Thesis research proposal
Master Information Science

Local currency networks in rural communities in Africa: A feasibility study of block chain payment network

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I. Introduction

Rural Africa communities have experienced a rapid influx of mobile devices the past decades (Pankomera & van Greunen, 2018). Combined with an increase of more than 20% in 2017 of internet access across the African continent, it opened opportunities to provide services over the internet to more remote areas, e.g. rural Africa (Pankomera & van Greunen, 2018). This development has also contributed to financial inclusion, especially in African economies (Pankomera & van Greunen, 2018). It enables mobile money services, e.g. M-PESA Orange Money and MTN Money, which enables peer-to-peer payments. M-PESA is one of the most successful implementation of mobile money in Africa, with 97% of the households in Kenya having an account as of 2014 (Suri, 2017). Nonetheless still 1.7 billion people of the world's population remain unable to use formal financial services, and over 50% of the poorest households continue to be unbanked (Demirgüç-Kunt, Klapper, Singer, Ansar & Hess.,2017). This demonstrates that a large part of the unbanked population do have a demand for peer-to-peer payments.

As Scott (2016) suggests that in the context in rural Africa, where there is a high dependency on cash and low infrastructure, - hypothetically – a quasi-bank account with digital money can be a more advantageous way to hold and transfer money. However in the same paper the author suggest that politics of mobile money can be challenging. The deployment of mobile money has been slowed due to struggles of regulators, banks and telecom providers (Scott, 2016).

With the success like M-PESA, mobile payment seems to be the solution for the large unbanked population. However, the literature of mobile payment suggest there is a need of a trust service manager that administrates, authenticates, authorizes and settles accounts (Lindman, Tuunainen, & Rossi, 2017). A distributed transaction platform addresses this challenge by a decentralized peer-to-peer networks like cryptocurrency (Lindman et al., 2017). The use of blockchain technology can circumvents these challenges due to its omission of the middle man in the infrastructure.

Another issue that a peer-to-peer payment network based on blockchain can address, are the high banking fees. According to Reeves (2017) the banking fees for people in the sub-Saharan Africa region, are four times higher than compared to people in the Middle East or North America (Reeves, 2017). Therefore making it even more inaccessible for local communities. By utilizing payment method based on blockchain, it not only addresses the need for a transaction service, but it also can reduce the cost of banking service (Reeves, 2017).

The sections in this proposal will be as followed: section II will cover my setting and research questions. Section III will provide an overview of the current literature on the topics: block chain payment systems and community currency. Moreover section IV will cover the methodology that I will use to conduct this research. Finally I will end this proposal with an time schedule on a weekly basis.

II. Setting and research question

The main goal of this research is to obtain practical knowledge about implementing a local payment network based on blockchain technology. With block chain technology, it eliminates the need to for intermediary party to process the transactions (Zheng, Xie, Dai, Chen, & Wang, 2017). Furthermore, the technology is well suited for this application due to that the transactions are made immutable, and therefore cannot be tampered after it is written in the blockchain. Moreover the proposed local payment network can utilize this technology to ensure the reliability and honesty of the transaction, this in turn will increase the chance of

adoption. Another beneficial property is its distributed nature, which results in no single point of failure of the network (Zheng et al., 2017).

Beside the technical aspect of the local payment network, I will also research how to organize such a network taking in consideration the cultural context. Community currency is an concept in the literature that complements the national currency in a specific geographic region or a community (Kim, Lough, & Wu, 2016). This contributes and stimulate local economic and environmental sustainability of a community (Kim et al., 2016). There are considerable amount of community currency circulating worldwide, over 4000 systems according to a study from Kim, Lough, & Wu (2016). My research would like to extend the current literature of community currency with a system design based on blockchain technology.

Based on the research setting and the topics, I have constructed the following research question:

Is it possible to implement a community currency network for rural communities Africa based on blockchain?

The main research question will be broken down into two sub-questions:

- *Organizational aspect:*
  Which properties of community currency are best suited for a local payment network in rural Africa context.

  Technical aspect:
- *Is there a blockchain implementation of suited for a local payment network based on lightweight devices.*

III. State of the art research

Blockchain technology

The introduction of blockchain enables the use of a tamper-proof distributed ledger where transactions can be recorded publically in close to irrevocable manner(Frey, Makkes, & Roman, 2018). These transaction are recorded blocks and incrementally linked in a append-only fashion (Frey et al., 2018). The combination of chaining mechanism ,utilizing cryptographic properties and peer-to-peer exchanges makes it almost impossible for an individual to manipulate a transaction in the blockchain (Frey et al., 2018).

However the whole ledger needs to be verified for a transaction, due to its chained nature. A node needs to download the whole blockchain ledger in order to perform the transaction verification. The size of the block chain is over 200GiB as of Jan 2019 (Blockchain Size. (n.d.). This can be a problem to implement on mobile devices, which have limited storage capacity.

In the study Frey et al. (2018), the researchers propose a new kind of protocol that verifies transaction on the bitcoin block chain. They suggest Diet coin, consisting diet nodes, that enables low-power devices to perform full-block verification with limited bandwidth and storage requirements (Frey et al., 2018). This is done by introducing a Merkle tree in order to verify the hash values on the transaction. In order to verify the correctness of the hash value of a transaction on the blockchain, not all the leaves of the tree are needed. Only hashes of all of the siblings up to the root node have to be proven of a given value (Ehmke, Wessling, & Friedrich, 2018). As shown in the figure 6 below from the study Frey et al. (2018) it limited the amount of storage needed. This makes it very suitable for its application in mobile devices.

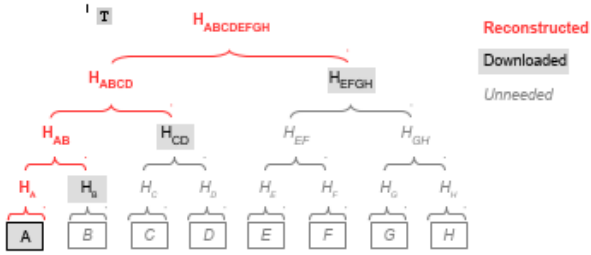

Figure 1: Example of a Merkel tree root reconstruction that only needs log(n) hashes. Reprinted from "Dietcoin : shortcutting the Bitcoin verification process for your smartphone" by Frey, D., Makkes, M. X., & Roman, P. (2018)., (March 2018).

Another approach is the use of the lighting network that has been proposed in a study of Poon & Dryja (2016) as an addition protocol to bitcoin. This paper suggest an off-chain instant payment network, to mitigate the limit of 7 transaction per second that the current supports (Poon & Dryja, 2016).

The lightning network enables participants to setup micro payment channels with two nodes and deposit a certain amount (Poon & Dryja, 2016). This transaction will be recorded on the block chain. However the micropayments afterwards on the payment channels are off-chain and therefore not subject to the 7 transactions per second limitation of bitcoin. Once opened, the channel allows for unlimited transactions between the two parties (Poon & Dryja, 2016). Once the channel is closed the end balances will be settled on block chain. Therefore resulting in only 2 transaction on the block chain (Acheson & Acheson ,2018).

With the distributed network of the Bitcoin, a network of micro payment channels can be established. If all the participants of the network has at least one micro channel op on the bitcoin blockchain, participants have access to all the nodes within the network (Poon & Dryja, 2016). This will ensure that not all participants needs to open a micro payment with their counterparty, but payment can go through intermediaries as well (Acheson & Acheson ,2018). The combination of lighting network, that will address the scaling problem of the bitcoin blockchain, and the lightweight implementation of Diet Coin will enable a scalable micro payment on mobile devices with limited resources available.

Community currency

From the organizational point of view, I will utilize the literature community currency. Like community currency, the local payment network complements the national currency. A big part of the population does not have access to banking services, therefore is a lack of currency (Dissaux, 2016). Therefore there is supply and demand mismatch in goods and services where direct barter techniques alone are insufficient (Ruddick, Richards, & Bendell, 2015). The poverty, i.e. lack of resources in national currency, can be solved by an introduction of local currency network so there is medium for exchange (Ruddick et al., 2015).

One of the challenges of community currency is the recirculation of the currency. The literature of community currency suggest that the most effective way to recirculating money is to enable the merchants to pay their suppliers and employees. (Kim et al., 2016). Another challenge for the community currency was the lack of a synchronous accounting system (Kim et al., 2016). The use of the blockchain will address this issue with its distributed ledger. Furthermore the same study suggests that a successful implementation, starts at the merchants due to the spending options people might have (Kim et al., 2016). Therefore people are more likely to participate in the local network if there are more spending options.

Based on the literature, the gaps of the current literature regarding payment platforms are both on the theoretical and practical level on the blockchain technology (Lindman et al., 2017). Another suggestion for a future study is to explore the option of an alternative bank account in the context of a social and solidarity finance (Scott, 2016). This research will

provide some practical insights on blockchain payment implementation and extend the community currency literature regarding an application of blockchain technology.

IV. Methodology

Based on the literature of Bon, Akkermans, & Gordijn (2016) this study will adopt the iterative and collaborative nature of “Low-resource aware framework for development of ICT4D services”.

The context analysis will be based on the literature study on ICT4D, specifically in rural areas. Furthermore specific context information will be obtained through interviews with experts who have been there in Mali from the VU Amsterdam. Next to literature study and the interviews, an assessment of the needs of the local people is required. The assessment of the users will be obtained through questionnaires by researchers who have the opportunity to visit the local community in Mali. I will submit the questionnaires to the researchers. The questionnaires will be answered by key-users of the payment network. This will provide some insights to the needs and the requirements of the local community.

Based on the information of the context analysis, I will design a concept of a local operating payment network on mobile phones. For the concept I will use the use-case scenario of Foroba Blon community radio service (“Foroba Blon”, n.d.). In a study of Daoudi (2017), she explored the economic sustainability of such a service. The conclusion was that web services can be sustainable for the rural poor in Africa (Daoudi ,2017). This research will extend that research by exploring the payment system based on blockchain for these kind of services (step 4 & 5). The use case scenario is as followed:

1. A customer in rural community wants to broadcast a radio announcement.
2. The customer calls the radio station to place an ad using Foroba Blon.
3. The cost of the advertisement will depend on the length of the message.
4. The customer will proceed to pay the cost of the advertisement
5. The Foroba Blon operator will able to confirm the payment
6. Foroba Blon radio service will broadcast the paid for advertisement.

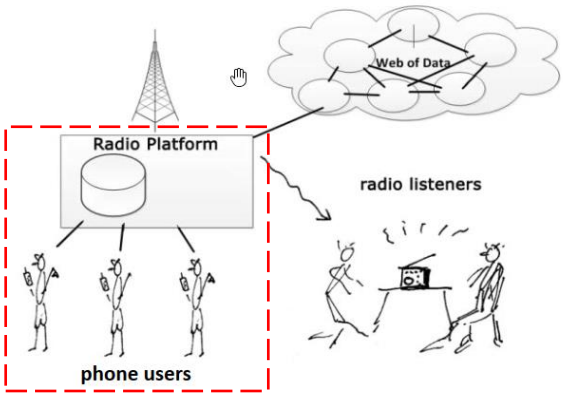

Figure 2: Conceptual design of the radio platform as a voice-interface to the Web. ”The Web of Radios – Introducing African Community Radio as an interface to the Web of Data”. Anna Bon, Victor de Boer, Pieter De Leenheer, Chris van Aart, Nana Baah Gyan, Max Froumentin, Stephane Boyera, Mary Allen, Hans Akkermans. Presented at the First International Workshop on DownScaling the Semantic Web, hosted by Extended Semantic Web Conference 2012.

This use case scenario will be used to construct requirements following the format as described in the study of Bon et al. (2016) as a format for use-case and requirements (Name, Summary of the key idea, Actors and goals, Context and scope, Use case scenario script,

Interaction and communication, information concepts and technology infrastructure). Based on the use case scenario and requirements, a conceptual design will be made and this will be modeled in a UML class diagram.

Once the concept is designed, I will perform two rounds of practical testing to get the insight of the local payment network. The first test will be conducted in a controlled lab environment. The main objective is to test the implementation of the technology. The following aspect will be tested: ease of use, speed of transaction, ease of setup, creating a payment request, receiving payment request and transferring the currency and type of Internet connection.

The lab test setup will be with 2 mobile phone, and an e-wallet application with bitcoins. In figure 3, a peer-to-peer payment transaction has been drawn conceptually.

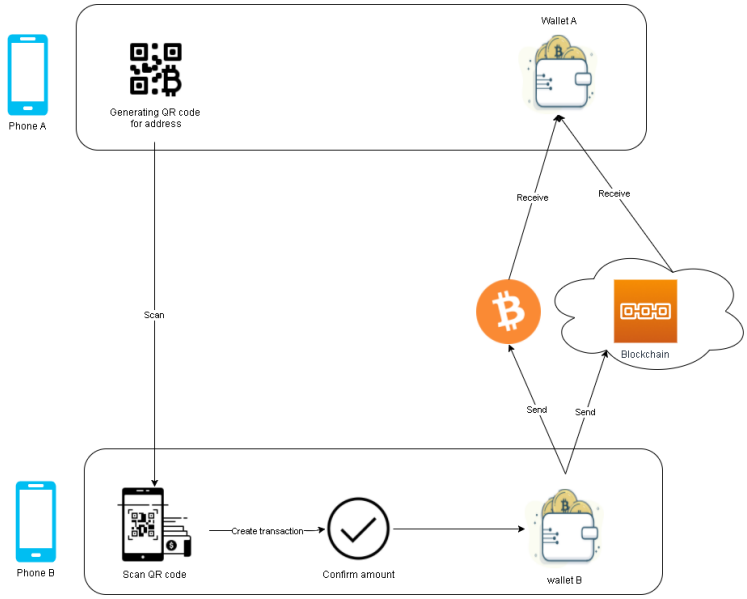

Figure 3: Bitcoin payment procedure concept

In the lab test I want to validate the payment procedure in figure 3. Furthermore the before mentioned aspects will be evaluated during the lab test. This will provide me with the practical insights of the implementation of the technology on mobile devices for the second sub question. The second test will be a field test in locally in Mali with local participants. The test will evaluated with a survey afterwards. This will provide me with the insight for both sub-questions.

V. Time frame

The time frame is that the research and writing this thesis will be done in period 5 and 6. I will take 2 courses in period 4, therefore leaving room in period 5 & 6 to fully focus on this thesis. The plan is to work from April 2019 till July 2019 full time on this project an complete it before end of period 6. Please find below a time schedule for period 5 and 6.

A general weekly overview in the period 5-6:

Wk	Date	Activity
14	1-4-2019	Literature study
15	8-4-2019	Perform Use case and requirement analysis
16	15-4-2019	Construct test criteria lab test
17	22-4-2019	Setup lab test (round 1)
18	29-4-2019	Perform lab test (round 1)
19	6-5-2019	Perform lab test (round 1)
20	13-5-2019	Evaluate lab test and adjustment
21	20-5-2019	Construct test criteria field test
22	27-5-2019	Setup field test (round 2)
23	3-6-2019	Perform field test (round 2)
24	10-6-2019	Perform field test (round 2)
25	17-6-2019	Evaluate field test
26	24-6-2019	Finalizing Concept
27	1-7-2019	Finalizing Thesis report

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