built a system that has specific rules set with the users that decide where and when data can be sent, and clear disclosure as to all of the places the data will be used and

stored. The policies are built by the users along with the banks and with the users' best interests in mind.

2.2.2 How Does Accountability Affect Banking Applications

Some common concerns we face today are how to allow youth and elderly have their freedom while limiting risk in giving it to them. In becoming independent, young people will need to manage their finances, yet are often tied to their parents' accounts until they can afford to pay for themselves. Parents of teenagers care that their children have access to money when they need it (i.e. can easily transfer money from the parents' bank account to the children's bank account), but also care that they can keep track of their children's spending. However, the parents and banks may be concerned that by allowing the easy transfer of money from one account to another, no new vulnerabilities are created, such that the system can be abused.

On another front, people may also have elderly parents (or grandparents) who want to have their freedom to do what they want, when they want. However, their caretakers (such as children) may want to keep track of them so that they do not make accidental mistakes related to their finances, as elderly people sometimes suffer from memory or cognitive issues that can impair their judgement at times. A solution, we believe, lies in easy to use mobile applications along with a simple monitoring systems. Certain mobile applications have already made certain tasks easier. For example, many banks have developed mobile applications that allow users to take a picture of a check with a mobile app and have it automatically deposit so that they do not need to go to the bank to deposit their checks, where they are then scanned and deposited anyway [5][15]. However, many people would like to track their elderly parents' purchases. They do not care about every little thing their parents buy, but they may want to track purchases that seem abnormal. For example, someone may want to track purchases made by her mother over $1000, since she does not think that her mother needs to make purchases over this amount, and thus it is likely an erroneous purchase.

Hence in the case of youth, elderly, and people in the developing world, we believe

a system that follows a set of rules is important for multiple reasons. Firstly, this means that users can count on the fact that all information will go through a series of checks before it is sent, so that the appropriate decision will be made as to what to do with it. The users can prioritize rules in the order that the user believes is necessary. For example, a parent can have a rule saying *first, if the requested amount does not exceed $100, second, if it is for eating dinner for the week, then transfer the requested amount of money to my son.* Also, users can count on the fact that the bank is manipulating their money in accordance with the rules they specified. Lastly, by having the details of each transaction, the bank can ensure that the users are not misusing the system.

2.3 How Cell Phones Have Changed Banking

Mobile applications have begun to shift our banking habits. While these applications have not solved all of our banking issues, they definitely make banking more convenient and accessible to many people.

2.3.1 Paypal, Square, Venmo

Paypal, Square, Venmo, and many other applications have brought banking into the pockets of people with smartphones. With these applications, transfers and transactions are much easier to make then they once were. Venmo allows someone to transfer money to another person right from their smartphone, as long as they know the person's phone number or email. Square allows us to take a credit card swipe payment right from our smartphone or tablet. Paypal, and many other applications gives you a similar functionality as these applications.

2.3.2 Mobile Banking Applications

CitiBank, Bank of America, and many other banks have also released applications recently that extend their website's abilities. For example, they allow users to make

easy transfers within their system[5][15][1] from a smart phone, like on the web. They allow users to check bank account and activity information from their phones. For feature phone users, they have also come up with text based applications to allow people to check their bank account details such as activity and balances. However, they have not made their transferring features available to feature phone users. Some of the bank applications let users take a picture of a check to deposit it. Other than for that feature, the banking applications have not leveraged the mobile device capabilities, such as location or barcode scanning abilities, and have instead simply replicated web based features.

2.3.3 M-Pesa

In 2007, Safaricom and Vodacom, two phone companies in Kenya and Tanzania, launched M-Pesa [19]. Users of M-PESA open their accounts with M-Pesa agents, and can withdraw and deposit cash with these agents. The *know your customer* process in Kenya requires documents that the Kenyan government issues. It also allows transfers with the use of a mobile device. This system is the most developed mobile payment system in the world. However, it still does not address issues of people in rural areas with out proper government identification.

2.4 Conclusions from Background

In this chapter, we have seen that there are applications made for mobile devices to bring banking to many people's fingertips. However, many of these applications do not make clear what all they are doing with their user's data, and they do not make much use of the smartphone, or give many capability to feature phone users. In the next three chapters I describe three sets of tools I have built, which address accountability concerns and leverage capabilities of smartphones, feature phones, and other available technologies to allow people who are underserved to become more involved in their personal banking.

Chapter 3

Applications for Parent/Youth Fund Transfer

3.1 Introduction

In the next three chapters, I describe the three sets of applications that I have developed. First I describe the pair of applications for a young person and his parent. These applications allow young people to request cash transfers from their parents' bank account to their own bank account. The next set of tools I describe is for an elderly person and her caretaker (often her child). These tools allow the caretaker to monitor the elderly persons spending. The third set of applications I describe allows people in the developing world to partake in banking through their mobile devices.

3.2 The Applications

I have built two applications to facilitate the transferring of funds from parents to young people. The first application was built for young people to request fund transfers from their parents for specific purposes using their smartphones. I chose to use smartphones since many young people have smartphones. In a study recently completed by the Pew Research Center, 79 percent of Americans between the ages of 18-24 were found to have smartphones [18]. The second application is for parents to

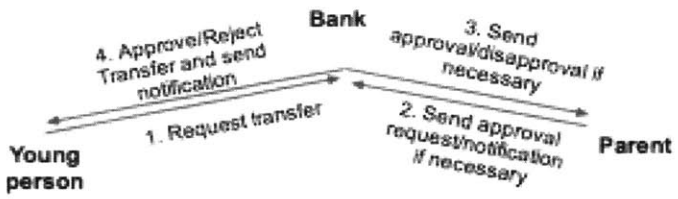

Figure 3-1: Process by which a young person requests funds from his parent

approve or disapprove a purchase when necessary. These applications let parents set rules as to what can be automatically approved and does not need to wait for their approval. For example, if a child is purchasing a textbook, the parent may allow the funds to automatically be transferred from his account to the child's account, but if the child is looking for funds to go out with friends, the parent may want to manually approve the transfer before it happens.

Since I approached the applications with accountability in mind, I looked at how to follow a set of rules and policies that clearly states how the applications may use the information to best help its users. Thus I have built these applications around a rule-based system that follows a set of rules defined by the users. The application for the young person asks the user how much money he would like to transfer, and what the reason is. If the reason falls into a category approved by his parent, and the total amount of money transferred this month including the requested transfer is below a certain parent-set threshold, then transfer is approved. If either of these conditions is not satisfied, then a request for transfer approval is made to the parent. This process is outlined in Figure 3-1

To determine what can and cannot be manually approved, the rules in Figure 3-2 are followed.

3.3 Scenario

Sam is the older of two sons and has just started tenth grade at a boarding school. He is on the football team and finished his first practice of the year. A bunch of his

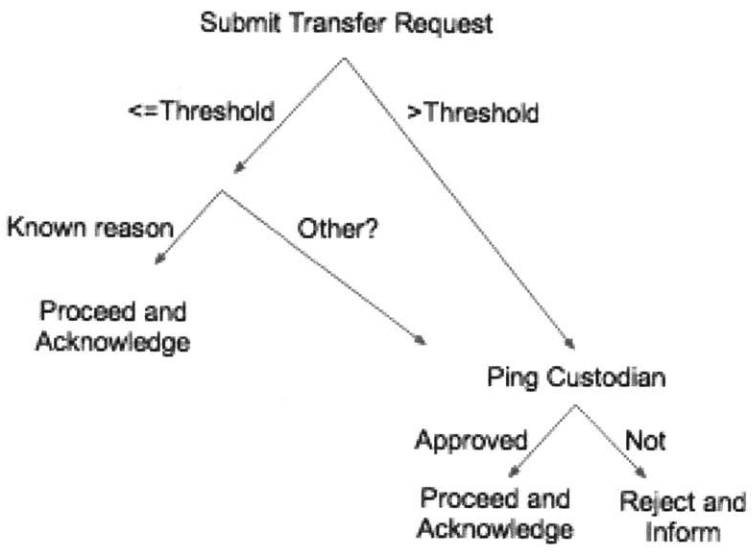

Figure 3-2: Decision tree showing what to do when a young person requests a transfer from his parent

buddies are going out for dinner after practice and he wants to join them, but he realizes he is out of cash. There is an ATM nearby, and he knows that he will need money for dinner and at least a few more meals. He has no money in his account, so he wants $100 transferred to his account from his dad. He opens his banking application and requests a $100 transfer from his dad's account. He attaches a brief message (<140 characters) explaining why he needs the money. The cash appears in his account by the time he gets to the ATM and he joins his buddies for the rest of the evening.

In the meantime, his father, Bill, receives an SMS saying that $100 has been transferred from his account to Sam's account at the time of the transaction, along with the reason for it. Bill has a limit set on transfers so that no more than $500 can be transferred per month with out his explicit permission. There is also a rule-based system checking that the reason provided by Sam fits into an *approved* category as specified by Bill (food, in this case). Thus Bill is confident that his son is not transferring exorbitant amounts of money, and that he is taking out funds for a good reason. He also has the details of the transfer in an SMS so he can follow up with

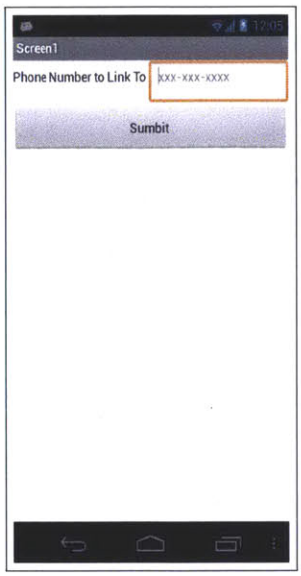

Figure 3-3: Screen that a young person will see when first opening his transfer application

Sam later if he has an issue with the transaction.

3.4 Setup

When a user initially downloads the application, he will see the screen shown in Figure 3-3.

The screen will ask the young person (Sam in our example) for his parent's phone number (Bill's phone number in our example) to which the application will be linked. After Sam types in Bill's phone number, he hits the *Submit* button. When the submit button is clicked, Sam will see the screen shown in Figure 3-4, requesting he wait while his parent approves the linking. Note that this application assumes that Sam's bank account is linked to his Bill's bank account, Bill's bank account is associated with Bill's phone number, and Sam's bank account is associated with Sam's phone number.

In the meantime, the application will check the bank's database (something we have simulated using Google Fusion Tables in this thesis but leave for the bank to do in practice) to confirm that the account associated with Bill's phone number is linked to Sam's account. If not, a message will be sent to Sam saying *This phone number is*

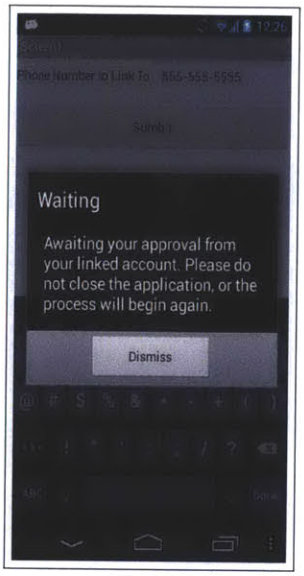

Figure 3-4: Screen that a young person will see after submitting his parent's phone number

not linked to this account. If the account is associated with the number, a text will be sent to Bill with the following message: *This phone number would like to link to your bank account. Do you approve? Please respond "Yes" or "No"?*

If Bill says *No* then Sam will see a dialog informing him that his request to connect has not been approved. If Bill says *Yes,* then the next message Bill receives will say *What categories of spending are acceptable (please give a comma separated list)?* Since we want to decide what items can automatically be approved, we must understand what categories of items Bill believes are approved categories. Bill should respond with a list of categories (i.e. food, textbooks, clothes) that tells the application what all of his approved categories are. The application will take the message and parse it by the commas and note what these categories are. This categorization will be used to decide what requests can and cannot be automatically approved.

The final question asked of Bill during set-up will be *What dollar amount is the monthly limit for spending?* Bill should respond with a monthly spending limit. Any spending above this limit must manually be approved, regardless of the purpose. Note that it could be 0 dollars if everything must be approved or a very large number if

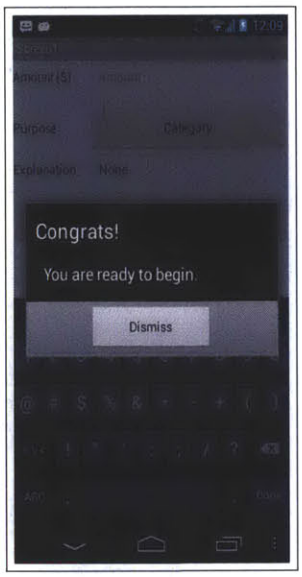

Figure 3-5: Screen that a young person will see when the parent has submitted all of the necessary setup information

nothing that falls into an approved category needs to be approved manually.

Once this quick setup process is complete, Sam is ready to transfer money into the his account. He will receive a message saying so as shown in Figure 3-5.

3.5 Making a Transfer Request

Once the application is set up, Sam can make a transfer request by simply opening the application and he will see the request screen shown in Figure 3-6.

To request a sum transfer of money, Sam must input the desired amount, select a category that this purchase falls into, and give an explanation as to why he is requesting these funds, by filling out the form provided on the screen as shown in Figure 3-6. Sam can also scan a universal product code (UPC) to submit with the request if he is looking for funds to be transferred for a specific purchase.

The categories to choose from will be shown in a menu that contains the categories provided by Bill at setup. Thus, when Sam clicks the *Categories* button, he will see the something that looks like Figure 3-7.

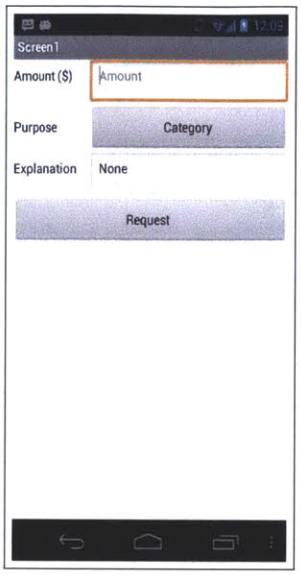

Figure 3-6: Screen that a young person will see when he wants to request a transfer

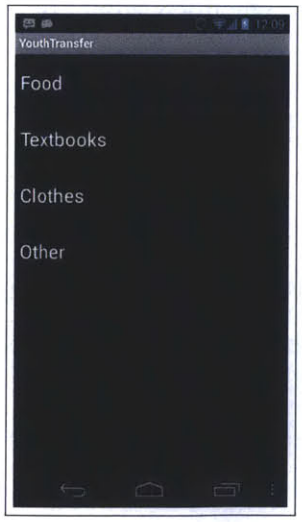

Figure 3-7: Screen for young person to choose a classification for his product

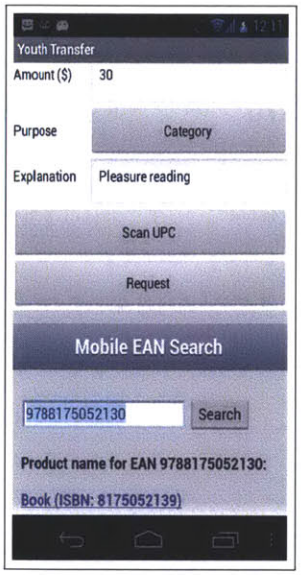

Figure 3-8: Example screen that a young person will see after a UPC code is scanned

If Sam decides to use the UPC scanning feature, the UPC code of the product will appear on the screen. For example if Sam scanned a book, he may see the the screen in Figure 3-8

And if he clicks on the link on the screen, he will see a link to purchasing the book online, as determined by www.upc-search.org from a place like Amazon.com, as shown in Figure 3-9.

Once the *amount, category, explanation* and/or *UPC code* have been specified, the *Request* button should be clicked. If the *amount* or *category* has not been specified, a dialog window will popup informing Sam that both the *amount* and *category* must be specified. If the request is valid, then the logic outlined in Figure 3-2 will be used to determine whether or not the request can be automatically approved or if it must be manually approved.

3.6 Transaction Approval

To determine what to do with the request, the specified information is sent to the bank's server's. Thus, there is a third party (independent of Sam and his father)

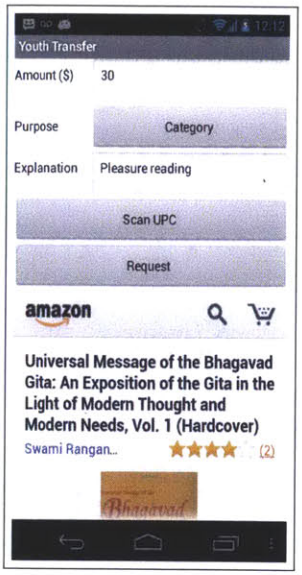

Figure 3-9: Example screen that a young person will see after a UPC code link is clicked

that determines if the transfer should be approved or not, strictly based on the set of rules defined by Bill. The bank first looks to see if transferring the requested amount causes the monthly limit on automatically approved transfers to be exceeded. If so, then the request is sent to Bill for manual approval. Next, the bank checks if the money will be used to make purchases that fall into *approved* categories. If it does, the purchase will be automatically approved. An SMS will be sent to Bill informing the parent of the transfer, and Sam will receive an alert informing that the transfer has been approved. Else, if *Other* is chosen as the category, then the transfer request will have to be manually approved by Bill regardless of the amount. If manual approval is required, the information will be sent to Bill via SMS, and pop up on his phone if manual approval was required. In the case of the book example from the earlier, the image in Figure 3-10 would also show up on Bill's screen if manual approval was required.

Bill can choose three different options.

1. He can click "Approve." This option will allow the transfer to proceed, but the funds are subtracted from the monthly amount.

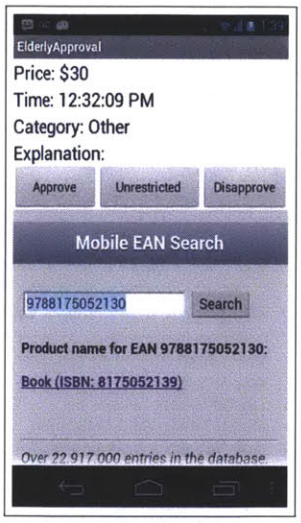

Figure 3-10: Example screen that a parent will see after a UPC code is scanned

2. He can choose "Unrestricted." This approved the transfer AND does not count the funds in the monthly limit.

3. He can "Disapprove" the transfer.

After the choice is made, Sam will be informed of the verdict via SMS and a dialog. If he has any issue with the verdict, he can follow up with his father outside of the application.

3.7 Accountability for Parent/Youth Fund Transfer

This application focuses on parent accountability between a parent and young person. We believe that parents will be willing to give their youth some amount of financial freedom and allow them to use this application if they are aware of what all the youth are doing with the money. Similarly, we believe that youth will only use this application if they are aware of how and when they can be monitored.

Thus, throughout this process, every transaction is recorded so that the parent and youth may look at the transaction history at any time. Each transaction will

have the amount, purpose category, explanation, time, and location (since we have GPS built into smartphones) of the transaction. This will provide the parent and child both with the knowledge of what the child is spending on, which may cause the parent to change the monthly limit or add approved categories if deemed appropriate.

We also have incorporated a rule-based system that will determine the appropriate response depending on the transfer - whether a notification suffice, or manual approval must be sought. Since the rules have been set by the users, they know exactly when and how their transaction data is being used by the other party.

Chapter 4

Applications for Monitoring Elderly Spending

In this chapter I describe a set of tools for assisting the elderly in their spending. Caretakers like to give elderly people as much freedom as possible, while tracking them to some extent to make sure that they do not do anything too erratic. In terms of finances, people may want the elderly they are caring for to have the freedom to buy what they want without accidentally spending too much money or making a purchase that they did not know they were making, which sometimes may be the result of memory or cognitive issues. This may happen, for example, when an elderly person forgets to check the price tag of something, is convinced that something is worth buying even though it is a hoax, or has mild dementia and forgets that they have already purchased something, and thus purchases it again. Thus, our applications allow a caretaker (often an adult child) to monitor purchases made by people she is caring for while leaving the process for the elderly as easy, and in some cases easier, than before.

4.1 Scenario

Tabitha is 72 years old and lives by herself. She has mild dementia, and has some decreased mobility that has come with her age, but is otherwise doing well. She has

one child, a daughter named Mary, who works full time and has two kids of her own. Mary loves her mother dearly. Tabitha does not want to leave her home to go to a nursing home. She has a few friends in the neighborhood and a smartphone, and she loves to shop.

Mary loves that her mom can keep her freedom, but is concerned about her mild dementia and occasional loneliness. Thus, she uses an app to track her mother's spending. Anytime her mother makes a purchase over $300 (a number that Mary set herself) or she makes a purchase that is the same as a purchase she made in the past 24 hours, Mary will get a notification informing her of the purchase and requesting her permission before proceeding. That way, she knows that her mother is not doing anything too erratic, or making mistakes because of her dementia.

4.2 The Application

Like the parent/youth fund transfer applications, the monitoring tools are built with the intention of the elderly person mainly being in charge, and the caretaker stepping in only if a rule that she set is not followed. Unlike the parent/youth transfer application, the elderly person spending habits are only being looked at after a purchase has been initiated, and not before. In the parent/youth application, we were able to screen purchases with the help of smartphones, because we noted that many youth have smartphones. However we did not want to rely on smartphones in this case since only 18 percent of American people over the age of 65 have a smartphone (unlike the 79 percent of Americans between the ages of 18-24) [18]. Also, the funds being spent belong to the elderly, and are simply being monitored by the caretaker, while in the case of the youth, the funds being spent are coming from the parent.

When an elderly person makes a purchase, they may do something that the agency through which they make the purchase (i.e. the bank, credit card company, etc.) will not consider suspicious, but may be an issue as far as the caretaker is concerned. For example, a credit card company may not find an issue with a specific purchase made by an elderly person, but a caretaker who knows the elderly person much better

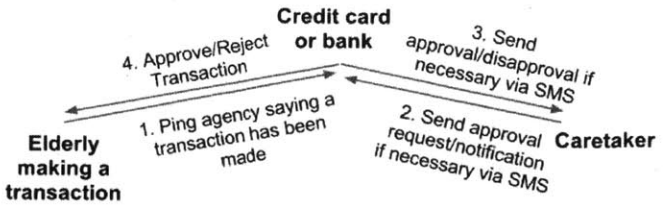

Figure 4-1: Process that occurs when an elderly person makes a transaction

can say whether or not the charge makes sense given the person's needs and spending habits. Thus we have proposed and simulated a system whereby the caretaker can set rules as to what purchases made by the person she is caring for requires notification, requires approval, or can proceed without any extra steps. The process followed by an elderly person using our tools is outlined in Figure 4-1.

4.3 Options

Credit card companies have various ways of determining if a charge is suspicious [4]. For example, if many transactions are made online, the credit card company may become suspicious. If a charge that does not match the cardholder's spending habits, the credit card company may also be suspicious. If a small charge is made, and then a large purchase soon follows it, the company may believe that this was a fraudulent charge, since thieves often make a small purchase to see if a card works, and if so, use it to make a large purchase. Lastly, if the transaction is made in person (as opposed to online) and not in cash, the location of purchase will be known to the agency. If the transaction comes from an unexpected place, some sort of alert will go off, indicating that the transaction is occurring in an unexpected location and thus may be fraudulent.

However, since a caretaker may know the person they are looking after better than the company, they may want to set their rules on what is normal or abnormal behavior for the elderly's spending. The caretaker can set checks on amount of money spent at once, location of spending, and monthly spending limits. These checks will occur with

the normal checks that the credit card company makes when you make a transaction. The only time it will stop the process is when something requires approval, but these should be rare occurrences since they are only meant to be required in abnormal cases. Right now, we ask people to fill out a Google Form initially to set up their rules, but in production it would be part of a user's profile on a credit card's website. Part of the form that we used is shown in Figure 4-2. The form will use the name of the elderly person who is being monitored.

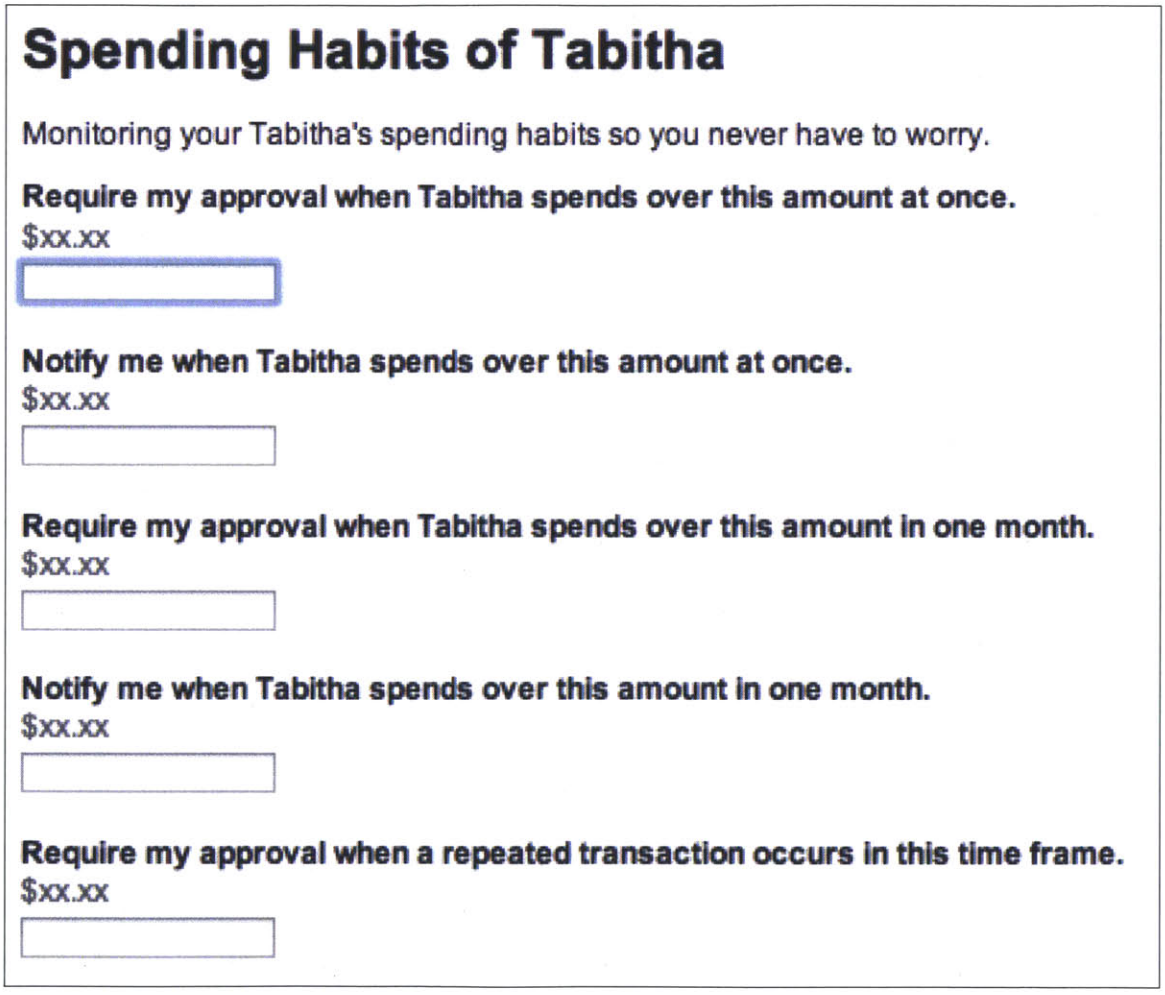

Figure 4-2: Part of the form to be filled out by Mary in our example to monitor Tabitha's spending

In the rest of this section, we describe the options people can choose from when deciding how to monitor their elderly's spending.

4.3.1 One-Time Spending Limit

A limit can be set on spending per purchase. For example, if Mary believes her mother should not ever need to spend more than $100 on any specific purchase, and knows that she never spends more than $300 on any purchase, she can set some restrictions. Mary can set a rule saying that the agency should notify her via SMS if her mother ever spends more than $100, and a rule that the agency should require her approval if her mother ever spends more than $300. The approval process is similar to the approval process described for a repeated transaction later in this section.

4.3.2 Monthly Spending Limit

Mary may also want to set monthly limits on her mother's spending that parallels the individual purchase spending limits. Mary can set a rule that if Tabitha spends more than a certain amount per month, Mary will be notified so she can check into her mother's spending habits if they are not consistent with her expectation.

4.3.3 Location Limits

As stated previously credit card companies look at the location of a purchase to determine whether or not it is potentially fraudulent. However, if a transaction occurs twenty miles away from the home of the consumer, the agency will likely think nothing of it. This makes sense from the company's point of view, since statistically speaking it is likely not a problem. However, if someone knows that her elderly parent will not be leaving the house and wants to make sure that purchases are not occurring more than five miles away from a certain location, then she has no way to set that restriction. However, we propose a parameter that allows a caretaker to set a radius on spending, so that any transactions that occur more than a certain number of miles away from the home address will cause a notification to be sent to the caretaker informing her of the unexpected charge.

4.3.4 Repeated Transaction

Another problem we hope to address is some amount of short term memory loss. We hope to combat it with a check for repeated transactions.

Identifying a Repeated Transaction

We define a repeat transaction as a transaction that has occurred sometime in recent history. To determine if something is a recent transaction, we must look at the time and the transaction. Firstly, we must determine what time frame makes something recent, then we must look to see if the purchase is the same. We let the custodian define *recently* by allowing them to set the timeframe which is recent, whether it be the past hour, the past day, or something else.

Then we must determine if the transaction is the same as any transaction made in the now defined *recent history.* This would be easy to do if we had a log of every item purchased in recent history. However, we are looking at the transactions from the agency. The agency will only have data about what company a purchase was made from and the amount spent. There will be no itemized receipt or something that clearly shows exactly what the purchase is. Thus, to define a transaction, we use the data that the agency will have: the company from which the purchase was made, and the amount transacted (i.e. $25 to Wal-Mart).

While we accept that there is a possibility that an elderly person may make a purchase from the same place for the same dollar amount while buying different items, we believe that the probability is low enough to be insignificant. We also anticipate that the caretaker will not define *recent* as a long enough time frame that the same regularly made purchases fall within the same time frame.

Hence, if a custodian has requested a check on recent purchases, when a purchase is made, the agency will look through recent purchases to see if the same transaction has been processed recently and respond as appropriate.

4.4 The Check at the Agency

At the agency, we run a check to decide what to do with a specific transaction. In Figure 4-3 we show the check that would be run to determine if the purchase is repeated. We will run similar checks to see if the purchase passes its one time spending limit, monthly spending limit, location limit, or any other rule.

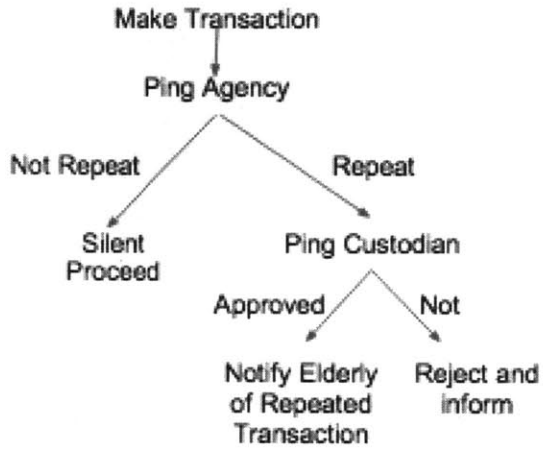

Figure 4-3: Logic to be followed to determine what to do with a repeated transaction

Using the logic in Figure 4-3, the agency will check if the transaction is a repeat transaction. If it is, the user will receive an SMS saying *A repeat transaction has taken place. Would you like to continue?* If the person says *No*, then the transaction will be cancelled. If the person says *Yes*, then the custodian will be notified, and the custodian's approval will be requested. The custodian will see a dialog on their smartphone indicating the amount being paid, and from what company the purchase is being made (such as Amazon.com or Wal-Mart). An example is shown in Figure 4-4.

The dialog has two options *Yes* and *No*. If the custodian does not approve the transaction, the elderly person will be notified that the transaction has not been approved. Else, the transaction will proceed as expected.

The message will in the dialog will be based on the rule that is broken, so it will change depending on which rule is broken. For example, if the elderly person makes

Figure 4-4: Dialog a custodian will see when a repeated transaction is detected

a purchase that is more expensive than her usual spending and breaks a one time spending rule, her caretaker may see the message as shown in Figure 4-5

4.5 Reducing Fraud

We believe this system may complement fraud detection. Sometimes fraud detection produces false positives. For example, Skype processes its charges in Luxembourg, which occasionally causes debit or credit cards to reject the charges because they are coming from a foreign location. People have to rectify the situation, sometimes by calling debit or credit card company to confirm that they have made the transaction. This can be a hassle for the elderly (or anyone). Also sometimes fraud detection will produce false negatives, such as if someone takes my mother's card and uses it in a neighboring state. That will likely not cause my fraud detection system to notice something suspicious, but it is a problem nonetheless. If in either of these situations, my notification system notifies me of the transaction, I can attend to the issue rather than cause my mother problems. Thus, the my elderly parent is not inconvenienced while the bank is doing their job of acting on suspicious activity.

Figure 4-5: Dialog a custodian will see when a one time spending limit has been exceeded

Because of the way this system has been set up, I can put a limit on the radius of where purchases can come from, and outside of this perimeter I can request to be notified. Thus if the card is used in a neighboring state 50 miles away, and my radius is 20 miles, I will get a notification. Also, if there is a false positive, such as the Skype charge in Luxembourg, I will be notified and can act on my parent's behalf.

Chapter 5

Application for Banking in the Developing World

The third market segment we address in this thesis is people in the developing world. Many people in the developing world do not have a convenient way of partaking in personal banking. There are often no bank branches in rural areas, and thus to go to a bank, people in rural areas often must travel long distances before being able to find a branch of any bank. Banks do not want to get involved with people in the developing world because the cost to set up a branch in a rural area with not many customers is not worth the investment. Also, accountability poses to be a difficult task. Thus, we have developed a mobile application to allow people in rural areas to partake in the banking process, while by creating a low cost solution that has accountability built in to the system for the banks.

5.1 Scenario

Ganesh lives in a village outside of Charkhi Dadri in rural India. He farms cotton, which he sells to large cotton buyers every year. They come to his village twice during the harvest season, pay him a large sum of cash, and leave with his cotton. There are no banks or other convenient means to keep his money in the village, so he keeps it in a cupboard, which he locks up. He has a bank account, but the nearest bank is in

Delhi, 125km east of where he is located, and since he does not have a car, he never goes there. He has had a feature phone for the past 5 years and will probably have a feature phone for the foreseeable future.

However, there is a new SMS service that allows him to keep money in his bank account instead of locked up in a cupboard. The cotton buyers can now text a phone number with their account information, Ganesh's phone number, and the amount that they want to transfer to him. This information is sent to a smartphone that is controlled by a local person who is employed by the bank, where the transaction is then executed. A text message is then sent to Ganesh and the cotton buyer with the details of the transaction.

This is great, because Ganesh now has much less cash to worry about. Also, he can now use the same process to complete everyday transactions. He can type in his account information, the phone number of someone he is trying to pay, and the amount of money being transferred, and within moments the transaction is complete. He can use text-based tools that already exist with many banking systems to view his account information and transaction history.

5.2 Setting up the Bank Account

The first step in getting a rural community in the developing world involved in banking is helping them set up accounts with the bank. However, establishing a bank branch is costly for a bank, and is likely not worth it unless the branch will have a lot of traffic and bring in many new customers that will be moving a high volume of money. Thus we propose setting up very small and simple branches. These branches will have two local villagers who run the branch and are employed by the bank. They will have a smartphone where they will be able to deal with the bank accounts of people in their village, but will not be able to have full access to the whole banking system. Their jobs will be to set up bank accounts, and assist the villagers with making transactions, as well as being a hub for depositing and withdrawing small amounts of cash. We decided to have two bankers to ensure the other is doing his job

properly and not abusing his power.

If a local person wants to set up a bank account, they can go to the local banker. The banker will have read and write access to a database that contains at least four pieces of data: the person's name, phone number, a pin number of the person's choosing, and the amount of money currently in the person's account. At setup, this amount will be the amount of cash given to the banker from the person setting up the account. Depending on the country, there will be various methods we will use to identify who someone is. One of the mechanisms, for example, may be the Universal Identification Number, a project by the Indian government that is trying to give a unique ID number to everyone in the country.

In addition to documents, one method that we will try to use in all rural areas to identify a new customer, is getting two people known to the bankers to identify the new customer. If the bank is located in a rural community, than everyone will likely be an acquaintance, or an acquaintance of an acquaintance of the banker. Thus, everyone should be able to be identified by two known members of the community (which may be the bankers) [8]. Once the customer is identified, they will be added to the local banker's database.

For our purposes, we have simulated the bank's database with a Google Fusion Table. Our sample database is shown in Figure 5-1.

5.3 The Banking Process

Given the ubiquity of cell phones along with the lack of smartphones in the developing world, we have decided to design a bank branch that relies on a smartphone application that only needs to run on one phone, the *broadcast phone*, which will be controlled by the local bankers. The idea is that the broadcast phone can communicate with the bank's database, and the phones owned by local people will be able to communicate with the bankers' phone via SMS. This gives anyone the ability to interact with the bank as if they had smartphones, since the broadcast phone is making requests on behalf of those with feature phones.

File Edit Tools Help | Rows 1 | Cards 1 | Map of Location

Filter | No filters applied

1-3 of 3

Name	Phone	PIN	Date Created	Balance (RS)	UID Number
Ganesh Sundar	+99-9999-9999	13245	2013-06-04	900	123456789123
Venkat Raman	+99-8888-8888	1654757	2013-06-07	18000	912345678912
Shiva Subbu	+99-7777-7777	324512	2013-06-10	4000	891234567891

Figure 5-1: Fusion Table simulation of a bank database containing required information

5.3.1 Making a Transaction

There are two ways to make a transaction: one is via SMS and the other is by having the banker make the transaction.

Transaction via SMS

To make a transfer of money from one account to another, the payer must send an SMS to the smartphone that acts as a bank with the appropriate information. The smartphone sitting at the bank will always be listening for incoming SMS messages that have the following properties: a PIN number, a phone number, an amount, and an explanation. To confirm that the transaction is valid, a transaction SMS must contain the PIN number that is associated with the phone number sending the SMS. We have built our system this way so that you must have a physical device and a piece of knowledge to make the transaction. Only then will the transaction succeed. This will prevent many fraudulent charges since just having someone else's phone or knowing his pin number will not be enough for someone make a fraudulent transaction on another's behalf. This is similar to how ATMs require users to have a card and know a pin number. This whole process is shown in Figure 5-2.

The phone number contained in the SMS is the phone number associated with

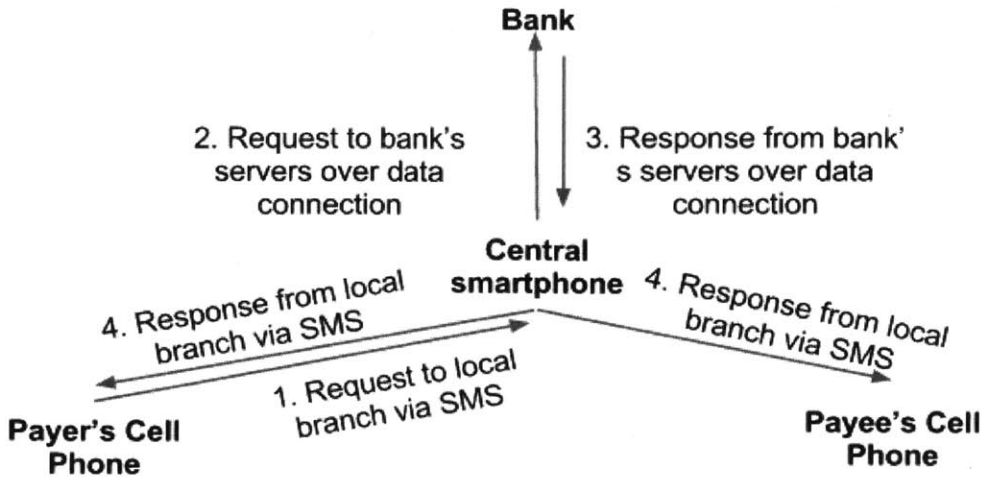

Figure 5-2: Process by which an SMS transaction is completed using our applications in the developing world

the payee's account. We decide to use the phone number since names may not be unique, but a phone number should be unique. The amount provided in the SMS is an amount of money that the payer agrees to transfer to the payee. The explanation provided in the SMS will be a reason for the transaction.

Once the SMS is received, the phone, serving in place of the bank, has an application that will parse the message and send the information to the bank's central servers, where the fate of the transaction will be decided. If the phone number that sent the message is not in the system, the application will send a message back to the payer saying *This phone number is not in the local system.* If the phone number that sent the message is in the local system then it is compared to the given PIN number. If they do not match, the payer will receive a message saying *Invalid PIN.* If they do match, then the application will check if the phone number of the payee (contained within the SMS) is in the system. If it is not, then the payer will receive a message saying *Payee's phone number not in local system.* If the number is in the system, the system will check that the amount is valid (nonnegative number). If it is not then the payer will receive a message saying *Amount invalid,* please try again.

Filter ▾ No filters applied

◀◀ ◀ 1-65 of 65 ▶ ▶▶

Date/Time	Phone	FromAcct	ToAcct	Amount	Purpose
27/06/13 12:05 AM	+99-9999-9999	+99-9999-9999	+99-8888-8888	40	Vegetables
27/06/13 11:36 AM	+99-3823-2134	+99-3823-2134	+99-5345-4234	30	scarf
27/06/13 2:14 PM	+99-1234-5678	+99-5555-66666	+99-8888-8888	497	Books
27/06/13 11:20 PM	+99-7777-7777	+99-7777-7777	+99-7777-6666	10	Babysitting
27/06/13 11:22 PM	+99-1234-5678	+99-3333-4444	+99-8888-7777	199	shoes

Figure 5-3: Database containing transactions

Else, the system will check that the payer has sufficient funds. If not, then the payer will receive a message saying *Insufficient funds.*

If all of the checks have passed, then the transaction will be executed, whereby the specified amount will be deducted from the payer's account and put into the payee's account. If all goes well, the payer will receive a message informing him that the transaction has been executed, with the details of who the money was given to, in what amount, and for what purpose, all facts provided by the payer. The payee will also receive a message saying that the payer has paid the payee the specified amount of money for the specified purpose.

Lastly, this whole transaction will be stored in a transaction history, along with the reason provided, both parties can look at all transactions involving their accounts whenever they please, using SMS-based tools that many banks already provide [5][15][1]. Our simulated transaction database is shown in Figure 5-3. To explain how current SMS-based tools work, I have included a diagram from HBSC Indonesia shown in Figure 5-4.

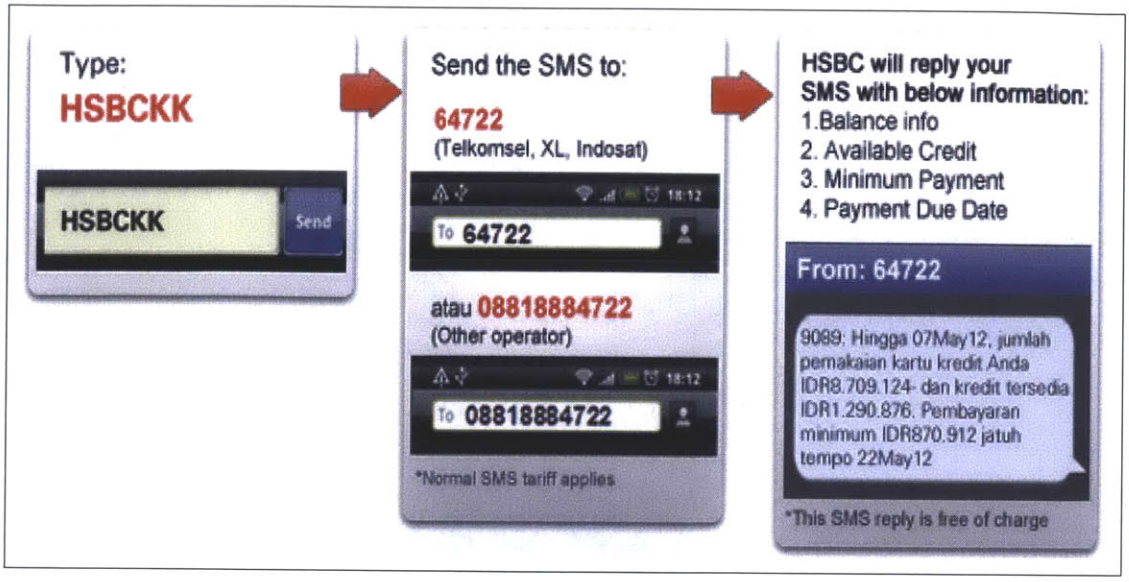

Figure 5-4: SMS interface explanation from HSBC [10]

Transaction in Person

We have also developed a method whereby people can make a transaction through the banker. In addition to allowing them to set up accounts, the bankers' smartphone application allows them to make transactions for people. They must input the phone number of the account that the transaction is coming from, the PIN number of that account, the phone number of the account that the funds are going to, the amount, and an explanation (all to be provided by the payee). The local bankers do not have read access to the database containing the PIN numbers, only write access. That means they can set up bank accounts, but not take their information. This fact, in addition to the fact that there are two bankers and not one, will prevent against many fraudulent transactions.

Once the data is inputted, the same checks as in the SMS-based version of the transfer are run on the given data. The transaction screen of the application is shown in Figure 5-5. This method is not expected to be used a lot, but exists in case someone loses their phone or has some other issue that prevents them from sending an SMS to complete the transaction. When the transaction is executed, an SMS will be sent to both parties involved in the transaction notifying them of the transaction details,

Figure 5-5: Application a Banker in the Developing World Can Use to Make Transfers from One Account to Another

as it is in transactions made via SMS.

5.4 Avoiding Illegal Transfers

In building this new application where anyone can transform money to anyone else in a system, we must be cautious to ensure we are not opening up a new way for illegal transactions to easily occur. Our first step is making sure that we know who our customers are. We try to do as thorough a job as we can to make sure we know who our customers are while making sure that we properly identify our customers, by using the means we have available to us. We have also built in authentication to the transferring process so that someone making a transfer will need the proper device and know the correct PIN number to make a transfer.

In this section, we discuss how we avoid money laundering schemes such as *structuring*, which are made to get around the checks that we have put in place. The solution, we believe, lies in tracking where money in the system is coming from. For example, if we are in a rural village that farms cotton, we know that money is only staying within that system, since people from outside the village do not generally

inject money into the system. The exceptions would be a few industrial buyers (such as the cotton buyers in our scenario), non-governmental organizations or other groups working in the area, or someone from outside the village who is sending money to someone inside the village.

Thus, we will have anyone who is external register with our local bank. If they have an account already with this bank, they can request to be registered in this local village and that way they can transfer money from their account into the local accounts. Thus, we have developed a way to move money where the source of the money is always known. The bank will be able to track where all the money in each village has come from, which will make money laundering in these scenarios difficult. We will also place a limit on the number of transactions per day and the amount that can be transferred in any one transaction, which we will determine based on what we think is reasonable in the specific area we are in.

Chapter 6

Reasons for Technical Choices

For all three sets of applications, we have a rule-based system that determines which parties to seek approval from and which parties to notify. The system is used and maintained by a service run by some intermediary and not on a device belonging to any party affected by the transaction. Also, to transmit information from one party to another, we use push notifications or the SMS protocol. In this chapter, we explain why we have made these choices.

6.1 Rule-Based System at the Intermediary

We have decided to use a rule-based system at the agency (i.e. the bank, credit card company through which the transfer or transaction is made), and not on the mobile devices of the users, to determine the type of action required. Having the logic executed in one location means that there is a lower chance of the logic being compromised, since we only need to monitor one system and not many. If it is stored on a local device, there is a probability that the device may be compromised if the user is not (or even if the user is) careful. Also, any changes to the system only needs to be updated in one location and not multiple locations, which means that two devices that are interacting will be dealing with the same system and not under different assumptions with different systems.

We also believe that allowing the agency to run software that monitors each trans-

fer or transaction makes sense because most banks and agencies already have software that monitor any account activity to determine whether or not transactions are fraudulent or illegal. Thus incorporating extra software into their already existing infrastructure to determine what to do with a transaction is not unfathomable.

In a later version of the application, we hope to have a reasoning engine that will determine if the request falls into a valid category based on the explanation and/or UPC code. However, since that involves natural language processing and machine learning that we did not feel were relevant to this thesis, we did not build our own reasoning engine. Instead, we built a system that followed a set of rules as explained earlier in the paper.

6.2 Transferring Protocols: Push Notifications and SMS Protocol

After considering various methods of transmitting messages, we chose to use push notifications and the SMS protocol to send information from one device to another.

For our parent/youth application, we decided to have the young person transmit and receive data via push notifications, since the application only runs on a smartphone. The parent can either have a smartphone and receive information via a push notification, or submit and receive SMS messages using a smartphone or a feature phone.

We chose to allow push notifications for people who have a data connection, because that makes interacting with a central server easy, since the server can push notifications easily to the phone [2]. Also, the device can always be listening for a push notification and based on the information contained in the notification know what to do with it.

For our elderly/caretaker application, we decided to have the caretaker receive a push notification if she downloads our application to her smartphone. Else, she can receive an SMS. The reasoning is the same as for the parent in the parent/youth

scenario.

However, for our application for the developing world, we decided to have the whole interaction happen over SMS, since we decided to make it work for all mobile phone users, many of whom do not have smartphones. We find that when people have mobile devices, they have SMS provided. Many people do not have a data plan or continuous access to wireless networks, so we could not rely on a protocol that requires internet access [17]. Many people have SMS services that allow for a high number of free messages to be sent. In places like India, people who pay per SMS can spend less than 2 cents per SMS sent [3]. We wanted to avoid making transaction via a phone call, because that process would require the bank to have people receiving the phone call, and then the bank will have no written proof that the payer initiated the transfer.

After thinking about the various tradeoffs, such as how many people have data plans who maybe using our application in the developing world, how much one SMS costs, and the fact that all cellphones have SMS capabilities, using SMS seemed most promising. We also looked at other tools, such as M-Pesa, to see how transfers were made, and many of those tools also used SMS [6] [19].

When someone sends an SMS, the SMS gets sent to a central forwarding service and then is forwarded. If it cannot reach the final recipient, it then tries again until the message times out. This will usually happen after three to five days. We hope that the banker's phone will be located in a place with good reception, so that it will always be easily reachable. If the banker does not have good reception, the transaction can still be made, however, it will not seem instantaneous as it would otherwise. When we tested our system, the whole transaction process, from sending a message, to checking what to do with the details, to the involved parties receiving a response, took generally less than 5 seconds, which we believed to be quick enough. If the reception was poor, then it could take up to a few minutes, which we believe is better than not working at all. Lastly, while message delivery is not guaranteed, we believe that the likelihood of failure is low enough that it can be dealt with on a case-by-case basis.

6.3 App Inventor

To build all of the mobile applications, I used MIT App Inventor, a drag-and-drop visual programming language to allow people to create Android applications. I chose this application because it is a good tool for prototyping and is a powerful tool that is easy to link to various databases.

6.4 Google Fusion Tables

To simulate the bank's database, I used Google Fusion Tables, because it is a tool that displays information clearly, and has an application programming interface (API) that allows an application to interact with it using SQL queries.

Chapter 7

Future Work

There are multiple ways to improve on the work I have completed thus far.

7.1 Natural Language Processing Reasoner

Currently, in the application designed for young people, a young person must classify his purchase into one of the categories specified. However, if there was a natural language processing engine looking at the explanation provided by the young person, then this person would not need to classify the purchase every time. Also, if the application had a way of understanding what category a product fell into by looking at its UPC code, which it will sometimes have, then there is another mechanism by which the application could classify a transfer request.

7.2 Implementation of Elderly Tools with Banks and Credit Card Companies

In this thesis, we have simulated banks and credit card companies' servers using Google Fusion tables. However, we have not had access to software that they use to mark suspicious charges. Thus, in the future, we plan to implement these checks in conjunction with a bank, to see how they may be useful to their users.

7.3 Community Banking in the Developing World

Currently, our applications focus on making banking plausible for people in the developing world. However, we have not focused our efforts on community banking in the developing world. In the future we hope to explore options to allow communities in the developing world maintain community accounts, so that they can make community purchases and maintain shared funds, while keeping track how the money is spent as well as tracking who has contributed how much money and at what times.

7.4 Tracking the Caretaker

Some elderly people have caretakers who are hired to look after them. These caretakers may be responsible for tracking the spending habits of the elderly person, and may be in charge of what the elderly person can and cannot spend on. However, we do not have a mechanism currently for tracking the caretaker, so as to make sure that she does not abuse her power. Thus, in the future, we plan to extend our system so that the caretaker can track the elderly person, and a family member can track the caretaker if the caretaker has been hired to look after the elderly person. We intend to do this by giving the family member a daily report of what all was approved and not approved by the caretaker that day.

7.5 Specialized Rules

In the future, we would like to add specialized capabilities to our applications. For example, if the caretaker of an elderly person knows that the elderly person is going to make a large purchase that will require approval, the caretaker can inform the credit card company earlier so that it can be automatically approved, much like people tell credit card companies when they are going to travel to a foreign place.

7.6 Cross-Platform

Currently our applications only run on Android devices. In the future, we would like to expand our service to all smartphones.

Chapter 8

Conclusion

Young people, elderly people, and people in the developing world are not as actively involved in their banking activities as people in other demographics. By making mobile based applications along with a rule-based reasoning system, we have built convenience around accountability.

I have developed mobile applications that allow young people to easily access funds while keeping their parents at ease because they know where and when their funds are being used. I have developed tools to let the elderly manage their finances while notifying a caretaker if something seems problematic. Lastly, I have developed mobile applications for banking in the developing world. These applications allow people to interact with a system via their feature phones, and allow a branch manager to control his branch with a smartphone.

All of these applications are built around the idea of sharing data responsibly, so that the users know where of all their data is going, and for what purpose. In the parent/youth application, the parents know what their children are doing with their money, and the young people know what details their parents know about the young people's spending habits. In the case of the elderly user, the caretaker can set rules as to what a bank or credit card company should be tracking and be able to make sure that the elderly person is not doing anything unexpected. In the developing world, especially rural areas, policies are put in place so that users can easily track all of their transactions. The policies make it such that it will be difficult to make

fraudulent charges, both from the perspective of the bankers, as well as the users.

If data is used responsibly, the ways in which it is being used is understood, and those who misuse it can be held accountable, then we believe people will be more open to sharing their data to improve their personal banking experiences. We believe that this is how people should think about data: focusing not just on *where* their data is being used, but *how* and *why* it is being used. This way, we do not develop systems with accountability built in as an after thought. Instead, we make software with accountability built into it from the start.

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