Blockchain-based Financial Infrastructure for Emerging Economies

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BLOCKCHAIN-BASED FINANCIAL INFRASTRUCTURE
FOR EMERGING ECONOMIES

Research in Progress

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Abstract

The transformative capacity of blockchain technology is a frequently debated topic in the information systems (IS) and practitioner literature. Yet, rigorous and design-driven research remains relatively uncommon. We document an ongoing design process towards a blockchain-based IT-artefact comprising financial infrastructure for stakeholders in emerging economies. Working with a young NGO, we utilize the design-science research methodology (DSR) in the design, implementation, and evaluation of the IT-artefact. The artefact enables stakeholders to conduct basic financial services by computing transactions, maintaining a savings account, and receiving targeted stimulus payments. Following six months of iterative design and development, we released a global pilot version of the artefact. Over the first nine months, the pilot generated a dataset of 6.6 million transactions amongst 189,379 verified users. By conducting design-driven research, we contribute novel practical insights to the IS discourse on the transformative capacity of blockchain technology and information communication technologies (ICT) in emerging economies.

Keywords: Blockchain, Design Science Research, Financial Infrastructure in Emerging Economies

1 Introduction

It is estimated that 1.7 billion people globally are unable to access the most basic financial services, a determining factor in preventing individuals in emerging economies from making the first leap out of poverty (Demirguc-Kunt et al. 2018; Mohan and Potnis 2017). The dominance of cash-based settlement procedures in emerging economies has been shown to impose ‘hidden tariffs’ on stakeholders throughout the value chain. Be it via storage and withdrawal costs, predatory middlemen, corruption or other forms of financial exploitation, the hidden ‘cost of cash’ often levies significant financial penalties on unbanked individuals (Chakravorti 2015). In this paper, we document interim results from an ongoing research project conducted in association with a young, non-governmental organization (NGO). We explore the feasibility of designing basic financial infrastructure for stakeholders in emerging economies, using blockchain technology. Because blockchain technology is an inherently transparent type of database architecture (Glaser 2017), we conjecture that this group of technologies may introduce a new level of transparency and accessibility to consumer oriented financial services in emerging economies. We are utilizing the design-science research methodology (DSR) in the design, development, and evaluation of a blockchain-based IT-artefact. The artefact enables users to send financial transactions to each other and to receive stimulus payments from a shared pool of assets, directly to their digital wallet, which acts as a savings account.
The research design is motivated by the research question: “How can blockchain technology support basic financial infrastructure for use in emerging economies?” In this paper, we document the ongoing design process leading to the current iteration of the artefact consisting of six months of iterative design, development, and evaluation, followed by a nine-month pilot testing phase, in which the artefact was opened for use by a global group of stakeholders. The pilot version of the IT-artefact presented in this research-in-progress paper comprises a system of smart contracts deployed on Ethereum, a public, permissionless blockchain, and Fuse, a ‘side-chain’ enabling low-cost transaction processing and scaling. By exploring the capabilities and limitations of novel information communication technologies (ICT) through empirical and design-driven research, we seek to contribute to the growing body of IS literature on the transformational capacity of ICT.

2 Blockchain Technology in Emerging Economies

A blockchain is a replicated database, maintaining a shared state amongst a global network of nodes. Values, such as the balance of coins or tokens, are assigned to addresses and public keys, denoting the value in possession by the owner of the associated private key (Glaser 2017). Nodes in the network compete to append the distributed database through a decentralized consensus mechanism. To elect the node in the network, tasked with propagating the next block, either computationally hard problems or randomized selection is used (Kolb et al. 2020). The latest generations of the technology have introduced the ability to deploy and execute basic scripting, known as ‘smart contracts’ in the shared database, paving the way for multiple interesting new forms of applications. To date, the most used applications emerged around financial services, providing innovate ways to conduct assets swaps or borrow money in decentralized money markets (Jensen et al. 2021, von Wachter et al. 2021).

In recent years, the practical and socioeconomic implications of blockchain technology have become a frequently discussed topic in the IS literature (Labazova 2019). Scholars have proposed blockchain-based IT-artefacts for a wide range of problems in the financial industries, from shipping (Müller-Bloch et al. 2017) across the settlement and clearing of financial transactions (Ross et al. 2019) and derivatives (Egelund-Müller et al. 2017; Jensen and Ross 2020) to issues concerning the management of sensitive data (Faber et al. 2019; Moyano and Ross 2017) or ticketing (Regner and Schweizer 2019). Yet, the lion’s share of contributions to the IS blockchain literature approaches the technology from a theoretical angle (Lindman et al. 2017; Rossi et al. 2019) examining how the unique properties of blockchain technology can create value for organizations (Ostern et al. 2020), innovate business model designs (Seebacher and Maleshkova 2018) or operate in combination with other technologies (Karger 2020).

The transformative capacity of ICT in emerging economies is broadly recognized within the IS discipline (Lwoga and Sangeda 2019; Roztocki and Weistroffer 2007). Scholars have examined commercially driven financial infrastructure such as M-PESA in Kenya (Agyepong and Twinomurinzi 2016), PayTM in India (Joshi et al. 2019), and KOMIDA in Indonesia (Yeow and Lim 2018). Recent studies in the information systems genre and beyond portray an increasingly detailed picture of the challenges faced by individuals in emerging economies, identifying high costs of banking and financial illiteracy as key drivers of financial exclusion (Schuetz and Venkatesh 2020). To remedy these issues, it is argued, ICT artefacts must be mobile and scalable (Realini and Mehta 2015) while facilitating targeted payments to exposed minority groups (Aker et al. 2016). To date, the majority of work on ICT in emerging economies explores the use of smartphones (Senyo and Osabutey 2020; Yawe and Prabhu 2015) with little work done towards expanding our understanding of the transformational capacity of blockchain technology in emerging economies (Larios-Hernández 2017).

3 Methodology

The design process for the artefact is conducted in accordance with the DSR methodology (Gregor and Hevner 2013). As authors, we work alongside the NGO team-members as active participants in the design and development process, while documenting the process throughout. At the time of the
development of the present iteration of the artefact, the foundation team comprised an emerging markets economist, a project manager, and two software developers. The author team primarily contributes to the software development process through an in-depth understanding of blockchain technology and financial architecture. Prior to the release of the present iteration of the artefact, the authors worked alongside the foundation team members for a duration of six months. The day-to-day design and development workflow was conducted in smaller sprints leading into bi-weekly meetings in which progress within the general workflow (Figure 1) was discussed.

Drawing on the rich literature on artefact evaluation practices, the project workflow (Figure 1) was constructed with emphasis on iterative integration of cyclical evaluation results (Herselman and Botha 2015). The artefact design process was conducted with cyclical ex-ante stakeholder evaluations of the artefact requirements, alongside an ex-post evaluation cycle following the conclusion of the present iteration (Venable et al. 2016). The evaluation process delineates a data-driven evaluation format in which granular blockchain transaction data is prepared for network analysis and curiously matched with publically available online data through non-participatory observation of users posting about the artefact on the social media pages Twitter and Facebook. The collection of qualitative data was conducted in accordance with the principles for netnography (Kozinets et al. 2014). We observed online communities emerging around the artefact and gathered publicly available information, establishing context for the quantitative analysis.

Figure 1. The cyclical DSR workflow, exemplified by the activities in the latest cycle

3.1 Artefact Requirements for the Pilot Project

The elicitation of effective artefact requirements (Hickey et al. 2004 was subject to multiple cycles of ex-ante evaluation cycles, resulting in the version of the requirements presented in Table 1. (Venable et al. 2016). A target user profile was drawn from a synthesis of the extant literature on ICT and financial inclusion in emerging economies and injected into the requirements elicitation process (Sein et al. 2011). The artefact requirements were initially targeted for a small user population, believed to be able to persuasively enrol users with similar needs (Hanseth and Lytyinen 2010).

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<tr>
<th>Requirement</th>
<th>Description</th>
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<tbody>
<tr>
<td>A</td>
<td>Low-cost transaction processing and stimulus distribution (I) The artefact pilot must compute peer-to-peer transactions at a low-cost ratio to facilitate small transactions. (II) The artifact must facilitate the issuance of stimulus payments directly to active stakeholder’s wallets.</td>
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<tr>
<td>B</td>
<td>Usability and accessibility (I) The artefact must be accessible with low hardware requirements in order to embrace financial inclusion. (II) The artefact pilot must exhibit a capacity for persuasive enrollment and subsequent retention of stakeholders, through visible growth of the active stakeholder count, using only minor resources for dissemination and enrollment efforts.</td>
</tr>
<tr>
<td>C</td>
<td>Commercial viability The artefact pilot should prove commercially viable through gradual integration in real (external) commercial activities.</td>
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Table 1. The artefact requirements for the present iteration
4 Artefact Demonstration and the Global Pilot Design

The current iteration of the artefact comprises a set of six smart contracts, deployed on the Ethereum blockchain and the Fuse sidechain in parallel (Figure 2.). The Ethereum blockchain was chosen due to high level of security and wealth of developer tooling available. The Fuse sidechain is a replicated version of the Ethereum blockchain, utilizing a ‘delegated proof of stake mechanism’. The Fuse sidechain requires less server on the network, which facilitates fast low-cost transaction processing. In comparison, the virtual machines of both blockchains are fairly similar, whereas the Fuse sidechain sacrifices on decentralization in order to gain a scalability advantage over Ethereum. We balance the lower level of decentralization on the Fuse blockchain by deploying the contracts with the largest security requirements on the Ethereum blockchain, whilst deploying the contracts with a lot of transactions on the Fuse blockchain. Because the Fuse blockchain is a replicated low-cost environment to Ethereum, the smart contracts can communicate through a ‘bridge-contract’. A simple browser-based user-interface (UI) was designed for browser and mobile accessibility. Through the UI the user can compute (I) transactions (send and receive) of Tokens, and (II) ‘claims’ of basic income stipends in Tokens issued in cyclical intervals. The contract system taxonomy is constructed as follows: The Token is the primary unit of exchange for the artefact. It maintains the balance of all user’s addresses and acts

![Figure 2. Artefact overview and critical flows between smart contracts](image)

1The link to the updated Github repository where the reader will be able to review the open-source codebase of the artefact is available from the corresponding authors on request.

2https://docs.fuse.io/the-fuse-chain/overview
as a claim on the yield generated by the crypto assets in the Reserve contract. Computing transactions through the UI communicates directly with the Token contract interface. Prior to computing any transaction, the Token checks the recipient address with the Identity contract, which stores a list of approved addresses. To become approved, users must execute a signup verification flow utilizing their email address, through which a single Token is issued to the address through the First Claim Reserve contract.

Supporters can contribute crypto assets to the Fund Manager contract which allocates funds to third-party applications, generating interest yield through lending the donated crypto assets on a money market\(^3\). The yield generated by the Fund Manager is sent to the Reserve contract, where tokens are minted at a free-floating ratio to the USD value of the assets in the reserve, approximating an exchange rate of $0.0001 per token. Buyers, who wish to purchase Tokens, can do so directly from the Reserve contract by sending a transaction in any approved crypto asset to the Reserve. The Reserve contract then allocates Tokens to the DAO contract, which submits a stipulated amount to the Basic Income contract. The Basic Income contract stipulates an ‘active period’ in which a given amount of Token is allocated for claiming by verified users. Users call the ‘claim’ function in the Basic Income contract through the UI, triggering a transaction of the daily stipend to their accounts. For the nine-month pilot, stakeholders were able to ‘claim’ Tokens from the Basic Income contract at a daily cadence. Additional allocations of the tokens were made to referral contracts through which stakeholders could refer friends for an additional sign-up bonus.

5 Artefact Evaluation

We follow a data-driven evaluation format in which blockchain transaction data is prepared for network analysis and checked against qualitative user data obtained through netnographic observational studies of user behavior in online communities (Venable et al. 2016). In Table 2, we summarize the results of the evaluation process by mapping the artefact requirements against the observed behaviour.

The current iteration of the artefact was deployed on the Ethereum and Fuse networks and opened to use on the 01.08.2020. Over the course of nine months, the artefact processed 6.6 million transactions amongst 189,379 verified individuals. The mean transaction fee stood at $0.00001, or 1/1000 of a cent, per transaction with an average processing time of 2.5 seconds. The average transaction value is $0.045, with a total of 151,858 participants computing three or more transactions. Through the course of the pilot, 44 donations were made to the Fund Manager. The contract currently holds crypto assets valued at about $120,000 which yielded an average return of 5.56% p.a. for the duration of the pilot. We explored the dataset utilizing a graph-based network analysis, in the open-source network analysis tool Gephi, creating a network graph with a randomized sample ratio of 1:54 of the total data-set. Nodes represent individual addresses, colored by their number of connected edges. Edges are weighted and represent transaction volumes (Figure 3).

As evident, most transactions on the network are computed by claimers (6.3 million), withdrawing a daily stipend from the Basic Income contract, indicating a dominant ‘claim and hold’ pattern where stakeholders sign up and user the artefact to claim the tokens successively (with some stakeholders having claimed up to 250 times). This pattern is partially confirmed by the large number of stakeholders claiming from several generations of the Basic Income contracts (BI1-BI2)\(^4\).

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3 For the current iteration of the artefact, the Fund Manager allocates funds to ‘Compound’ a smart contract-based money market where borrowers of crypto assets pay a variable interest rates to lenders. The interests generated by the Fund Manager is submitted to the Reserve. We invite the reader to view ‘Compound’ on compound.finance.

4 Please Note: Due to a technical issue, the Basic Income contract was redeployed midway through the pilot (BI1-BI2).
Throughout the nine-month pilot phase, we noted the appearance of several interesting transaction clusters. The qualitative data collected through the netnographic method, linked these clusters to organically emerging marketplaces, in which stakeholders traded items, services, or other crypto assets against the token on decentralized exchanges (purple nodes).

This revealed several fascinating stories warranting deeper empirical study of user behaviour, including (I) a group of stakeholders organizing through Facebook to build an online portal for the sale and listing of used items traded with the artefact Token (Marketplace 1), and (II) a liquid market for the token on a pre-existing decentralized exchange where stakeholders appears to be trading the token against other crypto assets, outside of the minting price range (Marketplace 2). The most recent evaluation cycle was completed following the recent conclusion of the pilot-phase. Table 2. summarizes these results.

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the token with the hope that it will appreciate in value over time. This pattern does not make any clear indication of the feasibility that the artefact can support commercial processes in an emerging economy. Evaluating the commercial viability of the artefact, is likely to require on-the-ground empirical studies of stakeholder engagement with the artefact.

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Table 2. Evaluation summary for the present cycle

6 Discussion and and Interim Conclusions

While it is not yet clear weather the group of technologies associated with the term ‘blockchain technology’ in the IS liture, is the appropriate design choice for financial infrastructure in emerging economies, the ongoing work presented here provides guidance on the feasibility of implementing a basic artefact for the emerging markets context. The ongoing work presented here is guided by the broadly posed research question: “How can blockchain technology support basic financial infrastructure for use in emerging economies?” Through the design, development, and evaluation of a blockchain-based IT-artefact, we demonstrate the feasibility of implementing a modest digital wallet with the ability to process transactions and distribute basic-income stimulus payments to stakeholders.

In the on-going pursuit of the research question, we define three key product requirements in collaboration with a small team of stakeholders at an NGO, drawing on the DSR methodology. The product requirements were designed in collaboration with the NGO design partners and delineate the ideal properties for future iterations of this artefact. We find that an ideal iteration of the artefact must (I) process transactions with a low cost base to facilitate direct stimulus or universal basic income payments to wallets (II) be accessible for use on low-cost smart-phones with internet connection and (III) facilitate commercial transactions between a large set of users, facilitating real economic value creation. We document the current progress on achieving these requirements through the deployment of a nine-month prototype. The prototype utilizes blockchain side-chain architecture as a scaling mechanism, conducting over 6.6 million transactions between 189,379 verified individuals across multiple emerging economies over the course of nine months. The present iteration of the artefact utilizes a test-deployment of a UBI scheme by which stakeholders can withdraw tokens minted against a claim in a reserve. This appears to have introduced strong growth incentive resulting in relatively fast adoption of the proto-type amongst a wide userbase, however, it does not appear to have generated a large amount of authentic economic transactions between the stakeholders at this point.

Given the ongoing nature of the design process for the iteration of the artefact presented in this preliminary paper, there are multiple limitations to the present study. Primarily, the design risk for the viability of the present iteration of the artefact is social and user-oriented (Venable et al. 2016). While the artefact is designed for organic growth through commercial adoption in emerging economies, the present study does not address or document the user experience of stakeholders in emerging economies. As a consequence, the interpretation of the provisional findings presented in this paper is liable to Type I errors, known as false positives (Pries-Heje et al. 2007).

While the artefact provides an indication of the feasibility of implementing financial infrastructure with blockchain technology, extensive empirical trials in emerging economies are a requisite, if a contribution to the IS literature on financial inclusion is to be made. Empirical trials must emphasize the path to adoption by linking transactional data to behavioral and observational data, contributing a new level of granularity in the collection of empirical data on emerging economies (Lwoga and Sangeda 2019). Future work on this artefact will include an expansion of the research design with a comparable study in which the artefact is benchmarked with existing financial services in emerging economies. Additionally, we intend to conduct a variety of improvements and enhancements whilst designing additional empirical trials to better gauage user behavior. For the prototype presented here, we omit discussion on certain crucial qualifiers for financial infrastructure. Given the pseudonymous nature of accounts on Ethereum, privacy features are a nesseary requirement to real-world success.

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References


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