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RESEARCH ARTICLE OPEN ACCESS

FOOD SUPPLY CHAIN TRACEABILITY USING HYPERLEDGER

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ABSTRACT

With the advent of globalization, supply chain systems in all domains have become highly complex due to the ever-growing networking and change of approach towards automation which have at times been limited in traditional supply chains. One of the key aspects to be targeted in conventional methodologies is the centralized nature of the supply chain. Due to this factor, there is deterioration in the quality, contamination and tampering of the food product that is delivered to the end user. In the proposed system, the aim is to build a decentralized system for a food supply chain that leverages the power of blockchain and smart contracts, deployed over a smart hyperledger fabric network. The primary objectives are aimed at implementing smart contract-based transaction validation at each step of the chain thus covering various parameters such as providing transparency, efficiency, and accountability with a view to overcome the challenge of tracking and maintaining the integrity of data throughout the entire process of the supply chain.

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INTRODUCTION

India's economy has always been built on agriculture. With the robust growth in country's economy and increase in common man's standard of living post pandemic, there is an expected rise in the expectations of food safety and quality. In recent light of the pandemic, there have been some eye-opening statistics in context of the food supply chain.Agricultural and processed food of India are exported to the broadest ranging 120 countries. India's agriculture commodities export alone accounted for $3.50 billion in March-June 2020. Up to 45% of food produced gets spoilt in the supply chain. Only a mere 7% of perishable foods are being processed [1]. The Associated Chambers of Commerce estimate a loss costing about $14 billion an year in the post-harvest across the country. The supply chain for the Indian fruit and vegetable industry is vulnerable; 30% of the crop is lost each year as a result of price changes, market demand, rising input costs, a lack of storage facilities, and unreliable transportation [1]. The entire process of supply chain must be accurate and coherent while delivering the product in order to gain the end user's trust. It becomes paramount for a delivery authority to checklist the following factors such as integrity, quality, and transparency of the traceability systems. Food Safety and Standards Authority of India (FSSAI) is constantly on the rise to enforce these standards to be compliant with any delivery authority to ensure high quality of products. Furthermore, problems at grass-root level such as lack of modern infrastructure, shortage of funds, out of place regulatory systems, unavailability of statistics and information at the low-level, and limited monitoring systems for traceability affect the supply chain directly or indirectly in the short as well as long term. With increase in number of users and subsequent demand, centralized systems are unable to handle huge volumes of data being produced, thus resulting in unavoidable bottlenecks that affect the performance of the entire network. On the contrary, distributed system offer characteristics such as fault tolerance, concurrent processing, real time scalability and effective storage schemas. Based on the above reasons, there arises a need to develop a food supply chain traceability system with a decentralized architecture based on the evolving blockchain technology in order to help the Indian market to not only improvise on their food quality and safety but to also help prevent or at-least minimize the significant losses suffered during the logistics process. The remainder of the paper is organized as follows, section II elaborates on the literature survey, section III on conclusion followed by acknowledgements and references.

Literature Survey

Blockchain: Data records in the blockchain cannot be changed later due to their structure. In addition to transactions, the blockchain may store other types of data like papers, identity management, and food traceability. These properties make blockchain technology ideal for managing the entire food supply chain by avoiding counterfeiting and ensuring transparency, quality, provenance, and integrity [6]. Food manufacturing has a more delicate value chain than other businesses, necessitating greater attention to handling procedures including manufacture and storage [7]–[9]. In addition, the quality of food is constantly changing, and ensuring food safety and quality has become an issue [9].

Hyperledger: One of the biggest blockchain projects, Hyperledger is composed of several open-source tools and subprojects. It consists of leaders from several industries that want to create a strong, commercial blockchain architecture. It is an umbrella project with the goal of offering business solutions and common standards for blockchain adoption. Hyperledger Frameworks such as Fabric, Iroha, Indy, Sawtooth, Cello, Explorer and Composer are the main projects that make up the Hyperledger framework. We have covered the architecture, objectives, and necessity of hyperledger projects in real-time applications in this chapter [24]. The first really extensible blockchain platform for executing distributed apps is called Fabric. In order to adapt the system to specific use cases and trust models, it provides modular consensus mechanisms. Moreover, Fabric is the first blockchain platform that supports distributed applications developed in general-purpose, standardized programming languages, independent of a systemic reliance on a native cryptocurrency. This contrasts sharply with the ”smart-contract” requirements of current block-chain systems, which call for the use of cryptocurrencies or domain specific languages for ”smart-contracts.” Using a portable idea of membership that can be connected with industry-standard identity management, Fabric realizes the permissioned model. Fabric proposes a whole new blockchain design and rethinks how blockchains handle non-determinism, resource exhaustion, and performance threats in order to accommodate thisflexibility. [25]

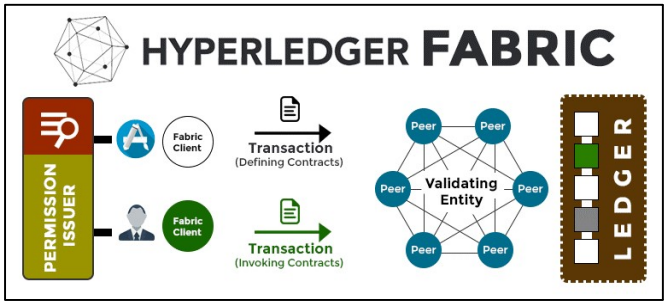

Fig. 1. Architecture of Hyperledger Fabric

Food Supply Chain: Big food brands typically choose to open up only a portion of information to the public in the existing supply chain in order to benefit their own businesses, which can result in customers not being sufficiently informed about the products and financial information of their suppliers [20]. As Reyna et al [10] suggested, a lack of knowledge could affect food security. Transparency in the supply chain is crucial for particular items with unique standards, such halal food, in order to maintain customer trust and ensure product quality [21].

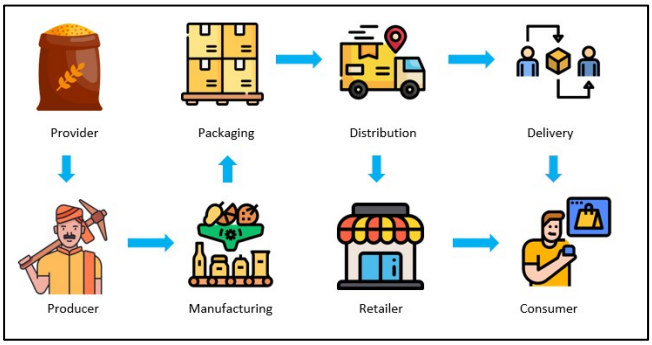

Fig. 2. Representation of Food Supply Chain

Although the government and other agencies have written laws and frequently inspect the quality of food, their authority can be the target of corruption and help major brand corporations hide wrongdoing. For instance, the Sanlu Milk Scandal was never made public because the firm managers [22]. Decentralization therefore allows authorized users to execute transactions and access history directly without the need for intervention from a central power source. A valid registered user has the same rights to review transactions and obtain a copy of the history [2]. Asymmetry and openness throughout the supply chain. When information is changed on the blockchain, the record is irrevocable. Immutability is achieved by running a blockchain mining process [23]. Once a majority of miners/users have voted to validate a particular transaction, transaction details will remain stored and cannot be changed without informing all users [17].

Decentralization: Unlike traditional transactions that require approval from a central authority, decentralization eliminates the central authority and eliminates information gaps by enabling direct transactions between users. Ensure all authorized users in your network have equal rights. Users can validate transactions with each other, keep copies of records, and have equal rights to access history at any time [2]–[4]. In the food supply chain, product information can be captured throughout the supply chain, from raw material suppliers to customers. Copies of recordings are kept by multiple parties and can be recalled at any time if needed [5].

Distributed systems are characterized by: Equal burden sharing, fast decision making, avoiding bottlenecks, all levels of authority with equal accountability.

Security: Blockchain consensus algorithms can achieve data security. Proof of Work is one of the consensus procedures, which requires all transactions to be verified by other users [10]. To approve transactions and add data to the database, a computer calculation must be defined by the user. When decentralization eliminates the central power source of the network, it also prevents the supply chain from collapsing. This is because a single failure does not bring down the entire network, thus reducing the chances of hacking. Technically, hacking can only be accomplished if the majority of users are hijacked, but this takes a lot of energy and time. [10]

Traceability: Greater traceability enables an accurate record of product movement, giving companies a clearer view of their supply chain, helping them make better decisions and avoid potential quality risks. [11]. The ability to track products back and forth along the supply chain increases the speed of isolating and identifying specific products from specific suppliers, making quality checks and product recalls more efficient. By showing the flow of resources and products, customers are better informed and confident about the products they purchase. Traceability is therefore considered an added value of food [12], [13]. Moreover, the traceability system can be a marketing tool to attract more customers and improve customer loyalty. Records are also a checkpoint for companies to ensure that their suppliers are providing quality products. Hence, an effective traceability system can be utilized as a tactical instrument for increasing partner trust [14].

Smart Contract: Smart contracts are digitized contracts that automatically function when certain agreements are met [10]. Transactions are much faster and more trustworthy with Smart Contact [15]–[17]. For example, payments can be automatically sent to the producer as soon as the product arrives at the warehouse. Programmed contracts can save [18], [19] paperwork, reduce processing time, and minimize effort compared to traditional supply chains.

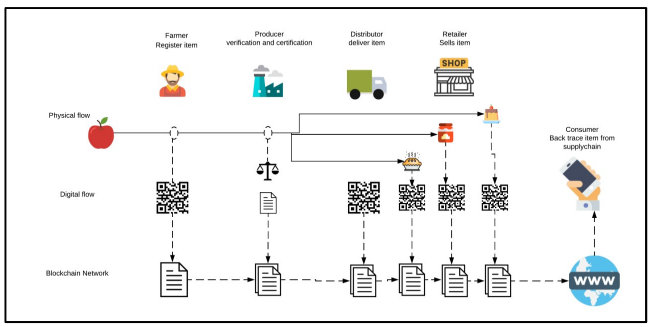

Fig. 3. Architecture/Flow of Food Supply Chain

In this way, the history of product movement within the supply chain can be recalled at any time without fear of possible manipulation.

PROPOSED METHODOLOGY & APPROACH

Proposed Methodology

1) Define the research objectives: The first step is to clearly define the research objectives. This includes identifying questions for research, the scope of study and expected outcomes.
2) Select the appropriate Hyperledger framework: As mentioned earlier, Hyperledger offers several blockchain frameworks, including Fabric, Sawtooth, Indy, and Burrow. The choice will depend on the specific requirements of the research paper.
3) Design the smart contracts: Smart contracts will be designed to track and trace the food products throughout the supply chain, including the activities of the farmers, distributors, suppliers, retailers, and consumers. These smart contracts will be developed using Solidity programming language.
4) Develop the application layer: The application layer will be developed using React Native framework to provide a user interface for stakeholders to access the data. This layer will include a web or mobile application that allows stakeholders to query the blockchain for information about specific food products.
5) Implement the blockchain network: The blockchain network will be implemented using the selected Hyperledger framework. This will involve setting up the network nodes, defining the consensus mechanism, and configuring the smart contracts.
6) Integrate the application layer with the blockchain network: Once the blockchain network is up and running, the application layer can be integrated with the network to allow stakeholders to access the data.
7) Test and validate the system: The final step is to test and validate the system to ensure that it is functioning correctly and meets the research objectives. This will include conducting tests to verify the accuracy and reliability of the data and analyzing the results.

Implementation Plan:

Phase 1: Planning and Research

- Define the objectives for research and research related questions
- Identify the scope of the study
- Conduct literature review and gather relevant information

Phase 2: Design and Development

- Select the appropriate Hyperledger framework
- Design the smart contracts for food supply chain traceability
- Develop the application layer using React Native

Phase 3: Implementation and Testing

- Implement the blockchain network using the selected Hyperledger framework
- Integrate the application layer with the blockchain network
- Test and validate the system to ensure it is functioning correctly

Phase 4: Results and Analysis

- Analysis of the data should be done in the testing phase
- Evaluate the system's performance and effectiveness
- Summarize the findings and draw conclusions

Phase 5: Documentation and Report Writing

- Document the system architecture and design
- Write the research paper and present the findings
- Provide recommendations for future research and improvements to the system.

In conclusion, the proposed methodology and implementation plan for tracing food supply chain using Hyperledger will involve defining the research objectives, selecting the appropriate Hyperledger framework, designing the smart contracts, developing the application layer, implementing the blockchain network, testing and validating the system, analyzing the results, and documenting the findings. The implementation plan will be divided into phases to ensure the project is completed efficiently and effectively.

CONCLUSION

India's food supply system must be flexible, adaptable, and effective if it is to be successful on a global scale. However, this intricate network faces a variety of difficulties, including:

- Supply chains are not entirely digitalized today. Traditional and manual paper-based tracking methods are still in use, making it difficult to achieve total visibility.
- The supply chain's data is stored all over a number of distributed platforms. Consequently, it is impossible to attain a complete knowledge of the entire supply chain.
- Each ecosystem participant has the ability to alter the data and make unsupported claims.
- Perishable food stuffs and numerous minor stakeholders with weak connections. The food industry has been affected by conventional supply chain inefficiencies.

This paper provides a base for a solid platform for future research in this field and identifies some possible research topics by locating and evaluating the most relevant papers.

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