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A Blockchain-enabled Decentralized Time Banking for a New Social Value System

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***Abstract*—Blockchain technology is reshaping the the traditional economies. People may have more trust than ever before as the transaction is immutable and transparent. Success in crypto-currency and other technical areas highlights many attractive features of the blockchain technology that can benefit more aspects of modern society. Time Banking is a generalized exchange economy not based on money, but values everyone's contribution on the same scale, the time expended. Time banking is a noble idea with great potential, but the security and trust issues are not well addressed. In this paper a BLockchain-ENabled Decentralized Time Banking System (BlendTBS) is proposed to build a trustful, dynamic and respectful community. People in this community are encouraged to be engaged in mutual serving relationships. For this purpose, the BlendTBS is designed to reward the residents who commit in socially beneficial activities. An initial prototype is implemented on a permissioned blockchain network and a small scale study is planned to examine the utility of BlendTBS to a traditional community on the island of Aneityum, Republic of Vanuatu. Within a selected community in the village of Analgahuat, deeper insights will be explored by observing the trust enabled by Blockchain technology that allows peer to peer service exchanges between any two individuals. Authors hope this position paper may inspire more interests in the roles that blockchain technology can play in modern society.**

***Index Terms*—Traditional Economy, Vanuatu, Time Banking, Blockchain, Smart Contract.**

I. Introduction

The explosion in Artificial Intelligence (AI), Machine Learning (ML), and Big Data is reshaping global communications, commercial activities, and social relations in industrialized economies [8], [16]. The superhuman capability of data processing and pattern recognition enables AI to outperform human workers in many data- and/or computing-intensive tasks [3], [21]. In addition, AI significantly cuts costs with very high efficiency for manufacturers and service providers [7], [27]. As AI begins to take over many jobs across the developed world [19], [23] and fundamentally changes the way in which we organize the economy and society [9], there are concerns about the value of human beings and how people can fulfill their obligation to society [24]. In contrast, developing economies increasingly abandon their traditional practices to join the global market economy and as a consequence, often experience negative health outcomes [18], [22].

The increasing sophistication and widespread use of AI is expected to create problems for both developed and developing economies. For developed economies, people are widely concerned about:

- AI and robots taking traditional human jobs;
- Redefining "human work" in age of AI/robots;
- Redefining a person's obligation to society - a social contract; and
- A lack of social cohesion and trust- people becoming anonymous strangers.

Meanwhile, as traditional societies become increasingly integrated into the global economy they are increasingly impacted by:

- Chronic diseases;
- Loss of social cohesion; and
- Loss of culture and land.

Although it may appear that developed and developing economies are focused on different issues, these problems are actually different facets of the same problem: defining the true value of a person. Traditionally, a society evaluates each individual by wealth, social rank, education level, etc. However, the wave of big data driven, increasingly sophisticated AI technology is accelerating the process of machines outperforming humans and thus, exacerbating many problems that have been challenging industrialized societies for decades. This technological revolution is fundamentally altering the way people in developed economies live, work and relate to one another [20]. Unfortunately, today's western society is still complicated by unsolved issues accumulated since the first industrial revolution in the eighteen century [15].

Recognizing the historical complexity, this project proposes to obtain a clearer understanding of the impacts of the high technology through an initial small scale study examining the utility to a traditional community of a mobile application to track economic interactions within a diffuse network on the island of Aneityum, Republic of Vanuatu. We seek to develop a system based on traditional decentralized economies that harnesses the trust enabled by blockchain technology to allow peer to peer exchanges between any two humans.

As a co-production of social services based on exchange economy, Time Banking is considered as a promising solution to promote a trustworthy relationship in a community [4].

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The values of individual's contribution are assessed according to the time consumed on serving activities, and are recorded in the time banking system [6]. The organizations and individuals could perform peer-to-peer service exchange by using their balances in the time banking system for transaction settlement. The time banking system encourages residents to make contributions to the local community, therefore, a new mutual-help relationship is constructed to strength bonds among community members.

Although time banking offers a prospective solution to shore up a benign relationship among community residents, it still face many challenges. Currently, only governments or authorized third-party organizations could combine fragmented public and private data to construct a time banking system. However, serving time credit standard is not transparent and individuals do not participate in the time credit evaluating procedure to oversee those agents in power. Furthermore, traditional time banking systems are mainly relying on centralized architecture, which are more vulnerable to single point of failure problems and become the performance bottleneck.

Blockchain, which acts as the fundamental protocol of Bitcoin [17], has demonstrated great potential to revolutionize the fundamentals of information technology (IT) due to many attractive features, such as decentralization and transparency. Blockchain and smart contract together are promising to provide a decentralized solution to enable a secured serving time credit exchange and data access control in a time banking system [25].

In this paper, a BLockchain-ENabled Decentralized Time Banking System (BlendTBS) is introduced, which is aimed at promoting an individuals' mutual serving relationship and constructing more trustworthy community. The decentralized blockchain network enables community members to participate in the service exchange process instead of relying on a centralized third-party authority to maintain service time data. The service time recording and transaction procedure are transcoded to a smart contract that is transparent to the public. The consensus algorithm enforced by blockchain provides tamper proof of transaction data in the trustless network environment.

The rest of this paper is organized as follows. Section II provides the background information. Section III illustrates the proposed BlendTBS architecture. Section IV discusses the experimental study to be conducted in Vanuatu. Finally, section V concludes this paper with our ongoing work.

II. Background and Related Work

Time banking has spread rapidly in recent years. For example, the nonprofit organization, TimeBanks USA [1] facilitates 276 time banks in North America through 27,000 members. In a time banking system, all members' time are treated as equal, which allows value created by service exchanges to remain within the local community. Apart from the obvious benefit of allowing people without money or a job to participate in value creation, a timebank creates opportunities for new relationships to form and strengthens bonds among community members [2]. Some research shows that more active involvement in one's community actually leads to higher levels of quality of life [11].

Time banking is a network, which functions as a platform letting people provide and receive services from each other by donate their time. Generally, it does not involve real money. One simple example is that one person can hire another one for massaging for one hour. Then, the masseur earns one hour credits and next time, the masseur can spend the credits to hire other people to work for him/her for one hour. There are five core values of time banking as listed by Edgar Cahn, the founder of modern time banking [4], [5].

Time banking is a noble idea and its potential has been recognized by more and more people [26]. However, it has not brought impacts as significant as its inventor expected because of several weaknesses. Some researchers pointed out that psychologically the metaphor of "bank" failed to serve its purpose of promoting the community centered, peer-to-peer service exchange [2]. Technically speaking, one of the weaknesses is that the security and trust issues are not well addressed. In a community consisting of dozens of residents it is very likely that people do not know each other very well. A person may know the others living in the next building but not the one who lives a block away. Therefore, a trustful relationship could not be built in a community and people normally would not take the risk of asking a stranger for help. Leveraging blockchain and smart contract, a decentralized time bank architecture can tackle this issue perfectly [12].

III. Blockchain-Enabled Decentralized Time Banking System

The BlendTBS creates a business logic in the contract ensuring the transparency and tamper-resistance. Data structure is created in the contract, which is also responsible for the data communication between the blockchain and user interface. When data is requested through the interface, an API would provide the function calls to fetch the data through the contract. Every function call would trigger the transaction, users need to prove the transaction so that the function can be realized.

Figure 1 illustrates the high level view of a blockchain enhanced design of a time banking application. Different from traditional web applications that rely heavily on a central server, the BlendTBS application uses a permissioned Ethereum platform to achieve the goal of partly decentralization. Each user uses his/her blockchain address to enroll the system. Considering the lightweight requirement for users, who may just join the blockchain network for sending transaction in a short time, it is not necessary for users to store the whole blockchain data. The containerized mining entities are authorized by the administrator and distributively deployed on the powerful cloud or the fog computing platforms. The decentralized miners work together as a mining services for entire blockchain network, while users merely interact with nearby mining nodes to launch transaction and send queries to blockchain.

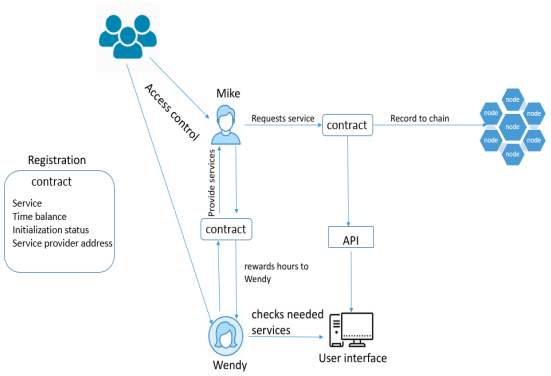

Fig. 1. Illustration of time banking system.

The architecture has three main components, registration, transaction, and access control.

- *Registration*: Registration is used to initialize each user. A data structure in a solidity contract called *struct* is used to store the registration information. Each user sends the registration request to the registration server, which is managed by the administrator and responsible for user identification and profile data storage. After being identified, registered user's address will be mapped to the *struct*, which records the time balance, status and service, etc. Therefore, through tracing the user's public blockchain hash ID, all data associated with user can be accessed to fulfill the operations of time banking.
- *Transaction*: When a user sends a transaction request to a miner service node in the time banking system, the miner will delegate user to send transaction after user's identification is verified. Similarly, user could interact with any miners to query time banking account data recorded in blockchain. Since miners synchronize chain data with the blockchain network, user side could easily send transaction and query data by communicating with miners rather than storing the whole blockchain data or carrying on computational mining task. Such a lightweight client mode allows resource constrained IoT devices to join the BlendTBS system.
- *Access Control*: To secure data accessing in the use of time banking, access control policy is enforced in the architecture design. The administrator controlled the access control policy services and could launch transaction to changed user's access right recorded in blockchain given pre-defined access authorization policies. After registration, every user can use his/her password and blockchain address to log on the time banking client. When the mining service receives data access requests (transaction or querying) form a user, the access control verification process is performed by the miner to ensure that only the authenticated users with authorized access right are allowed to grand services.

To start the BlendTBS, first of all, a group of users will be created with unique public keys and certain amount of time credits (in hours). The public key is a hashed value staring with 0, for example, such as "0x538eFE6CC766900A30B7Dc23bF060b2538C766B6". The public key is used to identify each user in the system, and the hours is the users' initial deposit, which can be spent to receive services from others. Then a smart contract is constructed among these users, which defines the transactions between the time and services. The smart contract plays an important role in the application. It is a bridge that connects the blockchain and the client side. The contract defines the data structure of the user's information, including the balance of time credits (hours), requested services, service provider address and initialization status, which indicate whether or not a user needs to be initialized with a certain time credit. A few functions will also be defined in the contract, like changing the balance of a user's time credit deposit, recording the needed service, user profile initialization, etc. To develop the functionality, a web browser, a blockchain server and plugins are used.

- *Web Browser*: The web browser provides an interface for users and therefore needs to be fast, secure and responsive with user interactions. As a modern web browser for development, chrome is a better choice then others. Users can easily load the application with large content without much delay. The most important reason for using Chrome is good compatibility. The chrome browser is executable on all mainstream operating systems, windows, Linux, android, ISO.
- *Plugin*: Web browser alone cannot work directly with blockchain. Matemask, a browser plugin, is used to connect the browser to the blockchain network. A user can log into a time bank with a unique hash value through the plugin. When a user takes an action in the time banking system, like submitting a service request, the action will trigger the plugin and the user will be asked for a confirmation since each action will cost gas. After the confirmation, the function in contract is called that either returns data from the blockchain to interface or stores the value from the client side to the blockchain.
- *Blockchain Server*: A software called Ganache was used for local development, it provides a list of users with default hashed ID and a port to listen to. Ganache will conduct auto-mining and every user has default Ethers, which is enough to process the transaction. The time banking is also deployed to a private blockchain consisting of several nodes who will conduct the mining work.

IV. Implementation and Experimental Study Plan

A. Prototype Implementation

Figure 2 is an example of service submission through the BlendTBS interface at the client side. A hash starting by 0 is the public ID of a user. Each user would have ten hours as their initial time credit deposit. A service request can be filled into the input field and users can select hours needed for the service. The request will be posted to the contract once being submitted. A data structure and some functions defined in the smart contract are responsible for storing the information and rendering the information to the

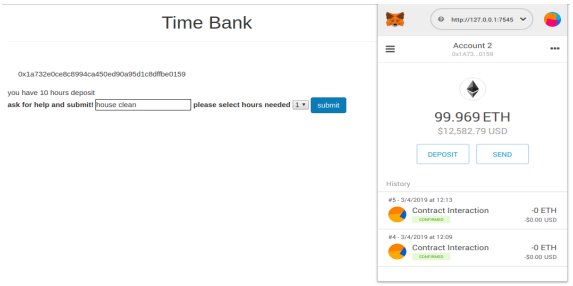

Fig. 2. Example: Service Submission.

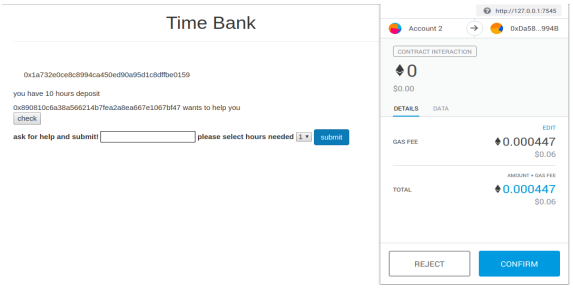

Fig. 3. Example: Service Providing.

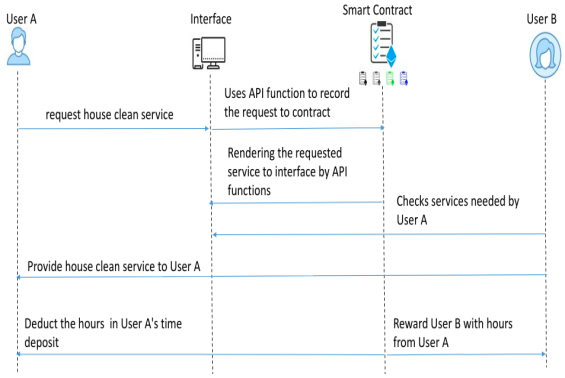

Fig. 4. The process of transaction.

Fig. 5. Example transaction block.

interface such that other users can view the services requested by others. The dialog on the right side is the transaction confirmation. In the blockchain, any action associated with the contract will be a transaction and this dialog will be triggered each time when there is a function call to the contract. This dialog is run by a plugin called MetaMask that connects the interface with the blockchain.

Figure 3 shows that a user with last two digits 47 can provide services to a user who has requested services. The user who requested services can finish the transaction by clicking the "check" button. Then, the service provider would be rewarded with the hour sent by the user who requested the service. Figure 4 shows the transaction procedure. Each transaction will produce an immutable hashed block as shown in Fig. 5. A block is added to the blockchain in time sequence. At the same time, gas will be costed when the block is created. "TX HASH" is the hash of the transaction and the transaction is sent from the user with ID of "0x1a ... 0159" to address "0xDa ... 994B".

This prototype is built in the lab environment and the experimental test are being planned. Currently there is not performance evaluation results for this position paper. The experimental location and a plan are introduced in the following subsections.

B. Introduction to Vanautu

Currently the 288,000 (2018 est) people of Vanuatu (Ni Vanuatu) collectively speak 106 traditional languages of the Austronesian language family. In addition there are two official languages reflecting Vanautu's colonial past (English and French) and a national pidgin, Bislama that are used in legal documents and taught in schools. Many of the larger islands (e.g. Malakula and Espiritu Santo) have more than two dozen traditional languages spoken by distinct cultures that have been interacting continuously for thousands of years [14]. At the time of European contact there were extensive trade networks throughout the archipelago and north to the Solomons and south to New Caledonia. These trade networks exchanged a wide variety of raw materials, plants, animals, brides, and also license to intangible cultural ideas such as songs and specific designs among groups speaking different languages, often on different islands [10]. Brides exchanged among these networks encouraged multigenerational friendships through kinship and bilingualism.

Since 2007, researchers have been longitudinally tracking the health consequences of market integration across a gradient of modernization within Vanuatu. These studies that now include five islands that vary in degree of infrastructure, access to processed foods, and control of malaria have demonstrated increasing levels of chronic disease with increasing modernization among and within islands [13], [18], [22]. These data indicate that the health of Ni Vanuatu are increasingly eroded as they seek to emulate the international market economies.

C. Experimental Study Plan at Vanuatu

In our plan, a proof of concept prototype of the BlendTBS system will be customized for a field study in Vanuatu. This Vanuatu-BlendTBS system will include an intuitive, icon driven interface designed to be easily accessible by the people of Vanuatu and likely other developing regions where formal education is limited, but where mobile phones are increasingly common. The Vanuatu-BlendTBS system has two primary functions that will allow participants to

exchange effort/labor (time) and also to reward or penalize pro- and antisocial behavior that they directly observe. Each participant's transactions will be recorded and encrypted in the blockchain. The continuously updated time credit score of each participant and the transactions and ratings from which it resulted will be observable by all. Once the prototype is developed, the team will travel to the island of Aneityum and recruit testers to pilot the Vanuatu-BlendTBS system over a one month period.

The village of Analgahuat on the island of Aneityum, Republic of Vanuatu has been chosen to pilot the Vanuatu-BlendTBS system because people living there have a number of characteristics that mirror or facilitate the adoption of the BlendTBS system, unlike most people of the US and other industrialized countries. These characteristics include that all island residents are related and well-known to each other, all land is collectively owned by extended families, and a primarily decentralized economy based on subsistence agriculture and small, nuclear family run tourist ventures. Analguhuat is the main village of the island and has a cell tower that provides sufficient local coverage required for the Vanuatu-BlendTBS system. We expect that system testers will be able to provide meaningful pilot data for our system without substantially altering their daily lives. We seek to design a system that allows testers to conveniently track ongoing interactions that characterize their current decentralized economic behaviors and will thus have utility to their daily lives.

V. Conclusions

In this position paper, we proposed to develop and apply BlendTBS, a blockchain-enabled decentralized time banking system, to explore a better understanding of a social value system in the context of exchanging economies. Although the experimental study will be conducted at the village of Analgahuat on the island of Aneityum, Republic of Vanuatu, we expect the insights gained will also benefit developed countries. The BlendTBS is expected to encourage people to actively participate in socially beneficial activities, and those who have trust-keeping behaviors will get benefits of more credits and obtain higher priority in the community. Consequently, the BlendTBS system will encourage the residents in the communities to behave nice and make the entire community more trustworthy and safer. Authors hope this position paper may inspire more interests in the roles that blockchain technology can play in modern society.

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