High-efficiency Traceable and Transparent Agriculture Food Supply Chain

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***Abstract*—Contemporary agricultural supply chains have transitioned from independent local entities to a global network of interconnected participants, characterized by complex interactions that affect the entire process of producing food, it's the process, transportation, and delivery to consumers. Frequent occurrences of fraudulent behavior indicate a lack of transparency within farming supply chains, leading to concerns about financial damage, erosion of customer confidence, and a decline in corporate brand reputation. This system eliminates the need for intermediate nodes and achieves a decentralized model for the farm food supply chain, thereby satisfying the requirement for transparency of agricultural food. This paper presents a framework that utilizes an association and smart contracts to monitor and document the processes of agricultural supply chains for food. The framework aims to establish accountability and visibility of supply chains, while minimizing information barriers between enterprises. By doing so, it seeks to eliminate the reliance on central institutions and agencies, and enhance the integrity, reliability, and security of transaction records.**

***Keywords*—Blockchain for Supply Chain, Ethereum Agri Food Supply Chain**

I. Introduction

The supply chain creates a complicated network chain structure by linking several businesses, including suppliers, logistics companies, processors, distributors, retailers, and customers. This intricate supply chain might involve hundreds or even thousands of steps, requiring a significant amount of time and spanning several geographical areas. As such, the traceability procedure is quite challenging in this scenario if the product has issues related to quality or safety. The process makes the final products traceable, which protects consumer health and safety as well as increasing customer confidence in the brand and company, especially in agricultural food supply chains. People are now increasingly concerned about food safety and quality as a result of many food safety incidents in recent years. It is challenging to monitor and trace issues in a specific connection since the modern agricultural food supply chains are characterized by a lengthy life cycle, several intricate links, dynamic information, etc. Foods grown by agriculture include sorghum, rice, peanuts, corn, and wheat. These foods are staples of human diets and are obviously important. The agricultural food supply chain traceability system's establishment and improvement from farm to fork is consequently essential.

There are three main issues with the current food supply chains in agriculture and culture. First, the supply chain has a large number of players and inconvenient communication between them, which causes the chain as a whole to cycle slowly. Then, there is inadequate information sharing and mistrust of the data among participants as a result of the huge number of participants and dissemination over many networks. Lastly, the agricultural food supply network is centralized where data can be readily manipulated and control can be centralized in the hands of a single management. Notwithstanding the fact that government agencies oversee the central manager, human oversight is prone to errors. Therefore, by efficiently monitoring product information and guaranteeing product safety, research on advanced traceability technology and related systems has substantial research value in assuring the quality and safety of agricultural products and ultimately ensuring consumer safety.

The food supply chain is a complex, multidimensional network with numerous parties involved, all of whom are necessary to ensure that food products reach consumers. There is still a lack of openness in the food supply chain at the manufacturing and distribution levels, despite recent significant technological advancements. This lack of transparency presents the industry with a number of challenges, including inefficiencies, waste, and fraudulent activities that could jeopardize the integrity of the supply chain as a whole. One of the main issues with the current food supply chain is the dearth of thorough product traceability to the original supplier.

It can be challenging to keep track of the places food commodities originate, the actions done, and the individuals engaged in their management when they are transferred from one stakeholder to another. Because of this, it can be difficult to ensure the quality and safety of products because they could be the subject of adulteration, mislabeling, or other fraudulent activities.

In order to address these issues, we thus propose a blockchain-based system that provides a transparent and verifiable supply chain network. Blockchain technology makes it possible for all parties involved—including customers—to view and analyze an immutable, transparent digital record of movements. Stakeholders will be able to track a particular product all the way from the farm where its raw ingredients, such tomatoes, are cultivated to the retailer shop where it is processed and placed up for sale with the use of the recommended system. The proposed blockchain-based system will revolutionize the food supply chain by offering several benefits. To begin with, the technology will improve the process of determining a product's quality. Several quality reports from the harvest will be stored in a blockchain network. These data might be used by processors as a standard by which to evaluate the quality of raw materials. Second, the system will increase the traceability and transparency of the things. After receiving the raw materials, the processor adds the pertinent reports to a blockchain network along with a timestamp. This would enable all parties to see data, from the shop to the farmer, including quality, processor, and retailer reports, prior to purchasing a product. The recommended approach will also strengthen the capacity to prevent fraud. Every stage in the system has a timestamp, making it entirely transparent, so any fraud or forgery—including hoarding—can be monitored. Blockchain technology allows stakeholders to verify that products are real and that they haven't been tampered with or corrupted in any way.

II. A General System

The worldwide food supply chain lacks a crucial element: trust. These factors include the rising expectations of consumers, disruptions in the supply chain, the increasing regulatory requirements, and instances of food fraud. Trust can only be restored through the implementation of transparency and traceability. This is precisely the point at which blockchain demonstrates its value. The transparent and unchangeable characteristics of blockchain render it a valuable tool for tracking the entire life cycle of the food supply chain. [1] The implementation of blockchain technology in the food supply chain ensures complete traceability of food-related data and enables efficient tracking of the origin of food in a matter of seconds. This technology also facilitates verification of food's quality and safety compliance, as well as enhances the security of supply chain data [3][5].

The global blockchain market's 2020 worth inside the food distribution system was $127.56 million. By 2025, the estimated value is expected to increase at a compound annual growth rate of 47.1003% to USD887.22 million. The food industry's requirement for transparency in the supply chain and easier food origin tracking to guarantee product authenticity, safety, and higher quality is mostly driving the rapid expansion. The growing acceptance of blockchain-driven supply-chain food systems may be ascribed to the necessity of proving eco-friendly production processes and ethical sourcing.

Through the utilization of blockchain technology, management can be effectively disrupted by recording and tracking cost, labor, waste, and pollution monitoring at each stage of the supply chain. We have the capability to trace the origin of a product in order to verify that the entire process of production and distribution is free from conflicts and follows fair-trade policies. Blockchains[7][9] can be utilized to monitor the quantum impact of a product on the environment by consistently documenting its environmental and carbon footprints.

The food sector is one of the largest industries worldwide, characterized by a complex global supply chain involving multiple stakeholders. The increasing demands for accountability, accountability, and food safety are the main drivers behind the necessity of digitizing the food supplychain. The food supply chain [4] has identified certain problems, and the use of blockchain[2] has been proposed as a possible decentralized and transparent ledger system to address these issues.

The document provides comprehensive information regarding the constituents, source, processing methods, transportation, and storage requirements of the food. Essentially, it encompasses the complete journey of food production from the farm to the dining table.

It encompasses the activities of manufacturing, refining, moving, selling, and using. During this process, food is transported from a farmer who cultivates the crops to the consumer who purchases it from stores. Each individual step necessitates the utilization of both raw materials and labor in order to progress to the subsequent step. A sequence of steps is provided.

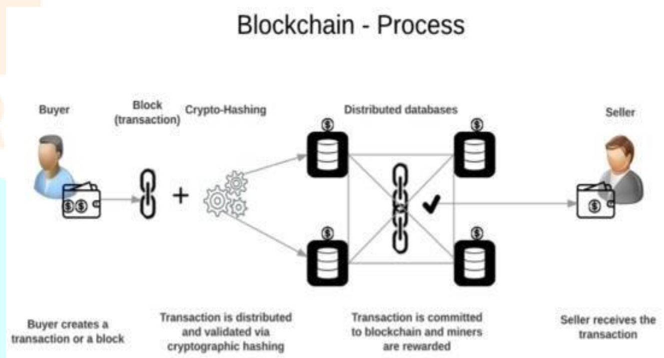

Fig 1 : Blockchain Process

A. *Production*

The food supply network [10] originates at this stage. It is the place from which all food originates. Local farmers have the responsibility of cultivating crops and raising livestock.

B. *Preparation and packaging*

This phase converts the unprocessed material and initial food into products that are appropriate for consumption. After completion, the food is forwarded for packaging to facilitate delivery.

C. *Distribution*

After the food is prepared for consumption, it is transported to the appropriate retailer or supplier. Distributors engage in the distribution of commodities, overseeing inventory management, cost reduction, and other activities aimed at enhancing the worth of a food item.

D. *Retailer*

This stage establishes a direct connection with the consumer. It handles the delivery of the final products. The entire process, from the receipt of the assigned products to their sale, is comprehensively addressed.

E. *Consumer*

The consumer refers to the individual who buys food from a store and consumes it.

III. About Blockchain

A blockchain is fundamentally a decentralized and distributed database or ledger.

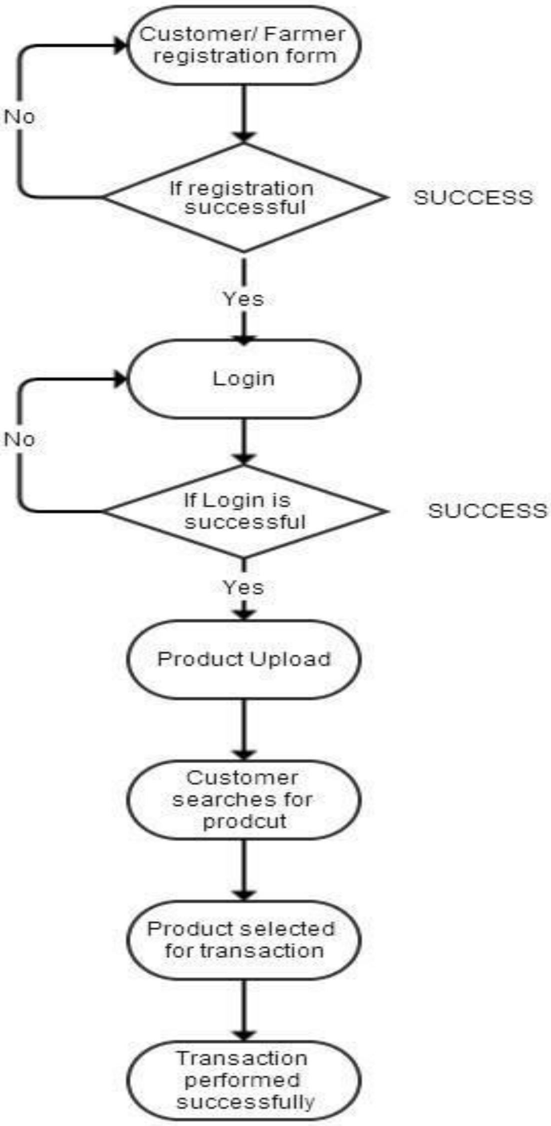

Fig 2: Transaction Entry

A. *Decentralization*

The capacity of an application or service to continue operating normally even in the case of a server or network failure is known as decentralization[6][7]. The service or program is spread throughout a network, where no individual server possesses absolute control over data and execution. Rather, each server keeps a copy of the execution logic and data that is synchronized[8].

B. *Abbreviations and Acronyms*

Every server or node in a network is interconnected with every other node in the network. Unlike traditional networking setups, servers now have multiple connections with other servers, allowing for enhanced connectivity and improved performance.

C. *Database*

A defined location where durable data is kept and may be retrieved at any time. A database enables the storing and retrieval of data, as well as providing management features to effectively handle data, such as export, import, backup, and restoration operations.

D. *Ledger*

A term used in accounting. Consider it as the process of storing and retrieving data in a specialised manner. Consider the existence of ledgers that are accessible to banks. For example, when a transaction takes place between a bank and a customer, like Alice depositing 200 INR into her account, the bank documents this information in a ledger as a credit.

Alice will withdraw a sum of INR75 in the future. The bank does not modify the current entry and decreases the stored data from 200 to 125. Instead, it registers an extra transaction in the same accounting ledger as a debit of INR75. A ledger is a separate database that tightly forbids the modification of existing data. This functionality allows the user to create and insert a new transaction in order to modify the current balance in the ledger. The blockchain is a database that shares the same characteristics as a ledger. It facilitates the storing of recent transactions in a sequential fashion, hence eliminating any potential for modifying prior transactions.[5][6][7] But past transactions cannot be altered. The 200 INR balance can be modified by conducting a new debit or credit transaction at any given moment. Nevertheless, it is unfeasible to alter past transactions.

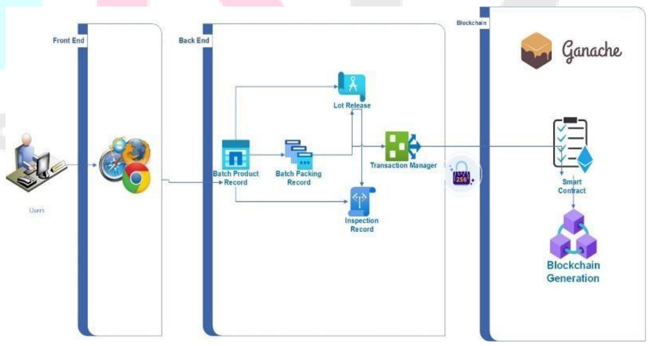

Fig 3:Architecture Diagram

IV. Details Of Proposed Operations

The agricultural food distribution network includes all stages of the farming and shipping process, extending from the farm to the consumer's plate. The process includes several entities and displays complex and extensive characteristics, which provide difficulties in monitoring the entire process. To maintain traceability, we diligently document the pertinent information, such as the product's unique identifier and lot number, at the start of every future transaction. Furthermore, we save the hash value to guarantee the integrity and genuineness of the transaction. A batch refers to a collection of food products that are stored together in a warehouse. Every batch is assigned a distinct identification known as the batch number. The hash of the data is retained in the Ethereum Blockchain[1][8], but the transactional data is saved in IPFS, in order to circumvent IPFS's limits and address the rapidly expanding blockchain data. An access control policy is implemented to restrict the ability to read from and write to the blockchain. This policy guarantees that only authorized users have the ability to carry out transactions, hence enhancing the security of the data. Smart contracts limit execution to certain entities in a comparable fashion. The system records entities and facilitates their interaction using smart contracts.

The farmer's duties encompass sowing crops and employing sensors to oversee and record several facets of agricultural growth, including water, air, sunshine, and soil conditions. The farmer furthermore archives this data on IPFS, utilizing photographs or video files. In addition, the farmer is responsible for creating informed contracts and safeguarding IPFS data hashes inside those contracts[2].

Prior to reaching the merchant, the finished product may travel through many steps of distribution. The distributor's main duty is to keep agricultural products that have been produced and distribute them to merchants in large numbers. The company's data, including the product's selling schedule, pricing, and additional particulars, is saved in IPFS. Likewise, the blockchain stores the hash value to ensure the integrity of the future data, as supervised by the oversight agency.

V. Conclusion

We introduce a system that use solidity smart contracts to monitor and execute transactions. This framework undermines the centralized structure, eliminates intermediaries and intermediary nodes, and establishes a decentralized model for the agricultural food supply chain. Consequently, it satisfies the requirement for traceability in the agricultural food sector. This paper proposes a thorough solution for a supply chain in the Agri-Food industry that utilizes blockchain technology. We have provided extensive data on the traceability, trade, delivery, and reputation of the suggested solution. We have undertaken a comprehensive evaluation and rigorous analysis of the effectiveness of smart contracts to ensure that the proposed solution is both efficient and robust. Presently, there are some deficiencies in the administration of supply chain information, particularly with the matter of dependable data collecting. Exploring techniques to ensure the dependability of information sources is a field that requires more investigation. In order to ensure dependable data collecting, next research can combine Internet of Things technology with blockchain.

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