

# Blockchain Design for Securing Supply Chain Management in Coffee Retailer Network

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## ABSTRACT

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Blockchain is a trusted distributed ledger shared across the business processes. Blockchain technology focuses on automating tasks in a distributed environment. Proving as one of the effective platforms, it helps in mapping the physical commodities to the digital ledger. A digital ledger is like an electronic register for storing the transactions that are taking place among various commodities. The physical commodities include suppliers, manufacturers, exporters, consumers and distributors wherein the distributor plays a major role in determining the product standards. To this end, this paper presents a Blockchain design for securing Supply Chain Management (SCM) in Coffee Retailer Network (CRN). The proposed design made with the view that it further be implemented with smart contracts to establish a private or consortium Blockchain application for the asset tracking processes in the coffee retailer network. The proposed model can bring transparency, sustainability and efficiency in asset tracking.

**Keywords :** Blockchain, Coffee Retailer Network, Logistics, Smart Contract, Supply Chain Management (SCM)

## I. INTRODUCTION

Tracking the physical commodities and providing transparent information are two of the most important aspects in logistics management, helping in the foundation of logistics as well as its optimization in the transactions of business and trade of relationships are done more easily with a system that is secured robustly. Understanding every detail of

every product in the supply chain using a trustworthy, secure and shared record can be done via Blockchain technology. A Blockchain network comprises of four basic properties that helps in providing its users with reliability and integrity in a SCM system. They are as follows :

### 1) Consensus

When there are multiple nodes performing the same task, it sometimes becomes tedious for the network to

identify that which node has succeeded in performing the task. Thus, to make sure that whether the tasks are valid, a common agreement between the nodes has to be ensured. Bitcoin [1] Blockchain uses this property to make sure that the transaction fired is valid and all nodes agree to the same.

## 2) Provenance

All the nodes verify each block in a Blockchain network and entire information about the block is present to the network before it is appended to it.

## 3) Immutability

Other users of the network are not allowed to erase, change or falsify their tasks in the network and only a new transaction addition can be made once the previous information is provided.

## 4) Finality

The copies of the shared ledger all hold the consistent record of truth and updates the records every time the network undergoes a change. What works for the Bitcoin network also works for any other Blockchain network including the supply chain.

In addition to the need for information, complicated supply chains depend on trust to function in an appropriate way. Historically, it came into observations that some organizations had distrust between them and this discouraged them from sharing or relying over the data in a shared environment. To solve this problem, a hybrid network of Blockchain named as Ethereum was introduced that proved a remedy in a shared, permission record of the ownership of the user in the network, place of origin and moving the commodities from one part to another, this helped in increasing the efficiency, transparency and developed trust for any business organization.

Few opportunities in the Blockchain are:

- Helps in concurrent access of information to all the participants in the distributed network environment.
- Leads in tracing the product and understanding its path to the destination and treatment of the product during its shipping and understanding

the storage requirements of the product are more flexible.

- Instant triggering of the risks that comes in the way while a product is shipped and analysis of real world issues easily.

Blockchain helps to eradicate the below mentioned short comings:

- Instant payment between the physical commodities like manufacturer and supplier is possible.
- No requirement of any legal firm or lawyers, bankers that add extra cost and delay.
- Easy elimination of delayed or defected products.
- Reduction in the lengthy multiple stepped procedures.

If we consider the supply chain of coffee, it starts with the extraction of the coffee beans and their processing by the suppliers so that they can be sent to the next process. The next process is called the manufacturing process in which the coffee beans are converted into coffee powder that is ready to sell. The ready to sell coffee is now sent to the distributors stage in which the distributors maintain the inventory of the product and subsequently sell the coffee product to multiple commodities i.e., retailers and wholesalers. The wholesalers further sell the coffee products in bulk to the retailer as they do not sell directly to the customers. Subsequently, the customers purchase the coffee powder from the retailer for their personal requirement and not for further resale.

Smart contracts will help companies to track the coffee products from the suppliers, maintain and coordinate the price, quality and delivery date of coffee digitally in a secure and faster manner using Blockchain technology. This also ensures the genuineness of the product by knowing how they have been transported all the way, from where they were grown (origin), bringing transparency into the supply chain system.

To this end, the objective of this paper is to design a Blockchain application that increases visibility and efficiency in the supply chain network of a coffee retailer, leading to traceable coffee trade network and solving the problem of storing critical data at different stages of supply chain and making it verifiable by all stakeholders in supply chain.

The organization of this document is as follows. In Section II presents literature survey. In Section III the proposed design of the blockchain based SCM is presented. Finally, Section IV concludes the paper with future work.

## II. LITERATURE SURVEY

Blockchain can affect the SCM system and eradicate the shortcomings of the existing SCM [1]. Yanling et al. [20] mapped the shortcoming points with the capabilities that are present in the Blockchain network and brought the capabilities and the enormous potential of a Blockchain in the following manner: -

| Supply Chain Point               | Blockchain capability         |
|----------------------------------|-------------------------------|
| Traceability                     | Auditability                  |
| Dispute Resolution               | Smart Contract                |
| Cargo integrity and security     | Verifiability                 |
| Digitalization                   | Automation                    |
| Compliance                       | Immutability and Transparency |
| Trust and stakeholder management | Disintermediation             |

To fulfill the needs in the logistics and supply chain industries, he discovered the great initiatives of having a Blockchain. Also stated the implications that Blockchain has over the governmental agencies and enabling the big scale deployment of the distributed ledger technology [2].

Some of the common research questions related to challenges of SCM are as follows:

### 1) Can Blockchain for SCM use pure Blockchain?

Blockchain for Supply Chain use private Blockchain due to the need of a trusted third party to check the condition of physical products. Sharing data with only a few parties in the network will require a third party to manage data sharing. From the author's perspective, private Blockchain might add little value over a trusted integrated database. Many of them suggested potential use cases for Blockchain enabled supply chain focus on private Blockchain; although we believe that a private Blockchain is a fundamentally different concept from Blockchain as it is commonly defined. The paper concludes that in order for Blockchain-enabled supply chain technology to reach its potential; it must be developed to adapt and extend pure Blockchain.

### 2) How can physical commodities be linked to the digital ledger?

Internet-aware sensors capture finely granular real-time data about products and environment characteristics as well as location and timestamps throughout the supply chain. So, lack of a digital footprint may no longer be an issue. Unfortunately, currently available technologies such as barcodes, RFID-tags, 3D-stamps, and sensors, have limitations that it is duplicable.

### 3) How can Blockchain-enabled networks be linked to other external markets?

Blockchain network cannot interact with other non Blockchain based networks. The connections in the network of supply chain are more complex than the simple transactions in Bitcoin, and the Blockchain that we know from Nakamoto's paper is not designed to handle the sorts of complex relationships often relevant to supply chains.

#### 4) How can Blockchain be developed/designed for complicated supply chain structures?

Relationships are often not one-to-one in supply chain. Issues arise when tracking divergent supply chains, defects, breakdowns, transformations, and so on.

#### 5) How can enough space be reserved to store the amount of information required by supply chains?

The amount of data to be stored and shared in Supply chain is huge and thus requires ways to manage this data [4].

There should be a well-established relationship between the physical parts in the management of supply of coffee and also a facility to inform the concerned authorities when a swift is made in the quality, quantity or packaging of the product. Correct and accurate commitment and coordination is needed among these physical commodities to increase the overall product quality [5].

The multiple elements of Blockchain affecting the supply chain system are consensus, privacy, location proof, performance, cost, scalability. Blockchain can provide scalability significantly by providing a networked and decentralized database in order for all supply chain parties to join. When different parties of the supply chain flow need to intercommunicate or learn information for one another, the Blockchain ledger offers such a procedure on a global scale with ease. Using Blockchain, the majority of events can be represented as electronic transactions recorded on the ledger, enabling them to execute faster and error free, increasing the system performance. Processes such as ensuring data validity and integrity or confidentiality last a significant amount of time in traditional supply chain systems, whereas Blockchain can provide these attributes as built-in. One approach is to implement the timestamp mechanism using Blockchain technology specifically for the supply chain data that is stored in external data repositories. Blockchain will not be used as database for storing all the information

as it comes rather it would be used more as a time stamping technology, having the ability to scale whenever needed for recording large data. Nevertheless, such approaches cannot be regarded as totally decentralized as they still have to rely on central trusted parties who will be responsible to validate the identity of the participators and assign the necessary credentials of the Blockchain. [9]

Blockchain can affect the existing practices or techniques used in supply chain, both in a positive and negative aspect [10]. The challenges of the traditional Coffee supply chain are visibility, traceable and security operations across the network. These challenges occurred due to the inaccuracy in the manually operated processes and the involvement of several middlemen throughout the supply chain system. The Blockchain technology enables the Coffee supply chain entities to use the Blockchain system to be connected directly in the network to receive the required information without involving intermediaries, which saves time, cost and efforts besides increasing the sustainability of the system. [8] Blockchain was found to provide the following properties- visibility, traceability, digitalization of supply chain, improved security and disintermediation [10].

There are various use cases in the logistics industry as well as the impact of Blockchain in the Logistics industry. The use cases are as below :-

- Citizen Services- Provisioning digital identities
- Retail- Encouraging and ensuring ethical, sustainable consumption
- Life sciences & healthcare- Enabling a single source of truth
- Automotive & Manufacturing- Managing physical assets with Blockchain
- Energy- Eliminating marketplace inefficiencies

The role of Blockchain in Logistics is explained in detail, such as

#### **6) Provisioning digital identities**

Governments and non-governmental organizations (NGOs) can use digital identities to provide a variety of citizen services and eliminate certificate forgery and identity theft through the development of digital identity systems that are cryptographically secure. Blockchain enables system security and facilitates trusted transactions, allowing the people with digital IDs to access a wide range of activities, including education, healthcare, voting, banking, housing, and other social benefits.

#### **7) Encouraging and ensuring ethical, sustainable consumption**

It is being applied by retailers and consumer goods manufacturers to drive fair and responsible business. Users can look up a product's supply chain history on the Blockchain-based system by scanning its QR code or NFC-enabled label with a Smartphone app.

#### **8) Enabling a single source of truth**

When data is stored on a Blockchain-based system, stakeholders gain controlled access to a single source of truth for the most current and reliable dataset. In the life sciences and healthcare industry, where data is often stored in silos and data security is paramount, Blockchain has huge potential to be deployed privately and securely.

#### **9) Managing physical assets with Blockchain-**

The representation of the physical commodities that help in enabling the tracking of the product in the past, present and future performance throughout the lifecycle of the commodity is known as a digital twin. This real case scenario shows how the manufacturers can increase data credibility and provide the protection of public safety using this technology.

#### **10) Eliminating marketplace inefficiencies**

Transformational examples include enabling the operation of self-managing utility grids and facilitating peer-to-peer energy exchanges. Blockchain technology is being used to streamline cross-border trading and back-office processes such as confirmations, actualizations, invoice generation, settlement, and auditing, reporting, and regulatory compliance across the energy trade lifecycle.

Thus, success factor is dependent on the different parties working in coalition to transform legacy processes and to jointly adopt new ways of creating logistics value [3]. Starbucks had introduced a project on developing a traceability and transparency system (Blockchain) enabling independence in the farmer's financial status and also creating a visible connection between the coffee bean farmers and the customers, also known as the enhanced "bean to cup" traceability feature [6].

### **III. PROPOSED DESIGN**

The proposed design comprises of implementation of a supply chain application based on Blockchain. Blockchain is preferred for this type of application as it can achieve the interoperable exchange of transaction information, transaction history, and transaction statements in compliance with the current industry standards. It will automate the tasks using the Blockchain platform and enables the mapping of physical commodities like grower, manufacturer, supplier, distributor and consumer. The system enables the various people associated in delivering the coffee to the intended consumers reach without any corruption using a decentralized database. The system focuses on automating the tasks of various levels over the distributed ledger technology.

### A. Objective of the work

The purpose of this work is to implement a Blockchain application that increases visibility and efficiency in the supply chain network of a coffee retailer, leading to traceable coffee trade network and solving the problem of storing critical data at different stages of supply chain and making it verifiable by all stakeholders in supply chain.

### B. Technologies Used

The framework and various other technologies may be used in implementing the proposed design. Some of them are listed below.

#### 1) Ethereum Blockchain Framework

Ethereum is used for establishing a public, permissioned Blockchain framework for the SCM application. Public Blockchain is proposed as it will be used by a number of participants all over the world and it is permissioned because admin will be the one in the supply chain process who will establish regulation in the system for the smooth functioning without any disruption or corruption.

#### 2) Solidity

It is used primarily for writing the smart contract code. Smart contracts are used for enabling the coffee product tracking processes on the Ethereum Blockchain.

### C. Advantages of Proposed Design

The major advantages of the proposed Blockchain enabled SCM are: -

1. Digitalization of the physically existing SCM system.
2. Traceability of the SCM removes the chances of corruption in the existing system.
3. Decentralization of the system leads to easy and faster retrieval of information regarding payment between the commodities, quantity of items.

4. Verifiability is possible because of decentralization of the system; we can verify the security of cargo and other physical commodities in the system.
5. Immutability and transparency is an aspect that can be ensured in the SCM system.

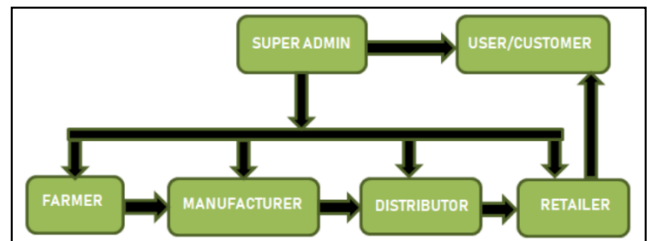


Figure 1. Flow Diagram of Coffee Retailer Network

### D. Roles in the Proposed Blockchain Application

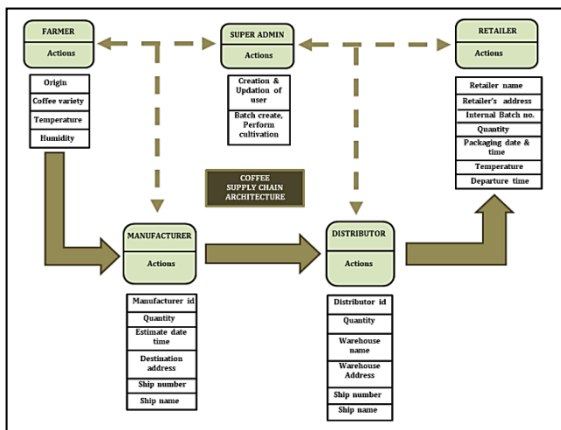
Figure 1 describes the phenomenon of how various commodities interact and maintain coordination in the SCM system of coffee using the Blockchain network. The description of the participants of the Coffee Retailer Network as shown in Figure 1 are as follows: -

- Admin- They are the main controllers of the network as they perform some of the major operations like creation of the batches as well as the users (participants) of the network.
- Farmer- Farmer grows coffee beans and after conversion of coffee beans into coffee powder, it is ready to be sent to next phase after updating details including coffee variety, temperature and humidity.
- Manufacturer- Manufacturers are the one who buys the coffee directly from the farmer (producer).
- Distributor- Warehouses and Organizations who purchase the coffee in bulk to sell it further to retailers are known as distributors (wholesalers).
- Retailer- At last, the Retailer is the one who sells the coffee directly to customers.
- Consumer- The consumer can access the whole blueprint of the lifecycle of the coffee that has

been delivered to them, from its origin to the customer's hands.

### E. Understanding general flow of Coffee Network

Figure 2 shows the architectural design of the proposed coffee network. It was made by understanding the general flow of the coffee network. The flow description is as follows.



**Figure 2.** Architectural design of the Blockchain-based Coffee Retailer Network

#### 1) Preprocessing of the Raw Materials

Every commodity submits their transaction after the successful completion of their assigned task or role in the Blockchain network. The initial step consists of the pre-processing step of the raw materials in which the suppliers submit the transaction in the distributed ledger after performing their task. The transaction log contains name of coffee variety, quality, quantity, origin. By doing this, every network party can verify important details about the specific raw material they have received. All paragraphs must be indented. All paragraphs must be justified, i.e. both left justified and right-justified.

#### 2) Manufacturing Stage

In the same way, in the manufacturing stage, the manufacturer has a similar interaction with the Blockchain network and the next chain participant. The manufacturer is able to check information about the natural resources they collected by reading and

verifying all the tags the latter includes in their transactions and then, proceed to the proper execution of the manufacturing step. New transactions with data fields, such as manufacturer name, field experience and others, are submitted after the completion of the stage.

#### 3) Distributors Stage

In this stage, the products are handed over to the distributors. The distributors further sell the coffee product to wholesalers and retailers. The transaction tag of this step consists of entities such as wholesaler/retailer name, merchant address, and exchange amount. The role of distributor is to sell the coffee product to the middle-men (wholesaler/retailer) who further sells it to the customers. The distributor can also check the latter's transaction tag containing origin of coffee beans, quantity, quality, manufacturer's name and many more.

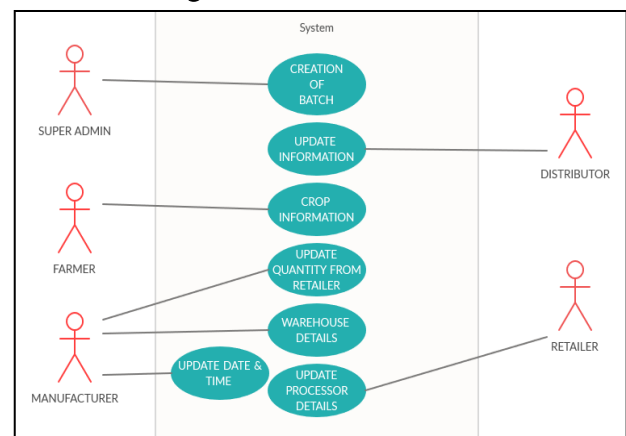
#### 4) Retailer of the Network

The same applies to the next wholesaler/retailer organization and their transaction tags consist of customer name, quantity.

#### 5) Coffee Consumer

Consequently, the consumer receives the final coffee product that they ordered along with the ability to check the lifecycle of the SCM of the coffee that they just purchased.

### F. Use Case Design



**Figure 3.** Usecase of the proposed system

The use case diagram shown in the Figure 3 depicts the different roles perform in the system and the permissions they have to update/modify batch of the coffee product. The use case shows that the interaction of stakeholders with the system. For example, Super admin creates the batch. With this distributors update the information from their where houses. Farmers and manufacturers can update the respective information such as crop information and product information. Finally, retailer can update the processor details.

### G. Functionalities of the proposed Applications

Figure 4 shows the smart contract design depicting the admin role activities. The various activities that can be done by admin and the users are listed as below:

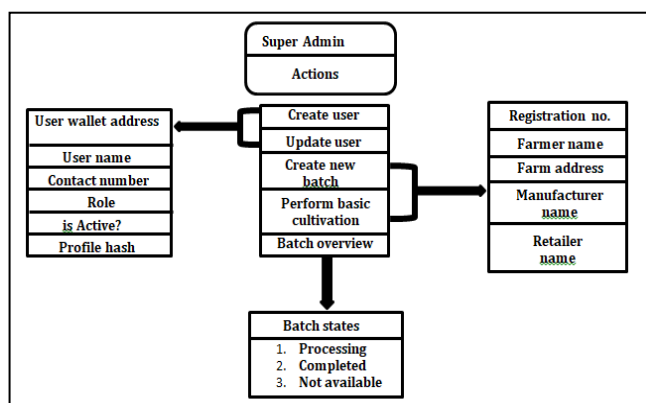


Figure 4. Admin role activities in smart contract

#### Admin Activities

##### 1) Creating Users

- Adding new user into the coffee supply chain network can only be done by the admin.
- In “Add User”, admin have to provide basic information of user like user wallet address, username, user contact no, user role, user status determining whether the user is activated or deactivated.
- Users can perform the functionalities of his role only if he/she has activated status.

- Admin can find out the newly added user in the user’s list.

##### 2) Creating New Batch

- To add new coffee batch.
- Here, you have to provide basic information of batch like Farmer’s Registration Number, Farmer’s Name, Farmer’s Address, Manufacturer’s Name and Retailer’s Name.
- By submitting “Add Batch”, you create new batch which can be updated by other roles in the further phases.

##### 3) Batch Overview

- Get all coffee batch information in batch overview and at what stage, the batch is processing.
- Admin can also check out the transaction details of any batch.

##### 4) Coffee Batch States

- Processing: when the stage is in process
- Completed: when the stage is completed by respective roles
- Not Available: Batch not reached up to this stage

##### 5) Update user

- Update of user profile can only be performed by an admin whereas a user cannot modify this information.

#### User Activities

##### 1) Batch Updation by Farmer

The role of the farmer is to update the batch information like origin and variety of coffee, temperature and humidity in which the coffee beans should be stored. After successful submission of farmer’s information, the batch progresses to the next step which is manufacturing.

##### 2) Batch Updation by Manufacturer

Manufacturers update the information regarding quantity, destination address, ship name, ship number, and estimated date time and manufacturer id.



### 3) Batch Updation by Distributor

In this phase, the distributor has to update the information consisting of details regarding quantity, Warehouse name, Warehouse address, Ship name, Ship address and Distributor's id. Consequently, distribute the coffee product to the various retail organizations.

### 4) Batch Updation by Retailer

Retailer has to fill the information of quantity, temperature, internal batch number, packaging date, retailer name and address of the retailer. Hence, this is how the Coffee Supply Chain completes for one batch.

### H. Observations

The proposed supply chain network of the coffee retailer using the Blockchain can provide the following according to our observations: -

1. Facilitation of fair trade with equality in prices have enhanced levels of transparency and scalable.
2. The needs that are required to be addressed for the physical commodities that are present at different parts of the trading areas can now be reported on time to the concerned authorities.
3. Tracking the origin of the physical parts and getting an insight about the quality is possible and there is an increase in the trustworthiness among users of the network.
4. Improved utilization of product like coffee which is used by people around the globe.
5. Quick analysis of the conditions and understanding the future repairs or the required replacements.

### IV. CONCLUSION AND FUTURE WORK

A supply chain management system using the Blockchain technology helps in ensuring consistent and reliable maintenance of the information digitally. Usage of a decentralized application results in

eradication of any corruption that can be done by the middlemen in the supply chain of coffee and they also foster simplification of data transfer and integration of various networks. It helps in providing the tool that help in removing frauds and errors, hence enhancing the trust relationships between consumers and partners. Overall, it provides the capability of digitization of the coffee trade at a global level that streamlines shipping with efficiency.

The proposed system has fully digitalized the movement of coffee commodities from its origin to the end users. To speed up the process, we can attach RFID tags on the coffee products which will then be scanned and the batch details will be updated automatically in a second. This will ease the labor work as well as decrease the time spent in supply chain process management and improve the customer satisfaction.

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