Blockchain Based Green Coffee Supply Chain Management to Improve Traceability and Transparency (Case Study on Sidama Coffee)

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Abstract. Ethiopia is one of coffee producing countries in the world, especially it is known for coffee Arabica. The coffee supply chain includes different participating organizations from its production place up to its consumption in the international market. Ethiopian coffee suffers from the two most prominent supply chain problems which are provenance traceability and transaction transparency for the participating parties. In this paper, we tried to implement blockchain technology for the Ethiopian green coffee supply chain to improve traceability and transparency by using Sidama coffee as case study. Distributed ledger technology was proposed to solve those problems by distributing a record of coffee transactions throughout the network participants. Among available blockchain technologies, we choose Hyperledger blockchain technology because it is suitable for business to business (B2B) model. We were able to design and implement a number of smart contracts using Hyperledger composer modeling language based on our field study and deploy them in the underlying Hyperledger Fabric blockchain network. The prototype system was able to create a traceable route for the coffee by recording every transaction in an immutable and untampered way and the transactions were transparent for participating parties since they get an exact copy of ordered transaction as a block. We also were able to solve confidentiality issues in the network by implementing multiple channels in the network.

Keywords: Supply chain · Traceability · Transparency · Distributed ledger technology · Blockchain · Hyperledger fabric · Hyperledger composer · Coffee · Peers · Smart Contract

1 Introduction

1.1 Background

A supply chain is the network of all the individuals, organizations, resources, activities, and technologies involved in the production of a commodity and Marketing of produced

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commodity to the different market places [1]. This involves multiple processes, from the procurement of raw materials, to design and fabrication of products by manufacturers, delivery of the resulting product to consumers, and can even include post-sales logistics support. Supply chain management (SCM) integrates all of these steps and orchestrates the people, input materials, processes, and technologies required to ensure a smooth flow. Given the complexity of most supply chain networks, there are many challenges associated with managing supply chains.

Coffee is the main source of the economy and culture of different countries throughout the world. Among those countries, Ethiopia is well-known as the origin of Arabica coffee that produces largely in the country [2]. Ethiopia's coffee has its own peculiar quality produced in the different parts of the country. Ethiopia produces coffee in different production systems like forest, semi-forest, garden, and plantation that made the country unique from other coffee producing countries. Although coffee is a traditionally worldwide traded cash crop with new markets emerging, many agricultural dependent developing countries like Ethiopia are struggling with the production and marketing of their coffee [3]. Coffee is the most important crop in Ethiopia even it is the most influential commodity to the national economy and it is also the leading export commodity. It plays a crucial role in generating foreign currency to the country at a large level. Coffee supply chains are often complex, with beans sometimes changing hands of times on the journey from producer to consumer. Small farmers typically sell their coffee beans to local traders, often agents for big coffee millers and exporters, who transport the coffee to the processing plant.

Blockchain technology is a distributed ledger that can record transactions among different participants as a cryptographical chain of blocks in a verifiable and permanent way [4]. It is a relatively early-stage technology when compared with the most prominent implementation current cryptocurrency like Bitcoin and Ethereum. Blockchain is a replicated distributed ledger technology (DLT) that verifies and stores transactions occurring in a peer-to-peer network [5, 6]. At its core, blockchain is a distributed ledger technology that leverages the resources of a large peer-to-peer network to verify and approve transactions [2]. These transactions are recorded chronologically in blocks and the blocks are linked together cryptographically and stored permanently on the blockchain which creates an immutable chain. The blockchain data structure is a timestamped list of blocks. Blocks are containers aggregating transactions. Every block is identifiable and linked to the previous block in the chain through cryptographic hashes.

Smart contracts [7] are semi-autonomous programs running on the blockchain. They can store and update variables and instantiate and invoke other smart contracts. It is a computer code running on top of a blockchain containing a set of rules under which the parties to that smart contract agree to interact with each other [8]. It is a computer protocol that facilities the transfer of digital assets between parties under the agreed-upon conditions. It is similar to a traditional contract in most ways including the definition of rules and penalties around the agreement except for the fact that it can also enforce the agreed-upon obligations automatically [9]. If and when the pre-defined rules are met, the agreement is automatically enforced. The smart contract code facilitates, verifies, and enforces the negotiation or performance of an agreement or transaction. Once launched, smart contracts are fully autonomous; when contract conditions are met, pre-specified and agreed actions occur automatically.

Blockchain has been employed for a number of use cases starting from its first implementation [10] for peer to peer Bitcoin transaction management. Even though Bitcoin was the first double-spending free peer to peer transaction, after that a number of cryptocurrencies platforms have been innovated like Ethereum [11], Corda [12], and Hyperledger Fabric [13]. Ethereum was the first blockchain infrastructure with smart contract implementation in addition to Ether cryptocurrency with a solidity programming language for business implementation.

Based on the participation of peers in the consensus process, blockchain platforms can be divided into two [14]. The first form of blockchain platform is known as a public blockchain platform. It means that the network is available for the public and any interested peer can be part of the network and participate in the consensus process. Among a large number of platforms, Bitcoin and Ethereum are the two most common digital currency platforms of public blockchain. Ethereum platform is not only a digital currency but also able to execute programmable smart contracts which can automate digital world contracts and process [9]. Ethereum is the most popular platform for smart contract development on the public blockchain infrastructure. The second form of blockchain is known as permissioned blockchain platform. In this type of platform, each participating party should have a digital credential and need permission to participate in the network consensus process. The main purpose of permissioned blockchain platform is to create confidentiality on transaction execution and ledger distribution and increase throughput [14]. Hyperledger fabric is the most dominant type of permissioned blockchain which is developed by Linux foundation.

Blockchain technology can potentially be applied to a wide variety of industries, including energy, supply chain, food safety, education, finance, insurance, medical, etc. IBM uses Hyperledger Fabric to implement a diamond supply chain [15]. The implications for supply chain management are promising, as it could provide a solution to the current challenges faced and help the overall supply chain become more efficient. By using a decentralized database to provide a shared reality across non-trusting entities such as suppliers, manufacturers and even consumers [7], a blockchain can improve transparency and traceability in the supply chain process. In the research work [16] the researchers use blockchain technology for school information management to create an immutable school record. As pertinent information regarding the physical goods and other relevant events are securely and reliably recorded on the blockchain, smart contracts can also be used to automatically execute when specific conditions are met [7, 14]. This provides flexibility and can help to simplify the complex multi-party systems that a supply chain typically consists of. Although the use case is clear, actual implementations of blockchain technology in SCM are yet to proliferate widely. Hence, more research is required to investigate the possibility and practicality of such an application. In our knowledge, there is no implementation of blockchain for coffee supply chain management especially in developing countries like Ethiopia use case which is saturated more than enough bureaucracy and unstable traditional system.

1.2 Problem Statement

As discussed above, the Ethiopian coffee supply chain encompasses all of the activities starting from the earliest stage of coffee plantation and collection up to the final stages of end-users or consumers. With the impact of globalization, supply chains typically cross the boundaries of both organizations and countries. Through all this stage there are a number of direct participants including the farmers (growers), collectors, exporters, primary coffee processors, secondary coffee processors, coffee roasters, and international coffee buyers. All the above participants (stakeholders) are direct participants; meaning they are the one that transacts the coffee supply chain business. Also, there are indirect participants like, Ethiopian Tea and Coffee Authority (EthioCTA), Ethiopia Commodity Exchange (ECX), regional organs, certification institutions, etc. on the chain to manage and control the market activities.

In between every transaction point, there is at list one contract paper that needs the third party for approval and including the contract paper, there is an enormous amount of data flows. So, throughout the coffee supply chain network, there are a number of processes and relationships across the stakeholders. All of those processes and relationships need proper management mechanisms in order to ensure the smooth operation of the Ethiopian coffee supply chain.

Having all the above participants, asset, business relation, and communication between them; there are different issues which need more attention for a better outcome in the coffee supply chain. The issues include involvement of third parties in the transaction, being difficult to trace coffee provenance and history in a digitized way, transactions are not transparent within the specified chain line for its participants, and trust between participating parties are impossible to build trust through reputation in the current supply chain system. Now a day Ethiopia's coffee is losing its price in the international market due to one or more of the above problems. Specifically, the international market complains about the coffee traceability including its production process and origin and purity. Also, through time, the existing market becoming more unfair especially for coffee farmers due to none transparency in the market. In addition, the system is vulnerable to black-market, which make the country lose lots of foreign currency.

In this paper, we propose a blockchain-based smart contract system to solve traceability and transparency issues in Sidama green coffee supply chain. What we believe is through a distributed ledger system it is possible to trace the provenance of coffee in the supply chain and it going to be easy to make transactions transparent among the participating parties while keeping the confidentiality of private data's in the supply chain network.

2 Methodology

2.1 Data Collection and Requirement Formulation

The data collection was undertaken in two phases. The first one is a visit to different stakeholders at Addis Ababa including EthioCTA, ECX, and Sidama Coffee Farmers' Cooperative Union (SCFCU). The second phase was the visit and data collection at Hawassa and nearby coffee growing and processing towns.

The collected data from different sources were analyzed in a way that suitable for blockchain-based system design and implementation. Other than the scientific literature, we used Federal democratic Republic of Ethiopia (FDRE) proclamation No.1051/2017 “Coffee Marketing and Quality Control proclamation” proclamation page 9657, FDRE Regulation No. 433/2018 “The Coffee Marketing and Quality Control Council of Ministers” Regulation page 10568, and “Coffee Marketing and Quality Control Directive” Directive page 002/2018.

Existing Supply Chain Model for Sidama Coffee. In our field study what we found is that, there are a number of participants in the Sidama coffee supply chain. Participants include growers, investors (commercial producers), suppliers, exporters, and coopera-tives/union. According to [15], the Ethiopian government establishes six coopera-tives/unions and SCFCU is one of those cooperative unions.

Sidama zone has 12 coffee-producing districts and throughout those districts SCFCU has 57 cooperatives unions with a total member of 86,658 farmers. Also, there are 112 direct exporter growers, each of them has more than 2hectare farms for coffee production, and coffee suppliers, who collect coffee from growers and sell their supply coffee product to ECX. In general, the total area to be cultivated by coffee in Sidama zone is about 80,592.24 hectares, among this amount of area 43,120.44 hectares cultivated with organic coffee in those 12 districts.

Then based on the above finding we tried to put a picture of the Sidama coffee supply chain as shown in Fig. 1. As clearly shown in the diagram, there are four main routes of the Sidama coffee supply chain. The first and the most common way are done through the ECX market including farmers, suppliers, and exporters as the main participant. The second path is through cooperative union in which at the lower level near to farmers there are farmers’ cooperatives of coffee grower and primary processor and in the upper level as exporter there is one cooperative union. The third path is direct exporter investors who have legality in coffee farming, processing, and exporting from the government. The last one is coffee growers who have the power to export directly to the international market and have such legality from the government.

Related to our research parameters, which are traceability and transparency, we found the following point from the data collection process.

- There has been a pilot physical project by ECX for coffee traceability before around three years ago. But it fails due to management problems like sorting, leveling, loading and unloading by man power. But still, there was no support from ICT based traceability implementation in the market.
- As we expected while starting this study, what we found is that transaction transparency is the main problem in the system.
- Also, black market is another main problem in the market process which makes the country loses lots of foreign currency.

2.2 System Setup

For the design and development of a prototype system to undertake an experiment on the proposed system local blockchain environment was established using the following hardware and software resources.

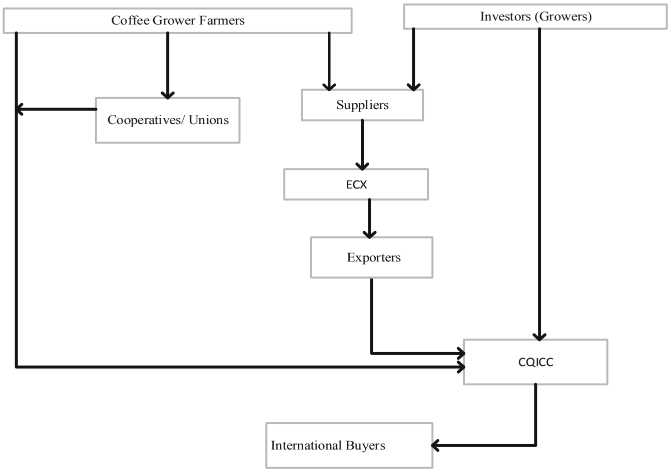

Fig. 1. Coffee marketing supply chain of Sidama coffee

Hardware Setup. For the deployment of Hyperledger Fabric blockchain node network local area network was established using six computers with the following specifica-tions.

- Five of them were HP computers with single socket 3.5 GHz speed, six core, 8 GB primary memory, and 1 TB HDD
- One Dell with single socket 3.6 GHz four core, 16 GB primary memory, and 5 TB HDD
- **Software Setup.** On top of the above hardware setup, different software setups were approached. Since the numbers of participants are much greater than six nodes, vagrant is used to design the virtual machines for the blockchain participant node. To orchestrate and configure the fabric peer network Ansible orchestration tool was used.

For the blockchain network infrastructure design and deployment Hyperledger fabric peer docker image was used. The process of selecting a blockchain platform should be derived from understanding the application area use case. In our research, the use case has B2B nature based on participants, interactions and asset transactions. So, we choose Hyperledger Fabric blockchain platform for our system blockchain implementation.

So, having Hyperledger Fabric there are different platforms and tool which makes application implementation and development easy enough. Among the list of tools we choose to use Hyperledger Composer for business network (Smart contract) development using object-oriented modeling language.

3 Design and Implementation

Almost all businesses are involved in exchanging some form of values. They exchange those values from one firm to the other in the business process through their agents or workers. While exchanging value they try to keep their own book of records which is the ledger of value exchanges by the respective business firms. In the context of Hyperledger fabric blockchain; there is a concept of an asset, which can be tangible or intangible, to represent values [18]. Value exchanges are formulated to a transaction which transfers the asset in the business process. The participants of the network commit the asset transaction in the network. So, in Hyperledger fabric, blockchain means it is a distributed chain of blocks throughout the network peers, where each block is a committed transaction to transfer assets from one firm to other by participants.

Table 1. Green coffee export supply chain participants

No	Participants	Role in the business network
1	Coffee grower	The main grower of coffee in the region including farmers and small-scale growers
2	Coffee supplier	The one who collect coffee from grower, process it to supply coffee and sell to exporters in ECX market
3	Coffee exporters	They buy supply coffee from coffee suppliers, process it to export coffee, create a contract with foreign buyers to sell export coffee, and sell their coffee based on their contracts
4	Commercial producers	They are coffee grower supplier coffee processor and event exporters
5	Union/Cooperative	They collect RCCP only from their members, they process supply and export coffee in their industry and they sell coffee for external buyers
6	EthioCTA	They control coffee production, processing and export process in general. They give export license for potential traders, they support farmers for better productivity
7	ECX	It creates a market system for supply coffee in the country
8	Coffee quality inspection and certification center (CQICC)	They inspect export coffee and certify its quality
9	Regional Organ	They follow RCCP and supply coffee production and primary markets
10	ECX warehouses	They give coffee quality inspection, grading service, and warehouse service for supply coffee

So, based on the data collected from our field study, we identity the participants and assets of the green coffee export supply chain in Sidama coffee as list in Table 1 and Table 2 respectively.

From the above list of participants from 1–5 are traders, means direct participants of the business, and from 6–10 are governmental regulatory and controlling indirect participants.

Table 2. Green coffee export supply chain assets

No	Assets	Description
1	Coffee	It is the main asset in the supply chain. It has different forms in different market places like at primary market red cherry coffee or coffee with pulp, at ECX market supply coffee and at international market export coffee
2	Contract	It is an agreement between two or more traders in the network like export coffee contract, contract between exporter and grower, etc.

Among a number of transactions in the Sidama coffee supply chain we tried to aggregate those transactions in some group and we select the following three transactions for this system implementation and testing purpose. The first transactions as shown in Algorithm 1 is simple coffee sell and buy between two parties which transfer the ownership of some amount of coffee with some amount of price. It is the most common transaction in different levels of the coffee supply chain, especially in the ECX market line. The second and the third transaction as shown in Algorithm 2 and Algorithm 1 are contract-based coffee transactions in the supply chain network.

Algorithm 1. Coffee transaction pseudocode

```
Input: coffeeSeller, coffeeBuyer, coffee[], transaction Centeer,
coffeeType, unitPrice, transactionStatus, physicalAddres
Output: tx
if coffeeSeller is valid id or coffeeBuyer is not valid id then
  throw error
else
  tx.coffeeBuyer.coffee[] <- coffeeSeller.coffee[]
  tx.coffeeSeller.price <- coffeeBuy
  er.coffee[]*coffeeSeller.unitprice
  tx.transactionCenteer <- transactionCenteer
  tx.date <-current system date
  tx. physicalAddres <- physicalAddres
  tx.transactionStatus <- transactionStatus
  tx.timestamp <- current system datedate
return tx
```

Algorithm 2. Contract agreement transaction pseudocode

```
Input: coffeeSeller, coffeeBuyer, coffeeType, quantity, unit-
Price, SellerRight, SellerObligation, buyerRight, buyerObliga-
tion, deliveryPlace, expiryDate, contractType
Output: contract
  if coffeeSeller is valid id or coffeeBuyer is not valid id
  then
    throw error
  if coffeeSeller or coffeeBuyer dicard then
    throw error
  if ethioCTA not approved the contract then
    throw error
  if ECX not register the cotnract then
    throw error
  contract.coffeeBuyer <- coffeeBuyer
  contract.coffeeSeller <- coffeeSeller
  contract.SellerObligation <- SellerObligation
  contract.SellerRight <- SellerRight
  contract.buyerObligation <- buyerObligation
  contract.buyerRight <- buyerRight
  contract.deliveryPlace <- deliveryPlace
  contract.contractType <- contractType
  contract.quantity <- quantity
  contract.unitPrice <-unitPrice
  contract.expiryDate <-expiryDate
  contract.contractDate <- current system date
return contract
```

Algorithm 3. Contract delivery pseudocode

```
Input: contract, coffeeSeller, coffeeBuyer, coffee [], quantity,
deliveryPlace,
Output: tx, contract
  if coffeeSeller is valid id or coffeeBuyer is not valid id
  then
    throw error
  if contract is expired then
    throw error
  if contract.quantity greater than zero then
    throw error
  tx.coffeeBuyer.coffee[] <- coffeeSeller.coffee[]
  contract.quantity <- contract.quantity - quantity
  tx.coffeeSeller.price <-
  coffeeBuyer.coffee[]*contract.unitprice
  tx.deliveryPlace <-deliveryPlace
  tx.date <-current system date
return tx, contract
```

3.1 Hyperledger Fabric Elements and Our Design Perspective

As stated in the introduction section, Hyperledger is the project under the Linux Foundation for the incubation of blockchain technology for business. It contains two categories of technology which are DLT frameworks with four initiative including Hyperledger fabric and tools including Hyperledger composer [19]. As mentioned above, for the proposed blockchain green coffee supply chain system we used Hyperledger Fabric, which is production ready framework, as a blockchain framework and Hyperledger composer as a business network development tool. Fabric is a framework that means it is not a platform like database management systems and web servers rather fabric is a set of infrastructure and application building blocks with practices and guidelines for creating blockchain applications [18]. So out of this framework based on the specific blockchain application requirements, it is possible to create infrastructure design that would use in the blockchain building block. So, in application development (chain code/smart contract/business network), we can access the underline infrastructure using standard components, API's, and functions. Hyperledger fabric basically has the following infrastructure elements.

Peers are primary concepts in Hyperledger Fabric since they are the backbone of the network. A peer is a Fabric application component that runs in a Docker container and is responsible for maintaining a copy of the ledger and providing programmatic access to the information on the ledger via the world state database [20]. An organization will typically have more than one peer, primarily for high availability. There are three types of peers which are

- Committing Peer: maintain leger and state. Commit transaction, may hold smart contract/chain code

- Endorsing Peer: Specialized committing peer that receives a transaction proposal for endorsement, response granting or denying endorsement, must hold a smart contract

Orderer node (Part of ordering service), approves the inclusion of transaction blocks into the ledger and communicates with committing and endorsing peer nodes. It does not hold either a smart contract or a ledger. Ordering Service is the network-level service responsible for determining the order in which transactions coming from any participant in the business network should be committed to the ledger which is the consensus process in literal blockchain definition.

Since Hyperledger Fabric is a private, permissioned blockchain, identity plays a critical role. Identity of individuals as well as Fabric Components such as peers and orderers are defined by their certificates from a pluggable Membership Service Provider (MSP). Any certificate authority can be (and often is) used, but Fabric also includes one in the box, called the Hyperledger Fabric Certificate Authority (CA).

Channel is a means of creating one-to-one private communication between channel participating peers. Each channel has its own private ledger record. So, channel in Hyperledger fabric is meant for the implementation of data and transaction confidentiality.

Based on the requirements we formulated above and the nature of the selected blockchain framework, regarding Hyperledger fabric infrastructure we suggested the following combination of elements as a design specification for the proposed system.

In business, organizations own the business values and they transact those values between them. In Hyperledger fabric network those organizations can be transformed as potential security domains and units of identity and can participate in the network through their peers [21]. They use their MSP to issue identities and certificates for their peers as well as clients for smart contract access privileges. The ordering service should be implemented as a separate organization with ordering peer only.

So, what we suggest is that every legally identified organization should be participated at least as a commuting peer to hold ledger. Governmental organizations should provide commuting peers since they act as legal regulators in most transactions. Growers and personal participants can be a member of authority organs and get their credential from them. Each organization, who contributes peer to the network should contain MSP-CA for network credential management. Every endorsing peer from any organization should contain the chain code. So, as shown in Table 1 while the system implemented it needs a minimum of ten organizational peer nodes.

As shown in Fig. 1, the Sidama green coffee supply chain has a number of vertical routs between different coffee traders which are independent of each other. Governmental organs are almost part of every rout of the network. The data and transaction in each rout should be confidential and transparent for their respective routes. So, in Hyperledger fabric infrastructure, we suggested transferring every rout to channels in the network. Regarding ordering service, we used a solo orderer for prototype testing but for real-world application design, we suggest Apache Kafka for stability and availability [22].

3.2 System Implementation

In the proposed system implementation process the first task was creating the local network by assembling the physical devices. The six computers were connected locally based on the universities network through data link-layer switch and each of them run Ubuntu 16.04LT Linux distribution. Since six nodes are not enough to host the proposed system organizational peers, we create a virtual environment on each computer with the following specification using virtual box software and vagrant tool.

- 2GB primary memory, storage expandable up to 50GB HDD, bento/ubuntu-16.04 vagrant box,

Then the Hyperledger Fabric infrastructures were orchestrated in the established network using Ansible automation tool based on each experimental setup. The smart contract was developed using Hyperledger Composer model language and deployed the network using composer CLI commands.

4 Result and Discussion

The system was implemented step by step starting from the blockchain infrastructure up to smart contract development and deployment. We implemented a smart contract for two types of asset moments in the supply chain using Hyperledger composer and deploy the resulting chain code on our design and implementation of Hyperledger Fabric blockchain infrastructure. A number end to end of tests were undertaken in the implemented system. In the system clients of a respective organization can submit transactions to the blockchain network and after the execution of those transactions; blocks are created and added to the chain as shown in Fig. 2.

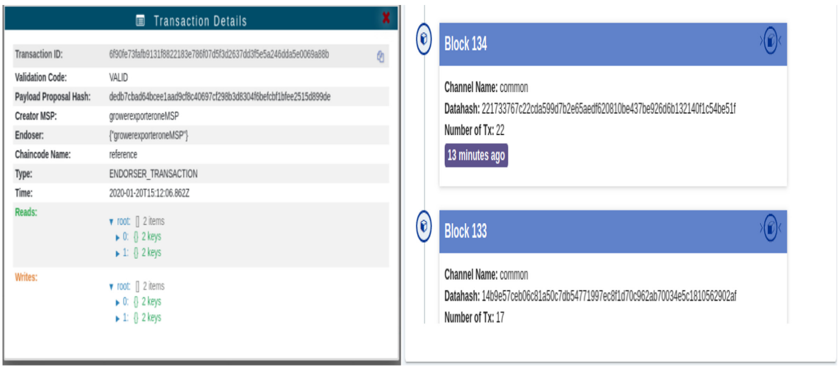

Fig. 2. Sample transaction detail after execution and added to a block and two consecutive blocks

4.1 Single Channel Configuration

First, we implement the system with a single common channel throughout the network in which all the participant organizations were part of the one common channel. What we found in this experiment is that whenever any transaction made in the business network all participants will be notified and get a copy of the block to add to their ledger then the transaction become transparent enough throughout the network.

The main problem within this configuration is each participating organization are part of every transaction processing which potentially slow down the network especially in transaction pick time because the ordering service operation is done is sequential. Since every commuting peers of the participating organization get the copy of the block in its ledger, confidentiality of transactions has a possibility of being compromised in the business process. The worst case is if the endorsement polity is vulnerable for error or mistake in the deployment process of smart contracts to the underlying blockchain chain infrastructure the endorsement process in system is may fail totally.

4.2 Multiple Channel Configurations

Then we configured the network from single channel infrastructure in to four channels to resolve the above problems in the first experimental result. Based on the existing market route as shown in Fig. 1, the first channel two channels were exemplary channels based on the business interaction between SCFCU and their member cooperatives, the third channel is an exemplary channel for direct growers and investors and the last channel is an exemplary for the normal supply chain route through the ECX market. EthioCTA, CQIC, and SNNPR have commonly participated in all four channels since they are a regulatory and controlling organization in the Ethiopia coffee supply chain network.

What we found in this experiment is that transactions are endorsed only by those endorsing peers of organizations who are responsible for the operation held by the specified transactions and the members of the channel get the copy of the block to be chained in their ledger. So, transactions are transparent within the channel and it is confidential from outside on the specified channel. Also is improves the speed of the system because all four channels can commit and order transaction in parallel.

4.3 The Effect of Number of Peers Per Organization

Within multiple channel setups, two experiments were undertaken which are single peer per organization and two peers per organization to test the availability of the organization on the network if one of its peer crashes. Then in both setup, we try to kill randomly the peer container of an organization in the network. In single peer node case availability is compromised in such peer shutdown cases since it only has one anchor peer. But when a node has two or more than two peers in the network if one of them fails even the anchor peer itself the rest of the peer will continue their participation in the network. Since the crypto operations in the peers are resource intensive while we increase the number of participating peers per organization it slows down the system as shown in Fig. 3.

The system was able to record every transfer of coffee in the network and create a chain of blocks that could be used as a single source for the history of the coffee

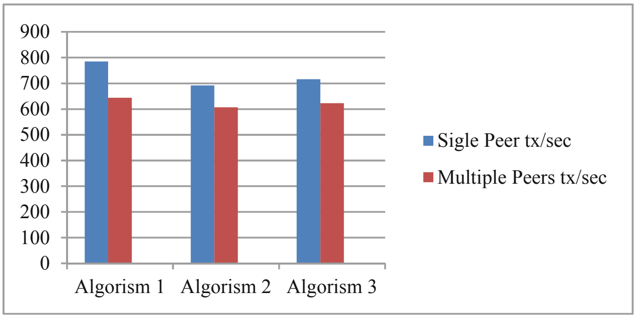

Fig. 3. Transaction throughput over single peer setup and two peer setups

rout in the supply chain. At any point in the network, we were able to trance where the coffee comes from with its detailed information. Also, the system was able to create a business contract between participating parties without the involvement of third and transact coffee based on the agreed-upon contract.

5 Conclusion and Recommendation

This paper tried to investigate the existing Ethiopia green coffee supply chain using Sidama coffee as a case study and it design and develop a blockchain-based solution to improve the most prominent problems which are traceability and transparency. The implemented prototype system was able to implement the most critical transactions which are the exchange of coffee products and a contract between participating parties. We were able to implement the blockchain network architecture for thirteen organizations based on the available resources. In the implemented system every transfer of the coffee was well recorded in the system with full information and the executed transaction were shared among participating parties which gives a single truth about coffee history in the supply chain. So, the resulting system makes coffee traceable throughout its journey from its source up to its destination. Since every participating organization gets its own copy of the ledger transparency was confirmed in the system. A Single network implementation architected had a problem of confidentiality but is solved using a multichannel system.

In the near feature, we plan to work on more detailed experiments like implementing more crash tolerance consensus mechanisms, incorporating more transactions in the system, and assessing mare scalable network architecture.

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