ISSN No:-2456-2165

Ethereum System for Coffee Supply Chain Management

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Abstract:- Blockchain technology has attracted popularity in recent years, and numerous applications have emerged as a result of this technology. The cryptocurrency Bitcoin is a very well-known Blockchain application. The BTC network has not only found the solution against 51% attack, but it has also made it easier to confirm the rightfulness of transferable records without the use of centralised systems. As a result, any application that uses Blockchain technology as its foundational architecture confirms that the contents of its data are destruct proof. This paper uses a decentralised blockchain technology approach- so that all stakeholders in a coffee supply chain do not rely on third-party organizations or authoritative governing bodies for streamlining the whole process of coffee supply chain management. In this paper, we describe a decentralized application on the Ethereum Blockchain for solving, three main issues pertaining to coffee supply chain management: transparency, material traceability, and data accessibility.

Keywords:- *Blockchain, Smart Contracts, BTC, Decentralized Application.*

I. INTRODUCTION

Coffee, due to its numerous advantages is one of the world's most valuable commodities. Cultivating and exporting coffee and its related products, have provided developing countries with various economic advantages to boost their economies. Even though coffee plays an important role in day-to-day life, the coffee supply chain still has several challenges which have not been addressed. Not to mention the various technologies that are being utilized by other industries to enhance the efficiency and transparency of their supply chains. This paper describes a functional Blockchain-based system to increase efficiency, material traceability, and data accessibility in a coffee supply chain.

The ever-increasing complexity of conducting various business activities pertaining to supply chain management has led to the need for more collaboration amongst every stakeholder in a supply chain. The globalization of the supply chain has also changed the structure of the supply chain. The coffee supply chain is very complex, as it simultaneously handles multiple relationships amongst every stakeholder in the supply chain. This information pertaining to different relationships involved in a coffee supply chain is gathered through various layers of data analysis and reporting. Hence, it is of great importance to establish a tamper-proof and transparent metadata infrastructure for the discovery of products or materials in a coffee supply chain. The current unfair ecosystem impacts the coffee producers in the form of fluctuation in the market and the rising price from the intermediaries. [1] This paper aims to build a blockchain-based application for the coffee industry to support its sustainable development.

In this system we intend to design a decentralised application for all stakeholders in the coffee supply chain to increase efficiency of supply chain management. This system is set up on blockchain and companies that intend to implement this system, need only to pay the amount of money required to create and change their Smart Contract status. Using fully disclosed Smart Contract information, any stakeholder in the supply chain can prove the athourized source of the business and can also serve as proof for goods requested by a customer and the status of delivery for concerned goods. For example, the processors are able to confirm that they have received the exact goods (e.g.: coffee variety, etc.) requested. By using this Blockchain-based system, the customer no longer has to be concerned about receiving a shipment with incorrect goods, as the shipment is handled by different elements (e.g.: importer, exporter, etc.) in a supply chain Problem Statement.

II. BACKGROUND

A. Blockchain Overview

Blockchain is a technology, which is a continuously growing list of records, called blocks, which are linked together and secured using cryptography. Each block mined after the genesis block contains a cryptographic hash code of the previous block, a timestamp, and transaction data, which is designed so that these transactions are permanent. [2]

The concept of Blockchain was devised by Satoshi Nakamoto in 2008. Blockchain or Distributed Ledger Technology (DLT) is a distributed ledger recording technology, which contains information about transactions or events. It can record transactions in a transparent, secure, decentralised, efficient, and low-cost way. [2]

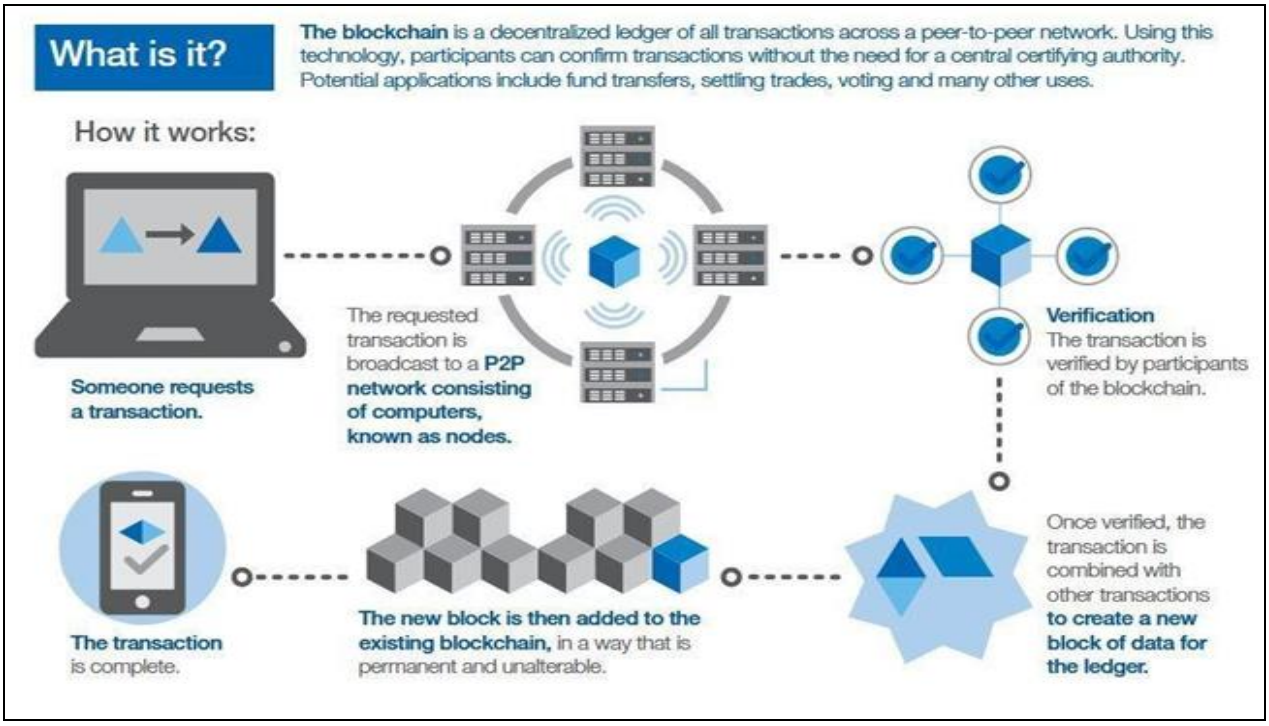

Fig. 1: The Concept of Blockchain Technology

Hence, the Blockchain Technology has the following characteristics: a distributed ledger, decentralized data management, data security, transparency and integrity, anti-tampering and anti-forgery, high efficiency, low cost, programmable features that increase flexibility and reliability, and no risk of a centralized database failure. [2]

Different types of Blockchains are available, some of the most important are: Public Blockchain, Private Blockchain, and Consortium Blockchain (hybrid Blockchain). Each type of Blockchain has its own advantages and disadvantages, allowing them to meet the needs of various applications. [2]

Specifically, using a) In a Public Blockchain, any member can transact on the network transactions which are transparent and are anonymous. A Public Blockchain, such as the BTC network, is completely decentralized. There is no central point of failure, as the system operates based on the user's consensus. However, a Public Blockchain is always vulnerable to system attacks. For example, an attacker could recreate and properly chain all the blocks that had been modified, without being detected; b) In a Private Blockchain, the transactions are kept secret, and the data regarding these transactions is not available for public view, but the members are known. A participant cannot read or write to the Blockchain, unless that participant has received proper authorization or an invitation to join the network, in a private Blockchain network. Large organizations usually use Private Blockchain, with permissions defined between various stakeholders of the enterprise Blockchain; c) A combination of both Public and Private Blockchain is called Consortium Blockchain, it is a hybrid model. Some organizations may choose this model, to have their own Private Blockchain network to share the data among the participants (such as banks, institutions, and other enterprises or firms). [2]

B. Smart Contracts

A Smart Contract is a computerized protocol that executes the terms of a contract agreed upon by the concerned parties. In simple terms, Smart Contract is a regular contract, but it is written using computer code to be executed in a Blockchain environment. Such agreements which are done in an IT-environment are frequently referred to as Smart Contracts. [2]

A Smart Contract is designed to assure one party that the counter-party will fulfill their promises with certainty. The main aim of a Blockchain is to complete a transaction without any third-party intermediary. Traditionally this third party is tasked with maintaining and executing the terms of contracts and building the trust between all parties that are involved. Thus, by doing this Smart Contracts can overcome moral hazard problems such as strategic default, and they can drastically reduce costs of verification and enforcement. [2] Creating fully automated Smart Contracts is one of the most promising areas of implementation of Blockchain Technology, which are performed without any human input or participation of any kind. Repeat transactions or transactions with a certain degree of importance can be performed using Smart Contracts. [2]

Verification, execution, and enforcement of the terms of the contract agreed upon by all participants will be done by Blockchain. These types of contracts are called Smart because they possess the ability to partially or fully self-execute and self-enforce. [2]

C. Existing Coffee Supply Chain

The existing coffee supply chain is a highly fragmented and complex process. It consists of multiple agents or intermediaries. These intermediaries are responsible for conducting various processes regarding supply chain management. These processes include growing the coffee, transporting raw materials and final product, converting the raw materials into the final product, etc. The main issue with the existing coffee supply chain is that there is a lack of communication amongst various elements of the supply chain. This issue leads to miscommunication and errors being made by members of the supply chain. This leads to a wastage of time and resources. The way in which the current coffee supply chain is handled is very inefficient. To solve issues like these, there is a need for new technology such as Blockchain, which can make supply chain management efficient and reduce the number of errors being made. [3]

The various stakeholders in the existing coffee supply chain are as follows:

- Processors: They perform the task of growing the coffee.
- Intermediaries: Intermediaries are usually involved in many stages of the production process. They perform numerous tasks. There can be various intermediaries performing different tasks in a supply chain.
- Government Agents: Government agents are involved throughout the process of coffee production in countries where the government is in control of the coffee trade.
- Suppliers / Brokers: This group refers to those who sell coffee beans to roasters in the appropriate quantities at a previously agreed-upon price.
- Roasters: They are tasked with roasting the coffee beans and thereby converting them into final products ready to be sold to customers for consumption. Some Roasters sell finished coffee products, while others ship the final products to retailers.
- Retailers: These places sell finished coffee products to customers for consumption. They can include grocery stores, restaurants, etc.

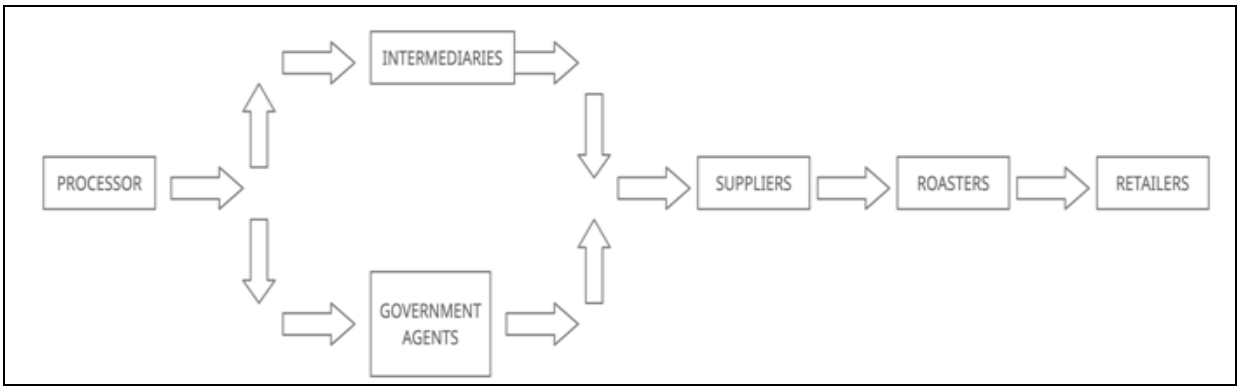

Fig. 2: Stakeholders in Current Coffee Supply Chain

III. RELATED SEARCH

A growing number of Blockchain based applications are being developed. Some of the applications, such as digital currency, stock trading, or financial securities, focus on payment verification. Some developers are interested in integrating Blockchain and the Internet of Things (IoT), such as recording IoT system data. Other decentralized Blockchain applications include games, gambling, online voting, car rental, and many more. [4]

Modern brands of global supply chain networks must always understand, that they can strictly track the flow of goods by using Blockchain in the supply chain. Currently, there is no developed system for merging Block-chain technology into the agricultural supply chain such as the coffee supply chain. The system proposed in this paper is the first of its kind, that attempts to integrate useful technologies such as Blockchain into an agricultural supply chain.

IV. SYSTEM DEVELOPMENT

Our design, the administrator (admin) is liable for providing user information to the contract, such as User Wallet Address, User Name, User Contact Number, User Role, User Status, User Profile Image, and creating a new batch. After the user obtains the administrator's authorization, they obtain a certain amount of recording rights for updating information concerned to their role in the coffee supply chain. In this system, only the administrator can create a new batch by using the create batch button. For creating a new batch the administrator will have to input details such as Farmer Registration Number, Farmer's Name, Farmer's Address, Exporter Name, and Importer Name. Once, a new batch is created the Farm Inspector is required to fill in details such as Type of Seed, Coffee Family, Fertilizer Used. After successful submission of Farm Inspectors' information, the batch progresses to the next step which is harvesting. The Harvester grows and nourishes the coffee beans and makes the beans ready for export by updating the contract with Coffee Variety, Temperature and Humidity. Once, the coffee beans are ready to export, users having the role of Exporter update the information required for exporting the beans. It includes

ISSN No:-2456-2165

Quantity, Destination Address, Ship Name, Ship Number, Estimated Date-Time, and Exporter ID. User has the role of Importer, import the coffee beans and update the contract with information such as Quantity, Ship Name, Ship Number, Transporter Information, Warehouse name, Warehouse Address, and Importer ID. After the coffee beans have been imported, it goes to the processing stage. The Processors have to update information such as Quality, Temperature, Time for Roasting, Internal Batch Number, Packaging Date and Time, Processor Name, and Processor Address. After updating the required information, Processor will have to get issued the Quality Certificate. The stages which are not yet updated in Blockchain are denoted by a cross sign and stages that have been completed are denoted by the right tick sign. This is how the Coffee Supply Chain completes for one batch. In this way, we can track the progress of coffee beans after each stage in Blockchain. [5]

A. System Architecture

Our Blockchain-based coffee supply chain management system is made up of six roles: Administrator, Farm Inspector, Harvester, Exporter, Importer, and Processor.

- Administrator: The administrator is responsible for updating or filling user information to the contract, the information includes - User Wallet Address, User Name, User Contact Number, User Role, User Status, User Profile Image, and creating a New Batch. In our system, only the administrator can update the User Status and User Profile.
- Farm Inspector: The farm inspectors are responsible for inspecting coffee farms and updating the information such as Crop Variety, Temperature and Humidity maintained during the process.
- Harvester: The harvesters conduct plucking, hulling grading, and sporting activities and make the beans ready for export by updating information such as Crop Variety, Temperature and Humidity maintained during the process.
- Exporter: The exporters are the organizations who export coffee beans. User's having the role of exporter are tasked with updating information such as - Quantity, Destination Address, Ship Name, Ship Number, Estimated Date, and Time and Exporter ID.
- Importer: The importer, imports the coffee beans from coffee suppliers and updates the following information - Quantity, Ship Name, Ship Number, Transporter's Information, Warehouse Name, Warehouse Address, and the Importer ID.
- Processor: Processors are the organizations who process raw coffee beans by roasting them at a particular temperature and humidity and making them ready for packaging and sale in markets. The processor adds the information such as - Quantity, Temperature, Roasting Duration, Internal Batch Number, Packaging Date and Time, Processor Name, and Processor Address.

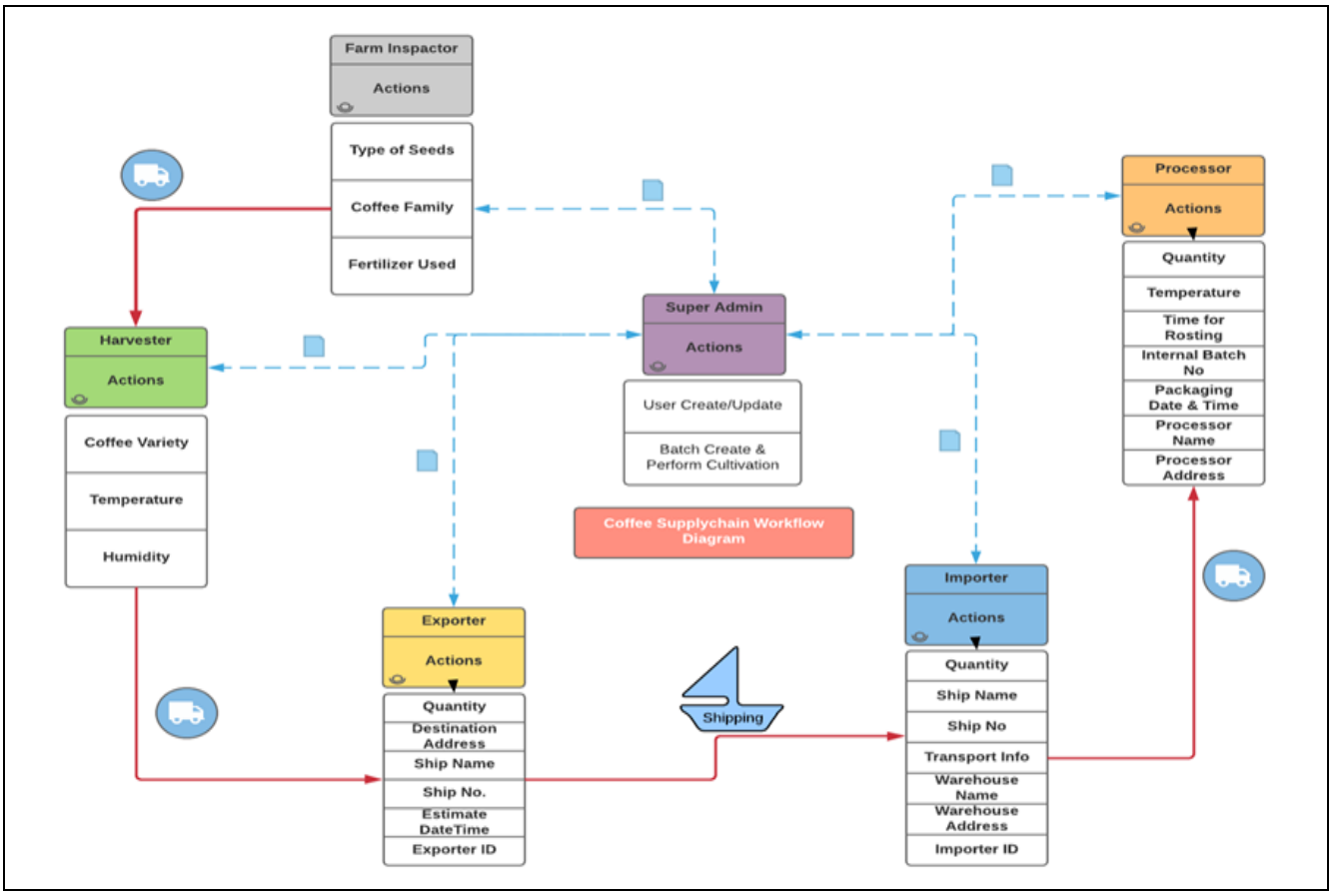

Fig. 3: Workflow of Coffee Supply Chain Management Using Blockchain

B. System Flow

According to our design, the administrator is in charge of pushing various user details to the contract, such as - User Wallet Address, User Name, User Contact Number, User Role, User Status, User Profile Image and. This information gets stored in the system. After obtaining the administrator's approval, the user can receive a certain amount of recording rights for updating information concerned to their role in the coffee supply chain. In this system, only the administrator can create a new batch. Each batch that is created by the administrator represents an individual coffee supply chain. The users are tasked with updating information regarding the progress of each stage in the supply chain.

For the creation of a new batch, the administrator has to input details such as - Farmer Registration Number, Farmer's Name, Farmer's Address, Exporter Name, and Importer Name. Once, a batch has been successfully created by the administrator, the first stage of our system is complete and user's that have been designated a role start feeding their information into the contract. Firstly, the farm inspector has to fill in or update the contract with information such as - Type of Seed, Coffee Family, and Fertilizer Used. Once, the farm inspector's form has been submitted successfully, the second stage is completed. After this in the third stage, the harvester has to update the contract with information concerned with their role. These details include - Coffee Variety, Temperature, and Humidity. In the fourth stage, user's having the role of exporter are tasked with filling in the required details, these details include - Quantity, Destination Address, Ship Name, Ship Number, Estimated Date-Time, and Exporter ID. Once, the exporter has completed updating the contract with information concerned with their role, the fourth stage is completed. In the fifth stage of our system, the user having the role importer updates the required details like - Quantity, Ship Name, Ship Number, Transporter Information, Warehouse name, Warehouse Address, and Importer ID. The sixth and the last stage is completed by the processor. The processor enters the following information to the Blockchain - Quantity, Temperature, Roasting Duration, Internal Batch Number, Packaging Date and Time, Processor Name, and Processor Address. [5]

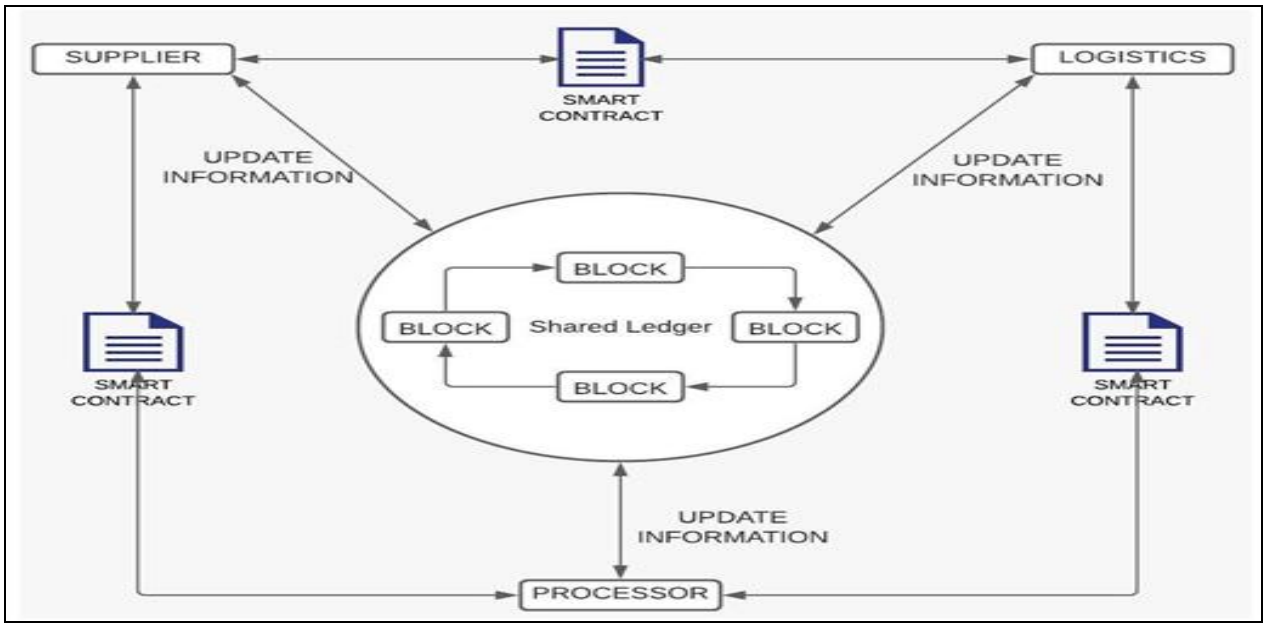

Fig. 4: Flow of Data in our System

V. IMPLEMENTATION

We here are describing the features of our system's architecture, including a complete overview of the system's purpose and user interface. Our mission is to use Blockchain features to provide more comprehensive, simple, and low-cost coffee supply chain management solutions for the stakeholders of a coffee supply chain.

A. Systems Structure and its Programming

This proposed framework used Ethereum as its backend operating system and uses Solidity as a high-level programming language for the writing of intelligent contracts in Ethereum's own programming language. [6] Solidity supports legacy, importing collections, etc. Solidity is built for Ethereum Virtual Machine (EVM).

The scheme is based on Ethereum's Blockchain, the public intelligent contract. In this paper, we use Ganache to create an individual chain and press an intelligent contract on this individual chain, in order to simulate the public chain situation with the private chain. [7] We use Metamask to balance accounts and handle contract details. It is a software cryptocurrency wallet used to interact with the Ethereum blockchain. [8]

The user's user interface is a website. The webpage on the server-side uses the Xampp suite, which has node.js [9] and web3.js [10] as the link between the smart contract and the interface of the user. After the setup of the server, you can bind the private chain and address information.

B. System Execution

➢ *Login Procedure :*

The user must select which account to log in to before connecting to the device. User accounts are generated once in Ganache, a workstation is hosted. It hosts up to 10 accounts with a base amount of 100 ethers in each. These accounts are test accounts and are hosted in the system for testing purposes. Users can choose one account and utilize its key from ganache to use that account in the system.

This key should be copied and pasted into the Smart Contract at the contract address and that file must be saved. After this, every time when the smart contract has been used the ether from a specified account is used.

➢ *Adding New Users, Creating New Batch :*

The administrator can monitor each user's details in our system, including adding new users and designating each user a specific role, so that they can update the Smart Contract with information relevant to their role in the coffee supply chain. To update the user profile, the user can update information such as User Name, User Contact Number, and User Profile Image. The User Role and User Status can only be updated by an administrator. The creation of a new batch can only be done by the administrator. The administrator decides which users will have access to a specific batch. In this system, the administrator can also monitor the progress of all the different batches simultaneously.

➢ *Accessing Information from a Contract :*

The details about any user are entirely public in order to achieve the purpose of information disclosure. Our system includes a Smart Contract data search function. The Smart Contract searches for the data from the Blockchain and provides detailed information. This function also facilitates all members of a batch to view and verify the information that any member has input into the contract.

➢ *Batch Updation :*

Once, the administrator has created a new batch and designated a role for each authorized user. The users are tasked with updating the batch. The users update a batch by updating the contract with information regarding their role. For example, a user with the role of exporter updates the Smart Contract with information such as - Quantity, Ship Name, Destination Address, etc.

➢ *Identity Verification :*

In this system, the only way any new member or user has to be given access to the Blockchain for updating the information stored in it is through the administrator. The administrator is the one who is responsible for admitting a new user to a batch. Once, the user has been authorized by the administrator, they can update the contract with information relevant to their role. The administrator as well as each stakeholder of a supply chain can view and verify the details of every other stakeholder, as the details about any user in the Blockchain are public. If a user needs to update information in the contract, they need to pay the required gas fees. For paying these fees, the user has to provide their wallet address to the administrator and then use the same wallet address to pay the gas fees. These checks and balances ensure the identity of each user on the Blockchain.

VI. INVESTIGATION

User functions include adding or updating information to the Smart Contract. These actions, require the User to pay a specific amount of gas fees for completing the task, as in some cases the contract data has to be overwritten, or in some cases, data needs to be added to the contract.

A. What is Gas?

When the user wants to modify smart contracts with state changes, the client has to pay some money in the form of gas tokens.Different operations cost various amounts of gas to run the operation. The gas price number is fixed for every operation.

Table 1: Rate for Gas Token for State Changes

OPERATION DESCRIPTION	FEE COST
Contract Creation	**32000 gas**
Adding New User	**119368 gas**
Updating User Details	**183008 gas**
Adding Farm Inspector's Data	**213439 gas**
Adding Harvester's Data	**239754 gas**
Adding Exporter's Data	**307632 gas**
Adding Importer's Data	**303468 gas**
Adding Processor's Data	**341523 gas**
Viewing Batch Progress	**-**

B. What is the Gas Price?

The present price of gas is referred to as "gas price". However, the higher the gas price, the faster the transaction will be completed in a block because the miner wants to receive more rewards from the transaction. Therefore, the transaction with the higher price will be given higher priority. Within five minutes, the transaction is completed in a block. The suggested gas price it provides is based on current network conditions and will fluctuate at different times.

C. What is Ether Value?

We need to convert ether into US dollars because we're utilizing Ether to pay for the procedure cost in the Smart Contract. To get the current conversion price, we go to the Coin Market Cap website.

VII. ASSESSMENT

User functions include adding or updating information to the Smart Contract. These actions, require the User to pay a specific amount of gas fees for completing the task, as in some cases the contract data has to be overwritten, or in some cases, data needs to be added to the contract.

A. Gas

In Ethereum, gas is the pricing value of the execution work. When a user wishes to change a state in the Smart Contract, they must pay the corresponding state change gas. Different software operations require different quantities of gas to operate. The cost of running a gas engine is a fixed amount.

B. Gas Price

The current price of gas is referred to as the gas price. The user can set the gas price for any Wei. However, the higher the gas price, the quicker the transaction will be completed in a block because the miner needs to gain more rewards from the transaction and will prioritize the transaction with the higher price.

C. Resultant Cost

The price, in reality, is the gas to run the corresponding function multiplied by the gas price multiplied by the current ether value. Here, we employ Remix, to measure the gas needed in our machine function execution. A remix is a web browser IDE used by developers to build solidity Decentralized Application DApps. [11]

VIII. CONCLUSION

This is the first paper to recommend, a completely functioning supply chain management system based on Blockchain technology. Users of our framework will experience, increased efficiency and greater transparency in supply chain management.

Each stakeholder can use this system to store critical information pertaining to their role in the supply chain. This information can be stored by each member of the supply chain by paying a very low transmission fee. The use of Blockchain technology in the coffee supply chain enables each stakeholder to view and cross-verify information uploaded by other stakeholders. Our scheme significantly increases trust among members of the supply chain due to its transparency in sharing information. It also makes important data regarding supply chain management more accessible. The described system, provides a simpler approach for coffee supply chain management, even for stakeholders with limited financial resources.

IX. FUTURE WORKS

This system's future work will serve as proof of code simplicity. Due to the simplicity of the code and lack of redundancy code, the employers of this system can be certain that the distributed application, will not consume large amount of resources. This system can be advanced for implementing data analytics for increasing the decentralized application's performance, simplicity, accessibility, and make the application more mergeable so that it is not only limited to managing the coffee supply chain but can also be used to manage other even more complex supply chains.

ACKNOWLEDGEMENT

We are very thankful you our college, New Horizon Institute of Technology and Management for presenting us with this wonderful opportunity of working on this exciting project. We would like to express our deep gratitude to the many people and organizations that have helped us during our graduate studies. First, we would wish to express our sincere gratitude to our Dean, Prof. Sunil Bobade, and our project guide, Ms. Taruna Sharma, and our project coordinator, Ms. Arathi Kamble for their enthusiasm, patience, insightful comments, helpful information, and unceasing ideas that have helped us tremendously at all times in our research and writing of this thesis. Their immense knowledge, profound experience, and professional expertise in Blockchain technology have enabled us to complete this research successfully. Without their support and guidance, this project would not have been possible. We could not have imagined having a better supervisor in our study.

We also wish to express my sincere thanks to the University of Mumbai for accepting me into the graduate program. Our thanks and appreciations also go to our colleagues in development.

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