UNIVERSITY OF COPENHAGEN
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Master thesis

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Banking the unbanked

Future-proofing the least developed countries as they go from cash to online payment

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Abstract

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Acknowledgements

Acknowledge Søren and Fritz, as well as friends and family...

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1 Introduction

Financial inclusion is the ability to have access to basic banking which includes efficient and secure transactions, trusted ownership, execution of payments, safe storage of money, and withdrawal of cash. This has been defined by The World Bank to be an important building block for both poverty reduction and opportunities for economic growth [4] and is one of the focal points of many international agencies, such as the International Monetary Fund (IMF)[1] and The World Bank[2], as well as non-profit organizations (NPOs) like the Norwegian Refugee Council (NRC)[3]. By having access to these tools societies will see many benefits. In Niger, a five-month relief program swapped from a monthly payment of cash to instead use mobile money services allowing for mobile commerce (m-commerce). This change saved the recipients 20 hours on average in overall travel and wait time to obtain the payments [4]. A similar study was performed in Kenya where the change to mobile money services allowed 185,000 women-headed households to increase their savings by more than 20%, reducing extreme poverty among these households by 22%. Additionally, access to digital payments allows for easier storage and a reduction in corruption in countries where trust in the government is low [4].

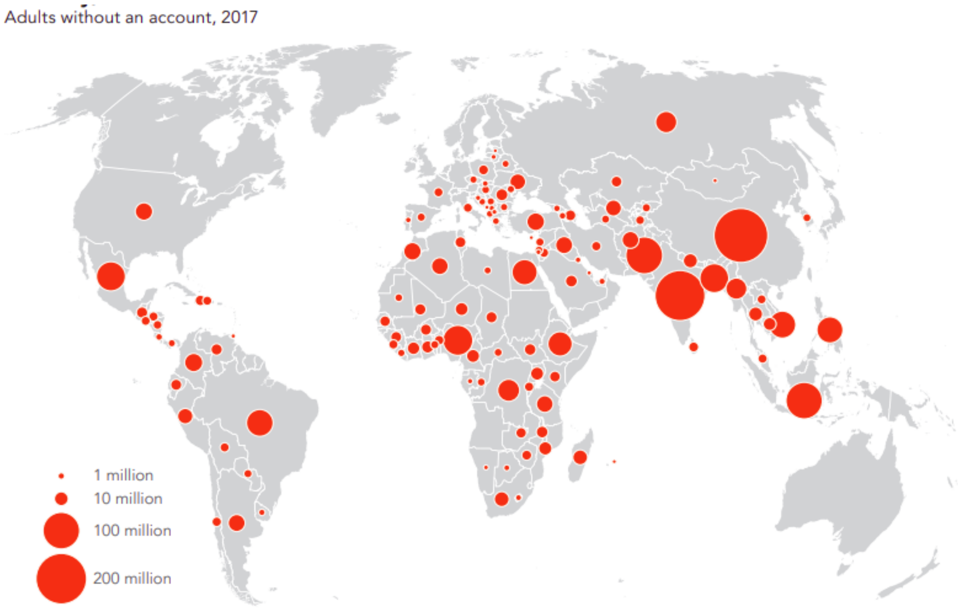

Figure 1: *The Global Findex Database*. Map of locations for unbanked adults in 2017.

[1] https://www.imf.org/en/About/Factsheets/IMF-at-a-Glance

[2] https://www.worldbank.org/en/what-we-do

[3] https://www.nrc.no/what-we-do/themes-in-the-field/cash-and-vouchers/

The Global Findex Database reports that 69% of adults in 2017 had a bank account [4], an increase of 7% since 2014 and 18% since 2011 [4]. 94% of adults in developed countries own a bank account, whereas only 63% of adults own an account in developing countries [4]. Globally, approximately 1.7 billion adults remain unbanked, with half of them living in just seven developing areas: Bangladesh, China, India, Indonesia, Mexico, and Pakistan.

When looking at developing countries and financial technology (fintech) it is important to consider what technologies are available in these areas. 1.1 billion of the financially excluded adults own a mobile phone [4], however, many developing countries have very little internet access. Our World in Data reports that for the majority of the countries in Sub-Saharan Africa (SSA), one of the least developed regions, the population with access to the internet is only between 5 and 20% [11], however for most of these countries, the mobile phone penetration rate[4] is greater than 40% [11].

Banking the unbanked is a $380 billion revenue opportunity [1] which has seen an increase in interest throughout the last decade, mainly due to the success M-Pesa has had in Kenya. M-Pesa is a mobile phone-based money transfer service launched in 2007 by the telecommunications company Vodafone Group and the mobile network operator (MNO) Safaricom. M-Pesa utilizes the Unstructured Supplementary Service Data (USSD), also known as ”quick codes”, a protocol similar to short message service (SMS) with the exception that it creates a connection allowing for a two-way exchange between the parties. Additionally, it doesn't store the messages on the mobile phone. The benefit of using USSD is that it is a feature available in both smartphones and dumbphones[5], making it available to every user with a mobile phone. With a mobile phone penetration rate of 103.769 [16] in Kenya, it is safe to assume that most of the citizens are covered.

In this thesis we will take an example-driven approach of defining the needs and requirements of a mobile banking application, as well as determine the best-suited country to onramp such a project, ensuring that the targeted country's needs, likewise, are met. When the requirements are defined we will implement a basic bank meeting these requirements, utilizing the technology that is available to them, with features that allow for any user to see the benefits of entering the mobile bank network. We will then evaluate the use cases of this product, measured up against existing mobile banks, before performing a security analysis looking at the potential attack vectors of the mobile bank. We will then discuss the implementation and reason for our choices before taking a look at the existing work done within this field which we have drawn inspiration from, as well as note what we find, could be a useful next step if this project were to be developed further. Finally, we will conclude with our findings.

[4]The mobile phone penetration rate refers to the amount of SIM cards in a certain country

[5]A mobile device without internet capacity and little computing power

2 Analyzing the needs of a banking service

2.1 The regions in need of becoming banked

Region	Account (%)	FI[6] account (%)	M[7] (%)
East Asia & Pacific	70.6	70.3	1.3
Europe & Central Asia	65.3	65.1	3.2
Latin American & Caribbean	54.4	53.5	5.3
The Middle East & North Africa	43.5	43.0	5.8
South Asia	69.6	68.4	4.2
Sub-Saharan Africa	42.6	32.8	20.9

Table 1: Financial inclusion statistics from six regions of the world, aged 15 and up [17]
.

We can from Table 1 and Figure 1 deduce that majority of the financially excluded people are located in the Middle East & North Africa (MENA) (43.5%), and Sub-Saharan Africa (SSA) (42.6%), whereas only 32.8% of the people in SSA are banked through traditional means. 20.9% are banked through mobile money accounts, showing a clear need for a fintech (financial technology) solution in these regions. There are many possible approaches to choose from when considering the implementation of a banking system, e.g. Bluetooth-based, blockchain-based, EMV cards (Debit and credit cards). To determine which approach, and which of the two regions has the best infrastructure to support the different approaches we will analyze them based on the following parameters:

- **Mobile penetration rate**

  The amount of active cellular subscriptions in the region

- **Smartphone penetration rate**

  The number of active smartphones in the region

- **Cost of entry-level internet-enabled device**

  The cost of a simple smartphone (in GDP per capita)

- **Data affordability**

  The price for 100 MB of data (in monthly GDP per capita)

- **Mobile infrastructure (Rural)**

  How well the rural parts of the regions are covered by 2G, 3G, and 4G mobile internet.

[6]Financial institution account
[7]Mobile money account

- **Mobile infrastructure (Urban)**

  How well the urban parts of the regions are covered by 2G, 3G, and 4G mobile internet.

- **Internet download speed**

- **Barriers from being banked**

- **Currently utilized banking services**

The mobile phone penetration rate was generally between 40-75% in SSA in 2017, with some countries above 80% and a few above 120% [11], suggesting that people have more than one cellular subscription. In Africa, this isn't uncommon due to several factors:

- Carriers attempt to attract subscribers with special deals, e.g. unlimited SMS, cheaper network calls, bonus monthly data plans [14].

- Costs of services matter a lot, particularly in poor countries, as such swapping between providers can be a lucrative investment [14].

- Network reception might be poor in remote areas of Africa, as such, another network might have better coverage in the given area [14].

In MENA however, the majority of countries have a rate above 100, with only a few countries, such as Iraq, around the 80s.

The smartphone penetration rate was 45% in SSA in 2018, with a projected increase to 67% in 2025. The same rate was 57% in MENA, with a projected increase to 74% [6], suggesting that a smartphone implementation might not meet the requirements that SSA and MENA currently have, since implementing such a system would cut off the majority of its potential users in SSA. An entry-level smartphone in SSA costs 4.6% GDP per capita and 2.5% GDP per capita in MENA, making these devices fairly expensive. For comparison, a similar device costs 0.8% GDP per capita in South America [2].

Internet and the cost of internet data are important factors for any implementation requiring internet, as such data affordability will have to be taken into account. In SSA, 100MB of data costs 4.3% of the monthly GDP per capita in 2017, a decrease from 2014's 8.6%. In MENA the same data is 0.7% of the monthly GDP per capita, which in 2014 was 1.2% [2]. The infrastructure to support the internet in these regions exist, but could be better. In rural Africa, the continent is covered by 22% 4G internet, 40% 3G internet, and 18% 2G internet, making 20% of rural Africa inaccessible, whereas 77% of urban Africa is covered by 4G and the last 23% by 4G. The rural parts of the Arab States, are covered by 44% 4G internet, 34% 3G internet and 10% 2G internet, leaving 12% of the region inaccessible. Quite similar to Africa, 78% of the urban Arab States are covered by 4G internet, with the remaining 22% covered by 3G [7]. Internet speeds have become better throughout the period of 2014-2017, further closing the gap being the developing countries and the developed ones. In SSA the average download speed was 0.5 Mbps in 2014, which has increased to 2.4 Mbps in 2017. Similarly, MENA has increased from 2.0 Mbps to 7.6 Mbps [2].

To summarize on the infrastructure, both regions have mobile phones available to them and a future of smartphones. SSA and MENA have both progressed well from 2014 to 2017, by providing cheaper data and faster internet. The internet is accessibility is good, with 3G or 4G covered in urban SSA and urban MENA, but with some rural areas not yet covered. With the infrastructure to support at least mobile phones, but not yet ready for smartphones, let's determine why the people aren't banked already.

Reason	**SSA (%)**	**MENA (%)**
Distance to bank	19	5
Services are too expensive	19	12
Lack of necessary documentation	18	7
Lack of trust in financial institutions	10	7
Religious reasons	4	4
Insufficient funds	51	44
A family member has an account	8	7

Table 2: Reasons for lack of financial accounts in SSA and MENA [4]

from Table 2 we can see that distance is a problem for almost one-fifth of all the unbanked people in SSA, whereas this isn't a major concern for the citizens in MENA.

Service costs are a problem for both regions, but seeing how SSA consists of a lot of developing countries with a poor GDP, it's that SSA leads this statistic.

18% of SSA lack the identification necessary to become banked, and banks are known to not take such risks. World Bank Group [18] reasons that people don't have an id due to the fee costs revolving around obtaining one. Often fees can cost upwards of 8-10 US Dollars [18], with an additional cost for travel costs and supporting documentation [18]. Additionally, lack of an id is often not a barrier in the peoples day to day life [18].

Both regions lack trust in financial institutions to a lesser degree than the previous reasons, this is understandable for both regions, particularly SSA who have had a history of corrupt governments, to this day, corruption is still at large in some SSA countries. With the COVID-19 pandemic, the trust in governments further increased due to mishandling of funds, overpricing, as well as hoarding of COVID-19 medication [13].

4% in SSA and MENA reason that religious reasons are a cause for them not to be banked. Many countries in SSA and MENA are highly religious but only a few of them list religion as a concern. Niger is a Muslim-dominant country with 98.4% of the population being Muslim [3]. Islamic finance comes with a set of rules which should be in accordance with Islamic law, particularly lending with interest is prohibited since it is deemed exploitative to earn money from interest [12].

The majority reason for both regions is the lack of funds to enter a bank, as such, to provide banking services for the poorest people in the world, the service has to be cheap, and there need to be additional reasons for them to become banked.

Lastly, 8% and 7% respectively cite that they don't have an account because a family member has one, this can be explained by the service cost of being banked, or because of financial literacy issues. In general, the amount of education in SSA is very low with some countries having less than two years of schooling on average [15]. The education level is overall better in MENA [15].

Overall MENA has very few reasons to not be banked other than the lack of funds, what hinders the region from mobile banks however is regulations. Most countries across MENA haven't allowed non-banks to launch mobile money services. [5]

SSA is already thriving with mobile bank services, particularly M-Pesa in Kenya. Many mobile network operators attempt to replicate the success of M-Pesa, utilizing their already existing mobile network to support USSD, as well as local mom-and-pop shops to act as agents providing the service of depositing and withdrawing. We reason that there are other potential means of providing a banking service with the existing technology available, however, before settling on implementation we will focus our scope on finding a specific country in SSA since the regulations in MENA prohibit non-banks from providing banking services.

2.2 Determining the best-suited country

Similar to how we determined the most-suited region, we will take an analytic approach to who has the biggest need, as well as best infrastructure by looking at the following attributes:

- Country specifics
  - Population size
  - Surface Area
  - Population density
- Financial specifics
  - GDP per capita
  - Percentage owning a financial institution account
  - Percentage owning a mobile money account
  - Percentage financially included
- Population specifics
  - Average years of schooling

- Literacy level
- Financial literacy level
- Cellular subscriptions
- Internet penetration rate
- Reasons for being unbanked

By comparing the amount of financially included with the average of the region, as well as comparing the number of mobile money accounts with the amount of financially included, we end up with just 11 countries. Notably, we have included Ethiopia due to the low amount of people within the mobile money ecosystem. The financial specifics of these countries can be found in Table 3.

Country	**M (%)**	**FI (%)**	**Financial inclusion (%)**
Burundi	0.7	7.0	7.0
Central African Republic	0.0	13.7	13.7
Chad	15.2	8.8	21.8
Congo, Democratic Republic of	16.1	15.0	25.8
Ethiopia	0.3	34.8	34.8
Guinea	13.8	14.6	23.5
Madagascar	12.1	9.6	17.9
Mauritania	4.0	19.0	20.9
Niger	8.7	9.5	15.5
Sierra Leone	11.0	12.4	19.8
South Sudan	0.0	8.6	8.6

Table 3: Financial inclusion statistics for some of the 11 most financially excluded countries in SSA

Write about the attributes and how we settled on Guinea, also mention how cash rules here.

3 Design

3.1 Determining requirements

In Guinea, two major mobile money services already exist, namely Orange Money and MTN Mobile Money, they both function similarly to M-Pesa, i.e. a user can use their mobile phone to send money to another user on the network through USSD codes. To exchange cash for e-money and vice versa they visit a local agent, typically a local shop, whereafter the exchange occurs. We identify several concerns with this method:

1. To become an agent an upfront capital is required. In the case of M-Pesa, this amounts to $1600 [9]. 2.04 times the GDP per capita in Kenya [9].

2. An agent has to be a licensed business [9].

3. Agents takes on a large role by having to register users, handle KYC (Know your customer) information and educating users.

4. Agents face a higher risk of being robbed, particularly in dangerous areas. 25% of agents in Brazil had been robbed between 2008 and 2011, losing on average $500 of their own money [9].

5. USSD is encrypted but phone network operators can view all messages, as well as swap phone numbers.

Having looked at the concerns of the existing bank services in Guinea, we will now define the requirements which are specific to guinea:

1. The product has to be different from existing mobile money services

2. The product has to be simple to negate the low level of literacy

3. The product has to be mobile phone-based to utilize the high amount of cellular subscriptions in the country

4. The product has to be widely available since 30% of Guineans reasons distance as a problem

5. The product has to be cheap to account for the 30% of Guineans reasoning that expense costs are a problem

6. The product should ideally be able to onboard people without valid identification, since 38% reason this as a problem

7. The product should either be in french, or support the three languages which more than 15% of the country speaks: Fula, Malinké, and Susu

Furthermore, we define two additional requirements to support the on-ramping of users and future of banking services:

8. The transactions happening in Guinea, and Africa, in general, is currently dominated by cash, whereas in the western world, the majority of them are done through phone applications or the internet, allowing for e-commerce and ease of payment. For this reason, we believe that two products are needed. One to facilitate the current technology of cell phones and one to facilitate the future of payments through internet devices.

9. A single-player mode has to exist, a reason to be a part of the banking services regardless of how many others use it.

Lastly, we list the important factors for consumer adoption of electronic and mobile payment systems proposed by Mallat [8], which overlap with some of the already listed requirements.

1. The product should show advantages over cash
2. The product should be convenient
3. The product should be easy to use
4. The product should be cheap
5. The product should be secure

With the problems regarding existing bank services, the requirements specific to Guinea, and the general product requirements in place, we propose a model inspired by the M-Pesa model. As per requirement 8, we facilitate two implementations, one for the currently available technology, and one for the transition from cash to internet-driven payments.

3.2 Protocol for the current generation of Guineans

To support current technology we propose a USSD channel with features similar to that of M-Pesa, Orange Money, and MTN Mobile Money with one large distinction - Any user of the service can become an agent, allowing users to exchange cash for e-money, which we will refer to as a *deposit*, similar to how a person would go to a bank and hand over cash in exchange for the amount being added to the users account balance. Conversely, a user can also choose to exchange e-money for cash. We will refer to this as a *withdrawal*. For this, the agent can choose a fee of their choosing which they can modify as they wish. For instance, if they have a monopoly in a given area they can choose whichever fee they like, however for an area with multiple agents, the fee will have to be competitive. When the user and the agent meet to start the exchange, an age-old problem occurs. Namely the problem of synchronism. Who trades first? It's a problem of trust, with no silver bullet. The common solution would be using a neutral third party, an escrow, however, the additional cost of a third person would make the service unattractive, therefore we reason that when a deposit or a withdrawal occurs, the person delivering cash trades first, in the case of a deposit, this would be the user and the agent in the case of a withdrawal. We rationalize this because we only have a history of transactions for one side of the market, namely the e-money transaction.

This modification solves several problems which we find the M-Pesa model has. Particularly, because a user can choose to become an agent at any time, with any amount of cash or e-money, they don't have to meet the capital requirements of M-Pesa. Neither do they have to be a licensed business, instead, this is a risk we, as a banking service, take. The agent's responsibilities are further reduced as they don't have the responsibility of onboarding other users. Lastly, it is up to the agent and the user to settle on a meeting place for the exchange. Ideally, they settle on a public place to reduce the risk of theft, whereas, if they leave an agent-approved store of M-Pesa, they become an easy target.

This modification additionally meets several of the seven requirements we listed above. 1) It's a modification of an existing product. 2) USSD can be difficult at first but given the limited user options and the fact that all options have to be available on a simple cell phone, the actions required by the user are fairly simple. This, however, is one of the reasons why we also facilitate a second implementation, which we will discuss in the next subsection. 3) The USSD technology is available on all devices utilizing the Global System for Mobile Communications (GS M), which is the most common mobile communications standard. 4) Where the M-Pesa model utilizes brick-and-mortar stores, this model allows for an agent to be an agent anywhere and to meet with users wherever they desire. 5) Two fees play a role in the expenses of this model, one is the agent fee, and the second is the network fee. The agent fee will eventually settle at a low due to market competition, potentially even free if the agent so desire, or if the user can't find a reasonable agent for a deposit, they can take on the agent role of delivering cash for e-money, essentially trading speed for a larger deposit since the user now has to wait for a counterparty willing to exchange with the user. Network fees can be applied, or we as the bank service provider can take the NPO approach of not taking a fee. 6) Lack of identification is one of the biggest deal-breakers and a topic of interest for many researchers worldwide. Luckily there are multiple ways to allow the registration of people without identification. One proven method is to utilize a user's phone data and assess the user based on that, this method is currently utilized by Tala[8], a company allowing for the people without a lack of identity to apply for loans. The lack of identification is a problem for traditional banks, it can however be less of a problem for mobile bank services, depending on how risk-averse they are. A study from 2010 showed that the average balance on M-Pesa accounts were \$2.7 [10], suggesting that the GDP per capita in Kenya was low, but also that most transactions can be considered micropayments (¡ \$1), allowing the banking service to take a higher risk. 7) Supporting multiple languages is fairly simple, we reason however that at the beginning of its lifespan, a single language is enough to determine whether the product will succeed or not. 8) the USSD protocol can support the current generation, however as the digital divide lessens between SSA and the developed world, internet-enabled devices need to take the charge to allow for a better user experience, better user interface, better access for the illiterate and to allow for e-commerce. 9) Lastly, we argue that single-player features have to exist. The protocol has several in mind but require partnerships with existing companies, stores, or governments to carry out. These include paying bills, buying airtime, which is the credit used for utilizing mobile phones, or paying at local stores.

[8] `https://tala.co`

3.3 Protocol for the future generation of Guineans

To support the transition from cash to online payment we propose an android application that acts similarly to that of the USSD protocol explained in the previous subsection. By utilizing an android application we can develop better user interfaces, supporting the needs of the most illiterate people of Guinea. Furthermore, as e-commerce and m-commerce increase as the digital divide is reduced, an internet-enabled application needs to be ready to support these features, allowing any user to see what they purchased, when they purchased it, and for how much.

3.4 Features

In total, these protocols will in their basic states allow for 12 features. Here we will list and document how they function through example. Each option starts by either dialing the USSD service code or having logged into the smartphone application.

1. **Transfer money** Alice wishes to send 10 Electronic Guinean Franc (E-GNF) to Bob. Alice enters the amount, followed by Bob's phone number. Alice is then prompted to confirm the transfer before finally receiving a receipt for the transfer.

2. **Request money**

   Alice wishes to receive 10 E-GNF from Bob. Alice enters the amount, followed by Bob's phone number, and if Alice wishes, she can add a reason for the request. Bob then receives a notification through SMS, the android notification system, or through a network-initiated USSD message. Bob can then choose to accept or decline the request.

3. **Deposit money**

   Alice wishes to deposit 10 Guinean Franc (GNF) in exchange for E-GNF, when starting the flow, Alice is presented with a list of agents who is willing to make the exchange. Alice chooses the best-suited agent and accepts their fee charges. Alice receives a confirmation message and a pending transaction has been made. The agent receives a notification notifying them about the pending deposit. We encourage the participant delivering cash to trade first throughout several steps of the flow as the mobile bank service only has an insight on the other half of the transaction. When Alice and the agent have contacted each other and settled on a place to meet, Alice will hand over the cash, where after the agent will confirm the pending transfer.

4. **Withdraw money**

   Alice wishes to withdraw 10 GNF in exchange for E-GNF. Alice goes through a list of agents willing to complete this exchange. Alice chooses the best-suited agent and accepts their fee charges. The agent receives a notification about the pending exchange. Both parties can start contact with each other to determine a meeting place to complete the transaction. When the exchange occurs, we encourage the agent to deliver first for the same reasons as mentioned in the deposit money case. When Alice has received the cash, she confirms the pending transfer.

5. **View transaction history**

   All users can see their transaction history, which for each transaction, lists the amount, the sender or recipient, the status (pending, completed, or declined), the completion date, and the type (transfer, request, withdrawal, deposit). Due to the character limitations of the USSD protocol, only five transactions can be seen at a time.

6. **Confirm pending transactions**

   To confirm a pending transaction, the USSD user will see a list of pending transactions when the option is entered. The user can then enter the id of the transaction before confirming the confirmation by entering their personal PIN code.

   On the android application, the user can instead do this directly from a fold-out option in their transaction history.

7. **Decline pending transactions**

   Similarly to confirming a pending transaction, the user will be able to see a list of pending transactions and enter the id to decline the pending transfer. This will not require the entering of a PIN code as the action does not involve the transfer of money.

   The decline option can similarly to the confirm option be found in the transaction history of the android application.

8. **View balance**

9. **Enable/disable becoming an agent delivering cash**

   If Alice wishes to deliver cash in exchange for e-money, they can sign up as an agent. In this flow, they note how much cash they are willing to exchange in a single transaction, as well as their fee for the service. Now when anyone else wishes to deposit or withdraw, they can request Alice as their agent. To disable this, Alice can use this option again which will immediately disable Alice's agent status.

10. **Enable/disable becoming an agent delivering e-money**

    Similar to how a user can sign up as an agent delivering cash, they can do the opposite of delivering e-money.

11. **Request help**

When entering the help menu option, the user is met with an input field and a description, requesting them to ask a question before pressing a button to submit the question. As we don't know which problems will occur, we leave this open-ended, such that we can determine what issues typically arise.

12. **Register account**

    Registering an account consists at its core of connecting the phone number to an account. To do this we ask for the user's phone number if they're using the android application, and their PIN code.

with an additional thirteenth and fourteenth for the android application of logging in and out of the service. This is not needed for the USSD protocol as the phone number is sent with the request.

4 Implementation

This implementation is a proof of concept that implements the before-mentioned features, and fulfills the requirements previously discovered. In this section, we will explain the architecture behind the USSD protocol, the android application, and the server that combines them. The complete architecture can be seen in Figure 2

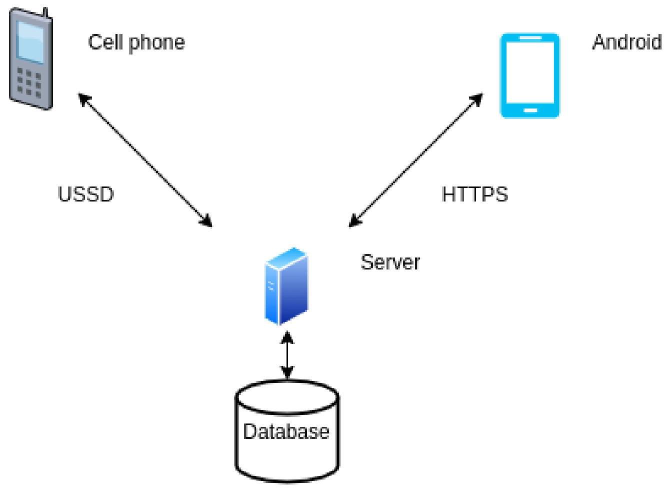

Figure 2: Software Architecture for a proof of concept covering USSD and internet transactions through an android application.

4.1 Server

We have implemented a fault-tolerant C# HTTP server which allows for multiple asynchronous connections at a time. This server supports the default operations of

GET, PUT, PATCH, POST, DELETE. The server has the features mentioned earlier implemented, with each of the actions involving transaction of money, unit tested to ensure correctness.

4.1.1 Database

For simplicity, we have created a memory-only database. This database consists of three tables, the user table with the database schematic available in Table 4, the transaction table, with schematics available in Table 5, and the question table, with schematics available in Table 6. As this database is stored in memory, it does not uphold the ACID properties.

User	
Column	**Data type**
ID	Integer
Phone number	Integer
ActiveAgentEMoney	Boolean
ActiveAgentCash	Boolean
EMoneyFee	Decimal
CashFee	Decimal
MaxAmountEMoney	Decimal
MaxAmountCash	Decimal
Pin	Integer

Table 4: The database schematic for the user.

Transaction	
Column	**Data type**
ID	Integer
From (User_ID)	Integer
To (User_ID)	Integer
Amount	Decimal
Fee	Decimal
Type	String
Status	String
Reason	String
Complete_time	DateTime

Table 5: The database schematic for a transaction.

Question	
Column	**Data type**
ID	Integer
From (User_ID)	Integer
Q	String
Asked_time	DateTime

Table 6: The database schematic for a question.

4.1.2 USSD API

A USSD request is sent by the mobile network operator as a POST request with the following parameters:

- **networkCode**

  This won't be relevant as we only operate on a single network.

- **phoneNumber**

  The phone number of the user starting the USSD session

- **serviceCode**

  The code the user has to call to start the USSD session

- **text** or **input**

  The input the user has entered, each step of the process separated with *. It's a text when it only includes integers, otherwise, it is parsed as an input. A text could look as such: *11*15*5*, and input could look as such: *1*please help me transfer money*.

- **sessionId**

  The unique id of the session created when the user called the USSD service code.

When developing to support USSD we will mainly utilize the *phoneNumber* and the *text*. When a user connects to the USSD protocol, they need to be met with a list of possible actions. As such, when the *text* string is empty, we return the following list in string format, such that dumbphones can parse it:

```
"1 - Help \n"+
"2 - Check balance \n"+
"3 - List transactions \n" +
"4 - Transfer money \n"+
"5 - Request money \n"+
"6 - Deposit money \n"+
"7 - Withdraw money \n"+
```

```
"8 - Confirm transfer \n"+
"9 - Decline transfer \n"+
"10 - Deliver e-money \n"+
"11 - Deliver cash \n"+
"12 - Sign up";
```

By parsing the text input and splitting the inputs we can map the first input to an action on the list. From here we can either continue the process by returning *"CON"* followed by the description of the next page. Otherwise, we use *"END"* followed by the result of their action, e.g. their balance. For each input required by the user, a new description is required. From Figure 3 we can see a complete USSD request for a transfer. If the input in the request is valid and parsable, i.e. the amount of a transfer is greater than 0, the recipient exists, etc. The transaction occurs.

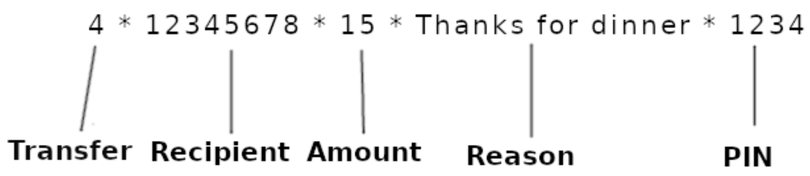

Figure 3: The input variables and their meaning of a complete USSD request

4.1.3 Android API

4.2 Android

5 Evaluation

5.1 subsection name

6 Discussion

6.1 Related work

The concept of mobile banking was first introduced in ... by ... It wasn't until the success of Vodafone Groups M-Pesa in 2007 that the world realized the potential that utilizing existing technology to allow for banking opportunities could lead to a major positive impact on the least developed countries, as well as a major business opportunity. Since 2007...

6.2 Future work

6.2.1 Pre-commit

The implementation for requests, withdrawals, and deposits currently works in 3 stages.

1. A request is made for one person to send money to the other.
2. the requested person and the requesting person meet and trades the cash.
3. The requested person confirms the request in 1.

This implementation does not take into account whether the requestee has the funds to finish the transfer. A pre-commit would be in order to prove that there is a sufficient amount of funds, thereby reducing theft opportunities.

6.2.2 Blockchain / Distributed Ledger technology

From section xx we determined that an E-money license costs xx, due to the unregulated nature of cryptocurrency it might be easier to work with cryptocurrencies instead. There are additional benefits to this.

1. Stablecoins (cryptocurrency typically pegged to the US Dollar) can allow for people in fluctuating economies to enter a stable one.
2. Cryptocurrency is currently a popular means of investing and is being sought by multiple people.
3. Cryptocurrencies allow for easy cross-border transfers.
4. No single point of failure as the data on a distributed ledger is shared between multiple nodes.

The drawbacks however include an increase in fees to countervail the transaction fees of the network, as well as the unknown future and regulations of cryptocurrency

7 Conclusion

References

[1] ACCENTURE. Billions of reasons to bank inclusively.

[2] BAHIA, K. State of mobile internet connectivity 2018.

[3] CONRAD HACKETT, ALAN COOPERMAN, K. R. The future of world religions: Population growth projections, 2010-2050.

[4] DEMIRGUC-KUNT, A., KLAPPER, L., SINGER, D., ANSAR, S., AND HESS, J. *The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution*. 04 2018.

[5] GSMA. Opportunities and challenges for mobile money in the middle east and north africa: What the data is telling us.

[6] GSMA. The mobile economy 2020.

[7] INTERNATIONAL TELECOMMUNICATIONS UNION. Measuring digital development - facts and figures.

[8] MALLAT, N. Exploring consumer adoption of mobile payments—a qualitative study. *The Journal of Strategic Information Systems 16* (12 2007), 413–432.

[9] MARK FLAMING, CLAUDIA MCKAY, M. P. Agent management toolkit - building a viable network of branchless banking agents.

[10] MAS, I., AND RADCLIFFE, D. Mobile payments go viral: M-pesa in kenya. *Journal of Financial Transformation 32* (03 2010), 169–182.

[11] MAX ROSER, H. R., AND ORTIZ-OSPINA, E. Internet. *Our World in Data* (2015). https://ourworldindata.org/internet.

[12] ROSS, M. L. Working with islamic finance.

[13] TRANSPARENCY INTERNATIONAL. Cpi 2020: Sub-saharan africa.

[14] UMEH, E. Three reasons why african mobile connectivity is misleading.

[15] UNDP. Human development report 2020.

[16] WORLD BANK. Mobile cellular subscriptions.

[17] WORLD BANK. The little data book on financial inclusion 2018.

[18] WORLD BANK GROUP. Global id coverage, barriers, and use by the numbers: Insights from the id4d-findex survey.

Appendices

A Source code

A.1 Server

A.2 Server helper classes

A.3 Android application

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