Developing Blockchain Powered Financial Inclusion Model for the Unbanked Population of Ethiopia

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Abstract

Financial inclusion refers to the delivery of affordable and usable financial access for unbanked and underbanked people. According to a World Bank report [6], there are approximately 2 billion individuals who lack financial access and an additional 1.5 billion individuals who are underserved by the financial service industry. Out of the total 2 billion, 2.1% (i.e., approximately 42 million adults) are in Ethiopia. This number is too big to ignore. This paper tries to solve some of the barriers to financial inclusion mainly lack of interoperability, high cost and high-risk. Its main objective is developing financial inclusion model for the unbanked population of Ethiopia using distributed ledger technology. Design Science Research Methodology (DSRM) has been used throughout the study. As a proof-of-concept, a prototype was developed using open source blockchain software. The prototype was evaluated by experts with relevant knowhow and experience.

Keywords: Financial Inclusion; Digital Wallet; Digital Currency; Blockchain

1. Introduction

Ethiopia is one of the highly unbanked nations. Since the liberalization of the banking industry in 1996, there has been continuous increase in the number of banked population in Ethiopia. However, we should not be complacent of this achievement as still millions are unbanked. According to a World Bank report in 2014 [6], about 41 million adults in Ethiopia are unbanked. According to [11], one of the primary impediments to providing financial services to the poor through branches and other bank-based delivery channels is the high costs inherent in these traditional banking methods. Research made by Bill & Melinda Gates foundation [11] explicates that using confidential cost and revenue estimations provided by three service providers in Africa, one in Asia, and three in Latin America, it is found out that agent banking does improve the economics for these institutions compared with branches, especially for high-transaction, low-balance accounts that are common among poor users. Though Mobile and Agency Banking in Ethiopia have been contributing a lot to financial inclusion, there are still many barriers [2, 3, 4]. Lack of interoperability, high cost and risk are the main interests of this paper. High mobile phone penetration rate was found out to be the most important potential for the development of mobile banking in Ethiopia [4]. Gallo *et al*. [1] assert that a financial transaction that is highly valued by the unbanked and underbanked is money transfer, whether within a country (i.e., internal payments) or across national borders (i.e., cross border payments). In recent years two important trends are fueling the payment industry: mobile payments and the rise of the blockchain. Thus this paper focuses on developing blockchain-powered financial inclusion model for the unbanked population of Ethiopia.

In line with this, the main objectives of this paper are to:

- explore the potential of blockchain,
- explore how to develop best blockchain-based model for financial inclusion,
- develop Blockchain Powered Mobile and Agency Banking Model, and

- develop and evaluate a prototype using open source blockchain software.

2. Background and Related Work

2.1 Background

Banks and Micro Finance Institutions have been trying to reach the unbanked population of Ethiopia through branches and branchless banking. Henok Arega [4] states that unlike some successful attempts which use Telco-led mobile and agency banking service such as MPesa of Kenya, Ethiopia's mobile and agency banking has not been much successful mainly because of interoperability issue as Ethiopia uses bank-led model. Samman [15] describes that globally 38% of adults remain unbanked. Yet among the survey respondents who do not have an account, only 4% said that the only reason for not having one is that they do not need one. The major reasons include lack of identity, regulations, no banks, cash instead of digital payments and high costs and fees. According to [10], many banks and financial entities envision the blockchain as delivering value to their customers in the form of reduced fees, faster funds transfers and simplified processes. The same research further explains that much less heralded, but potentially far more dramatic, is the transformational impact blockchain could have on the world's massive unbanked population. Among many other uses, blockchain could bolster these efforts by becoming the backbone to open the closed-loop mobile money services. Right now, many of the mobile banking services offered by banks and micro finance institutions are not interoperable. But blockchain could expand interoperability to link these fragmented, closed loop services both domestically and internationally. Swan [9] predicted that blockchain could be the Fifth Disruptive Computing Paradigm following mainframe, PC, the Internet and mobile phone and social networking.

2.2 Blockchain Technology

At a very high level, blockchain is a decentralized ledger, or list, of all transactions across a peer-to-peer network. This is the technology underlying Bitcoin and other crypto currencies, and it has the potential to disrupt a wide variety of business processes [8]. If the Internet is the foundation for digital innovation of all kinds, blockchain technology is the underpinning of a radical rethinking of how we pay for things—as well as how we verify who owns what and who has the right to buy and sell it [7]. Five components that make up blockchain are: blockchain database, cryptographic tokens, peer-to-peer (P2P) network, consensus formation algorithm and machines/nodes and programming language.

The creator of BitCoin Nakamoto [5] defines blockchain electronic coin as a chain of digital signatures. Each owner transfers the coin to the next by digitally signing a hash of the previous transaction and the public key of the next owner and adding these to the end of the coin. A payee can verify the signatures to verify the chain of ownership.

2.3 Related Work

To the best of our knowledge, no research on blockchain technology has been undertaken in Ethiopia. Voorhies *et al*. [13] conducted a research with the objective of fighting poverty profitably by transforming the economics of payments to build sustainable inclusive financial systems. They stated that blockchain can play a crucial role in fighting poverty profitably. Baruri [7] investigated how financial institutions (FIs) are using blockchain to foster financial inclusion. The paper identified four ways FIs are using blockchain to foster financial inclusion: blockchain-powered economic identity, inclusion through blockchain-powered remittance service, blockchain-powered services for refuges/migrants and blockchain-powered digital identity for citizens in poverty. Gallo *et al.* [1] mentioned two important findings from their research on blockchain First, they suggested that when regulating blockchain and virtual currencies, it may be to the benefit of regulators to engage with financial institutions early and be part of the innovation process, tailor Know Your Customer (KYC) to the risk profile of the unbanked to facilitate

adoption, and apply principled based approaches given blockchain's ever changing nature. Second, FIs using blockchain for internal and cross border payments can lower the costs, shorten settlement time and provide a better user experience.

Probably one of the thorough researches made is by Bill & Melinda Gates Foundation. This research [12] developed what they called the "Level One Project Guide" with the objective to create a more level-playing field to establishing national digital financial services system which benefits everyone – the poor, bankers, mobile operators, payment technology companies, the government and more. The research details important requirements to meet the objective mentioned before. The research suggests that blockchain can be used to move digital assets of all kinds, including fiat currencies. This could be used as an alternative to current transaction switching and settlement models. In theory, it could also be used to lower the costs of providing these functions. The authors found out that blockchain fulfills many of the criteria mentioned in the key findings of the Level One Project Guide. Moreover, Ethiopia can benefit from latecomers' advantage as it hasn't invested a lot on its payment system.

3. Methodology and Approach

The methods employed in this study are literature review and questionnaire followed by interviews. These methods are used to understand the interest of FIs in Ethiopia, in particular commercial banks and MFIs, in regards to blockchain-powered financial inclusion. Also, how the solution is viewed in the eyes of regulators such as National Bank of Ethiopia (NBE) is studied. Moreover, the view of technology service providers was taken into account. Purposeful sampling was used as it is required to reach respondents to address specific purposes related to the research questions. Design science research approach was adopted. Thus important findings from literature review, questionnaires and interviews were taken into account in designing the proposed model.

4. Data Collection, Analysis and Model Design

4.1 Data Collection and Analysis

We distributed questionnaires followed by interviews to 9 commercial banks, two MFIs, one technology service provider and the National Bank of Ethiopia. The respondents gave important ideas based on their knowledge and experience. However, we also noticed that the technology is new to most of them and challenging to some of the respondents.

4.2 Data Analysis and Model Design: Expected Functionalities

Consistent with the recommendations in [12], our findings indicate important features. In general blockchain-based systems can be permissioned or permissionless. Our findings show that the system to be designed be permissioned rather than permissionless. Most respondents chose permissioned blockchains considering the current regulation in the country. However, we found out that there are more compelling reasons as explained in [14] such as limited capacity. For instance BitCoin (a permissionless blockchain) currently supports around 300,000 transactions per day compared to the Visa network which currently handles 150 million transactions per day in the USA. The result of questionnaires/interviews and literature review also point out that the system to be designed be open-loop, be capable of immediate funds transfer, effect push rather than pull payments, enable same-day/real-time settlement, adhere to open international standards, have irrevocable transactions (called immutability in blockchain), have shared fraud service, use tiered KYC and be governed by its direct participants. As to whether to use value-added or not-for-profit/cost recovery model, the cost recovery model was chosen by most respondents. It was also found out from interviews that the system should have regulatory support of tiered KYC and interoperability. Interoperability is currently a requirement by NBE.

According to NBE directive [17] only financial institutions that are licensed by NBE are allowed to

engage in mobile banking services. Hence, FIs shall form consortium for the permissioned blockchain. The same directive stipulates that FIs can carry out mobile banking through their agents. Therefore, we propose involvement of other interested parties (as agents) so that ubiquity can be achieved easily. The use of Ethiopian Postal Services offices as cash-in and cash-out outlets will be highly beneficial.

To achieve ubiquity for the unbanked, any FI in the consortium or its designated agents should be able to provide cash-in and cash-out services. Moreover, the system shall have one common name say "bitBirr System" and each FI can create branded digital wallets to use on the system. Any FI in the consortium should also be able to recruit agents.

Under this system, FIs will deposit cash as collateral with NBE in exchange for NBE-issued digital currency. However, to avoid inflation due to the injection of digital asset, equivalent flat currency shall be removed from circulation by NBE. NBE starts the genesis block and issues the digital asset bitBirr. FIs can then transfer bitBirrs from their accounts to the digital wallets of users and agents by accepting fiat currency. Agents also use digital wallets and give cash-in and cash-out service using the same network. The same wallet can be used to purchase items.

The following steps summarize the processes discussed above:

1. FIs form Consortium including NBE, agree on blockchain parameters and rules, install/configure blockchain, join the peer-to-peer network. NBE is granted all permissions but can be revoked later based on the agreement of the Consortium.
2. FIs deposit cash as collateral with NBE in exchange for NBE-issued digital currency – bitBirr - after agreed permissions are granted.
3. FIs recruit agents and transfer bitBirrs from their accounts to the digital wallets of agents by accepting fiat currency (Birr) after agents are granted agreed permissions.
4. FIs and Agents transfer bitBirrs from their accounts to the digital wallets of users by accepting fiat currency (Birr) after users are granted connect, send & receive permissions before receiving bitBirrs.
5. Users transfer money among themselves.
6. FIs and Agents transfer bitBirrs from their accounts to the digital wallets of merchants by accepting fiat currency (Birr) after agreed permissions are granted to merchants.
7. Users purchase items using their wallets.
8. Merchants transfer money among themselves.
9. Users Cash-in and Cash-out at FIs or Agents

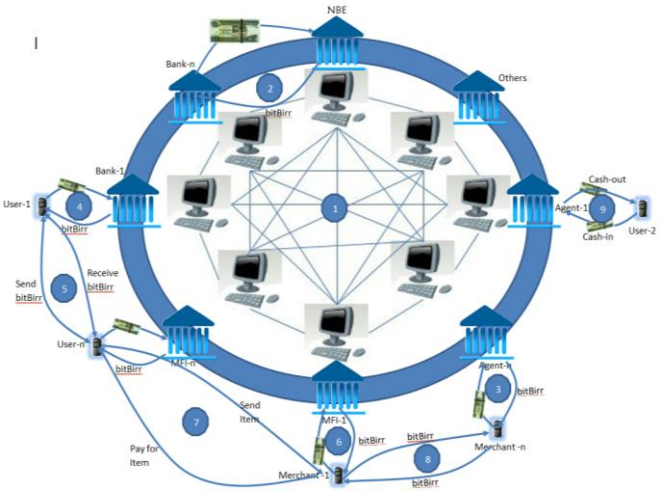

Figure 1: Processes in the bitBirr System

There are basically eight types of permissions in permissioned blockchain. Three of these (connect, send and receive) can be considered as low risk. Users who obtain them can only connect to the blockchain and transact on their own behalf. Three more (issue, create and activate) are medium risk, because users who obtain them can respectively issue assets (e.g., bitBirr), create streams, and manage other user's low risk permissions. Two final permissions (mine and admin) can be considered as high risk – nodes with mine permissions participate in the consensus algorithm, while those with admin permissions can modify all other permissions for users. The purpose of a blockchain is to create decentralized databases, which are not under the control of any individual party. Therefore, it is natural and necessary to extend this philosophy to the

administration of permissions. For all medium risk and high risk permissions, a blockchain can be configured so that individual administrators are unable to change those permissions on their own. Instead, a certain proportion of the administrators have to agree before the permissions change takes place, with the proportions defined by the admin-consensus-blockchain parameters such as 60% of the admins have to agree.

Ttable 1 is a summary of suggested permissions of each participant (responsibility matrix) in the blockchain network based on our findings.

Table 1: Responsibility Matrix in the Blockchain Network

Participant	*Permission*	*Remark*
NBE	Connect, send, receive, issue	Admin-consensus-* and other parameters such as mining diversity and mining turnover have to be agreed by participants.
FIs	Connect, send, receive, create, activate, mine, admin	
MFIs	Connect, send, receive, create, activate, admin	MFIs can also mine provided they have reliable Internet links. Otherwise, it will affect the consensus mechanism.
Agents	Connect, send, receive, activate	
Merchants	Connect, send, receive	
Users	Connect, send, receive	
Others	Connect	Others such as Ministry of Communication and Information Technology

Each user in the system will have private/public key pair as unique identification of the wallet (customer). However, it is also necessary to know who the owner of a certain public key is in the system. In the current situation of Ethiopia, there are no unique identifiers of customers such as national identification cards for KYC purposes. Therefore, mobile phone numbers are suggested to be used as main identifier of customers. But, there must be a way to map these telephone numbers to public key addresses of the wallets and to accounts (if available) on core banking systems. The public key may be used in text or QR code format. Table 2 shows example mapping of addresses:

Table 2: Mapping of Addresses

Public Key	*QR Code*	*Telephone Number*	*Account Number (if any)*
1Chq2vqES4LqiLjvNeQLt33CjafmYqJYQM		+251911225210	

There are many ways to store private keys safely [16]: desktop wallets, mobile wallets, online wallets, hardware wallets and paper wallets. Wallets store the private keys to access a public address and spend funds.

4.3 The Proposed Model

Based on the functional requirements identified using conceptual data from literature review and empirical data from questionnaires and interviews, the proposed model has five layers.

a. The Presentation Layer

The presentation layer is the interface where users interact with the system and have wallets which could be desktop, mobile, online, hardware or paper wallets. Antonopoulos [16] states that at a high level, a wallet is an application that serves as the primary user interface. The wallet controls access to a user's money, managing keys and addresses, tracking the balance, and creating and signing transactions. More narrowly, from a programmer's perspective, the word "wallet" refers to the data structure used to store and manage a user's keys. Based on the type of clients, wallets can be Simplified Payment Verification (SPV) or Full-Node. Participating FIs have to run Full-Node Wallets. Antonopoulos [16] further explains that although nodes in the bitcoin P2P network are equal, they may take on different roles depending on the functionality they are supporting. A bitcoin node is a collection of functions: routing, the

blockchain database, mining, and wallet services. A full node contains all four of these functions. Therefore, a full node contains the functions at the top three layers. All nodes include the routing function to participate in the network and might include other functionality. All nodes validate and propagate transactions and blocks, and discover and maintain connections to peers.

b. The Services Layer

This layer contains services provided by the system such as send, receive, deposit and withdraw bitBirr. According to [1], a financial transaction that is highly valued by the unbanked/underbanked is money transfer, whether within a country or across national borders. Therefore, the model includes these services. As blockchain transactions are immutable, each service is realized by transferring ownership. For instance, if one owns 10 bitBirrs and wants to transfer 8 bitBirrs to another person then this is realized by sending 8 bitBirrs to the receiver and 2 bitBirrs to oneself. To deposit cash, one gives cash to an FI or Agent and the FI or Agent sends the same amount of bitBirr to ones wallet. For withdrawal, the reverse of the previous process is done. So, Send and Receive are the basic operations for all the services.

c. The Blockchain Layer

This layer is the core of the model and what differentiates the system from others. It is the core because most of the requirements from literature review as well as empirical data such as interoperability, low cost and low risk features are realized in this layer. It contains a tamper-proof database which essentially is list of all transactions organized into blocks from the beginning (genesis block). This is also the layer where transactions are secured using PKC and are summarized using Merkle Tree (Hashed Pointer Binary Tree). It is also the layer where transactions are verified (mined) using various consensus algorithms such as Proof of Work (PoW) and Proof of Stake (PoS).

d. The Integration Layer

This layer is used to integrate the blockchain layer to traditional database systems. It is the layer where blockchain accounts are mapped to core banking system accounts. Respondents of questionnaires/ interviews were asked whether it is crucial to integrate the DLT network with core-banking system of financial institutions or not and they somehow agree to it. This shows that integration of the blockchain with core banking system is an optional component for serving the unbanked.

e. The Database Layer

This is the layer which contains the core banking system database and traditional bank accounts. This is an optional component as availability of traditional bank accounts is not mandatory. However, since it is important that the unbanked are brought to the formal financial system in the course of time, this layer together with the Integration Layer will be highly beneficial in the future.

4.4 Prototype Development and Evaluation

Multichain, a permissioned/private blockchain platform, has been selected for developing a prototype. As blockchain is a decentralized P2P network, it is required to have more than one node to simulate such network. Therefore, VMware Workstation version 10 was selected to create multiple nodes and implement the model. Windows 7 was installed on each virtual machine. Note that the prototype focuses on the core blockchain functionality and not the presentation layer such as designing a mobile wallet for multichain. However, Multichain Web Demo was used to demonstrate the presentation layer.

The steps followed in the prototype development include: installing and configuring four virtual machines using VMWare and Windows 7, installing Python 3 and PHP 5, downloading and installing the multichain software, creating blockchain, issuing a digital asset called bitBirr, installing and configuring MultiChain Explorer and Multichain Web to manage nodes and wallets.

Four subject matter experts evaluated the prototype developed for the features listed below.

- Transferring assets among nodes.
- Check blockchain parameters such as whether the 'anyone-can-*' parameters are set to "False" as this is a permissioned blockchain.
- Consensus mechanism based on blockchain parameters: admin-consensus-admin, admin-consensus-activate, admin-consensus-mine, admin-consensus-issue or admin-consensus-create.
- Granting/revoking permissions.
- How the system behaves when nodes leave and join the network.
- Test round-robin mining in multichain.
- Test mining diversity and mining turnover.

The evaluators were posed to answer the following questions:

- Can you send and receive the asset –bitBirr? Are these transactions reflected on all available nodes?
- Are the balances reflected on each available node after sending bitBirr?
- What rights does each node has?
- Is the consensus mechanism working as expected?
- Does granting and revoking permissions work? Is the right number of nodes required for consensus?
- Can nodes leave and join the network without affecting the system?
- Do nodes mine/verify transactions in a round-robin fashion?
- Does mining diversity function as expected?
- Is it possible to modify transactions? How does the system respond?

At the beginning, the evaluators were given a brief overview of the system and the basic commands and procedures to test the prototype. After that, a laptop on which the prototype was installed and configured was given to each evaluator to see the features for themselves independently. They started the evaluation with the above questions but were given the freedom to test the prototype for any feature they deemed important. They all tested sending bitBirr and verified that the balances for each wallet are reflected on each node immediately.

In general, all of them verified that the prototype developed behaved as intended. However, they recommended testing it in a real environment using WAN connections instead of virtual machines and LAN environment to have a real feeling of the system.

4.5 Discussion

The purpose of this paper was to show the possibility of creating blockchain-powered interoperable mobile banking system without a trusted third party by a consortium of FIs for reaching the unbanked population of Ethiopia. The research tried to answer how blockchain technology can be used to create interoperable, low cost and low risk mobile and agency banking system in Ethiopia without an intermediary and thereby improve financial inclusion. With blockchain technology interoperability is achieved without a trusted third party which has positive impact in decreasing service costs. Also as the system uses hashes to create shared, tamper-proof ledger, it was shown that it has low risk and is secure. The use of PKC makes the system more secure as only the owner of a private key can transact. The service will be ubiquitous which highly improves service availability to the unbanked. The paper also tried to develop blockchain-powered model for inclusive financing. A prototype was developed to demonstrate how the model can be implemented by the consortium of FIs. The prototype was evaluated by experts and the results show it is a promising system for inclusive financing.

5. Conclusion and Future Work

This paper started with the objective of developing blockchain powered financial inclusion model for reaching the unbanked population of Ethiopia. The model proposed in this paper solves most of the barriers in reaching the unbanked: lack of interoperability, high-cost and high-risk.

Since blockchain-powered system uses shared, tamper-proof ledger, it is automatically interoperable

and reduces risk and fraud. The system is secure as PKC is used. Most existing mobile banking systems in Ethiopia use SMS and send transactions in clear text and hence will suffer security breaches sooner or later. In addition, there is no single point of failure in the blockchain system as the ledger is replicated across multiple nodes. Nodes can also leave and join the network without affecting the system.

The proposed model eliminates trusted third parties. This has a positive effect in reducing costs. However, this doesn't make third parties out of the game as the blockchain system requires continuous maintenance and update. Since settlements are done in real-time, it allows the most efficient use of capital thereby lowering the amount of capital required.

SPV Wallet along with SIM overlay technology were recommended so that people with feature phones can use the system. However, the detailed implementations of overlay SIM for mobile wallets have not been covered in this research. Therefore, it is recommended that these features are handled in the future. The use of overlay SIM requires further research. In addition, how to map public keys to mobile phone numbers and the integration of the blockchain layer with the database layer requires further research.

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