Food Supply Chain Traceability Using Hyperledger

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***Abstract*—Globalization has led to an increase in complexity in supply chain systems across all industries as a result of increased networking and a shift in automation strategies that were occasionally constrained by old supply chains. The centralized character of the supply chain is one of the important factors that conventional approaches should focus on. This causes the food product to be provided to the end user to be of lower quality, contaminated, and tampered with. The goal of the proposed system is to create a decentralized food supply chain system that makes use of blockchain technology and smart contracts, deployed across a sophisticated hyper-ledger fabric network. The main goals are to enable smart contract-based transaction validation in order to overcome the difficulty of tracking and maintaining the integrity of data throughout the entire supply chain process, each stage of the chain therefore covers a variety of factors, such as offering transparency, efficiency, and accountability.**

***Index Terms*—decentralized, blockchain, traceability, smart contract, supply chain, food**

I. INTRODUCTION

Agriculture has traditionally been the foundation of India's economy. Post pandemic, there has been strong economic growth in the nation and an improvement in the standard of living for the average person, which has increased demands for food safety and quality. There have been some startling data recently about the food supply chain in light of the epidemic.

India exports agricultural products and processed food to more than 120 other nations. From March to June 2020, India exported just agricultural products worth about $3.50 billion. Up to 45% of food production is spoiled in the distribution system. Just 7% of perishable foods are processed at all. [1]. According to the American Chambers of Commerce, postharvest losses cost the nation's economy roughly $14 billion annually. The fruit and vegetable sector in India has a weak supply chain, and each year 30% of the crop is lost due to fluctuating prices, changing consumer demand, growing input costs, a lack of storage space, and unpredictable transportation [1].

To earn the trust of the end customer, the entire supply chain process must be precise and consistent when delivering the product. The following criteria, including the integrity, quality, and transparency of the traceability systems, must be checked off by a delivery authority. The Food Safety and Standards Authority of India (FSSAI) is constantly expanding to enforce these requirements so that delivery authorities can be satisfied with the high quality of the items.

Additionally, issues at the local level like outdated infrastructure, a lack of funding, misaligned regulatory frameworks, a lack of low-level data and information, and insufficient monitoring systems for traceability have an immediate or long-term impact on the supply chain.

As the number of users grows and demand rises, centralized systems become unable to process the massive amounts of data being generated, creating inevitable bottlenecks that impair the operation of the entire network. Distributed systems, on the other hand, offer traits like fault tolerance, parallel processing, real-time scalability, and efficient storage structures.

Based on the aforementioned factors, it becomes necessary to develop a food supply chain traceability system with a decentralized architecture based on the developing blockchain technology in order to assist the Indian market in improving both the quality and safety of their food as well as helping to prevent or at least reduce the significant losses experienced 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.

II. LITERATURE SURVEY

A. Blockchain

Nakamoto originally mentioned blockchain in 2008.The first decentralized ledger was characterized by the paper's unknown author(s) as a database that anybody may contribute to and is not under the control of a single or group of individuals. Since then, other additional blockchains, including Ethereum, Ripple, and many others, have been discussed. 248 active blockchains were mentioned in May 2019. Although there are many different blockchains, there is no direct path to interoperability, at least not without a reliable third party. Consider a client who wishes to exchange their Bitcoins for ether. They would need to spend the desired quantity of Bitcoins and produce the same amount of ether. While it may be feasible to consume Bitcoin (by sending money to an address that doesn't exist, like the address 0), it is not possible to generate Ether or any other cryptocurrency on demand. Although additional solutions are on the way, for the time being the issue is resolved with the aid of reputable brokers (also known as escrows). In some circumstances, such as "atomic exchanges" and hash-locking, the problem of interoperability is resolved since game theory makes sure that a broker only gains while adhering to the protocol. However, the overall issue of trustless interoperability is still up for debate. [2]

B. Hyperledger

A Linux Foundation project called the Hyperledger Project aims to create an open source blockchain development ecosystem. The Linux Foundation wants to foster a setting where groups of businesses and software engineers may interact and work together to develop blockchain technologies. The Hyperledger platform itself

An open centre for enterprise-grade blockchain initiatives to incubate and mature through all stages of development and commercialization as opposed to another coin. Eight initiatives under the Hyperledger Project are currently in development: Three development tools are available for each of the five frameworks that are in the works.

- Sawtooth: The endeavour to develop an open source blockchain is being made by Intel. A modular framework for creating, implementing, and operating distributed ledgers is called Hyperledger Sawtooth. Proof of Elapsed Time (PoET), a new consensus technique, targets large distributed validator populations with low resource usage. It enables the wide-scale deployment of both permissioned and permissionless ledgers.
- Iroha: This is a comprehensive group of libraries and parts that will make it possible to integrate distributed ledger technologies into already-in place infrastructure. Mobile libraries and applications are given a lot of attention. In order to guarantee validated nodes, networkwide default reputation system implementation and data storage and synchronization performed off-device are used.
- Fabric: This blockchain development platform enables the creation of modular enterprise apps. With a focus on plug and-play features like pluggable consensus and specific membership services for various user roles, it is designed to be a component-based system.
- Burrow: Similar to the EVM, this permissioned blockchain node carries out smart contracts. A multichain ecosystem with application-specific smart contracts is how Burrow is designed to be performed. A Burrow node can offer services for contract execution to a number of connected blockchains that are interoperable with one another but operate in distinct domains. The consensus engine, the permissioned EVM, and a remote call gateway for contract execution make up the three primary parts of a Burrow node.
- Indy: This software development kit (SDK) for Hyperledger enables self-sovereign identity to be incorporated into distributed ledgers. To develop better decentralized identity managers and provide new functionality, this SDK offers wrappers for several languages.
- Composer: This is a front-end interface for Hyperledger that allows the deployment of straightforward blockchain networks for certain use cases. We can create straightforward smart contracts using Hyperledger Composer and publish them to a private blockchain network. Only a small group of core users would update the code for a ledger like Fabric in a vast development environment. The majority of users would be using Composer to access the blockchain and do daily tasks like upgrading and accessing it.

- Explorer: With Hyperledger Explorer, users may query blocks, search through transactions and related data, network health and information, the different kinds of smart contracts being executed, and transaction families that have been stored in the ledger, just like with any other standard blockchain explorer. New projects will not need to create a brand-new explorer module because this project will work with any Hyperledger-deployed blockchain.
- Cello: This is a deployment management tool for blockchain as a service instance. Cello makes it easier to create blockchain instances and requires less work to create, manage, and terminate blockchains. It offers a blockchain service that is containerized and can be installed on pre-existing cloud infrastructures, bare metal, virtual machines, or specialized container platforms. [3]

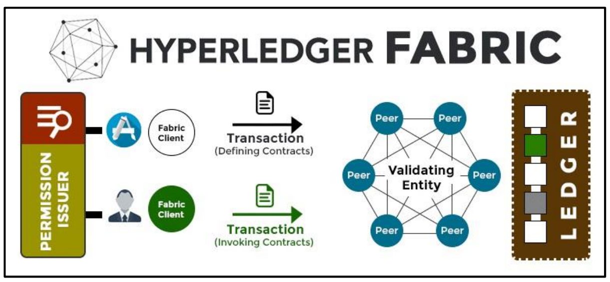

Fig. 1. Architecture of Hyperledger Fabric

C. Food Supply Chain

Farmers, shipping businesses, wholesalers and retailers, distributors, and grocery stores are just a few of the many different actors that make up the global food chain. Below is a description of the key steps in a general agri-food supply chain.

- Production: The farm's entire range of agricultural operations are included in the production phase. To raise crops and cattle, the farmer employs unprocessed, organic materials (fertilizers, seeds, animal breeds, and feeds). We may have one or several harvests or yields throughout the course of the year, depending on the cycles of the cultivations and/or animal production.
- Processing: This stage involves the whole or partial conversion of a main product into one or more secondary products. A packaging step is then anticipated, during which each package may be individually identifiable by a production batch code that contains details such as the production day and a list of the raw ingredients utilized.
- Distribution: The product is prepared for distribution once it has been packaged and labelled. Delivery times might be constrained to a given range depending on the goods, and there might be a step for product storage (Storage).
- Retailing: The products are delivered to merchants (merchants) at the conclusion of the distribution process, who handle the product sale. The client, who will purchase the product, will be the chain's final user.
- Consumption: The consumer, who purchases the product and requests traceable information about quality standards, place of origin, production processes, etc., is the chain's final user. [4]

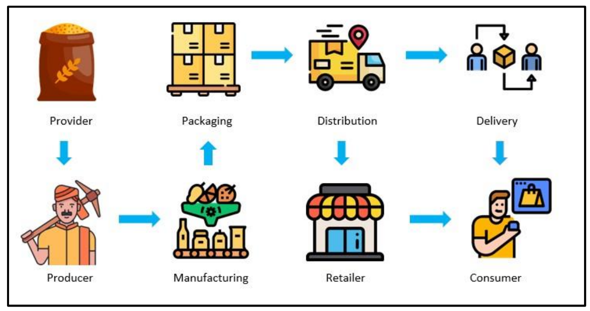

Fig. 2. Representation of Food Supply Chain

D. Decentralization

Decentralization enables direct transactions between users, which, in contrast to conventional transactions that need approval from a central authority, eliminates the central authority and closes information gaps. Make that your network's authorized users all have the same rights. Users have equal rights to access history at any time, can maintain copies of information, and can validate transactions with one another. [5]–[7].

Product data can be recorded at every stage of the food supply chain, from raw material suppliers to consumers. Multiple parties maintain copies of the recordings, which can be recalled whenever necessary. [8].

Equal load sharing, quick decision-making, minimizing bottlenecks, and equal accountability at all levels of authority are traits of distributed systems.

E. Security

Data security can be achieved with blockchain consensus algorithms. One consensus process that demands that all transactions be confirmed by other users is called Proof of Work. [9].

A computer computation must be defined by the user in order to authorize transactions and add information to the database. Decentralization prevents the supply chain from collapsing by removing the network's central power source. This is due to the fact that a single failure does not bring the entire network to a halt, decreasing the likelihood of hacking. Technically, hijacking the majority of users is required for hacking to succeed, but doing so requires a lot of effort and time. [9]

F. Traceability

Increased traceability makes it possible to accurately track product movement, offering businesses a clearer picture of their supply chain and assisting them in making better decisions and avoiding potential quality issues. [10] The speed at which certain products can be isolated from particular suppliers and identified rises with the ability to track products back and forth along the supply chain, improving quality controls and product recalls. Customers may make more informed decisions and feel more confidence about the products they buy by displaying the flow of resources and goods.

Traceability is therefore considered an added value of food [11], [12]. Additionally, the traceability system can be used as a marketing tool to increase client attraction and loyalty. Records are another way for businesses to verify that the products coming from their suppliers are of high quality. Therefore, a tactical tool for boosting partner trust can be an efficient traceability system. [13].

G. Smart Contract

In 1994, Nick Szabo developed the idea of a "smart concept," which he defined as a computerized transaction protocol that carried out the terms of a contract. He claims that the necessary hardware and software should have the contractual provisions (such as collateral, bonding, the definition of property rights, etc.) encoded and embedded. This makes the system secure against any malicious attack while also reducing the need for any trusted third party when using smart contracts for communication. Contracts for blockchain based smart contracts are nothing more than scripts stored on the blockchain, which has the power to carry them out. A smart contract's unique addresses can be used to initiate a transaction by leveraging the blockchain technology. Let's use an illustration to better understand how smart contracts function. If you wish to rent out your flat or sell your house, you can easily do it by deploying a smart contract in a blockchain network already in place. relating to the property, the blockchain can be used to store data, and Any member of that network has access to the information, but they are unable to alter it. You can locate a buyer for your property in this way without the use of a third party. Blockchain-based smart contracts may provide a number of advantages for a

variety of potential applications, including:

- Speed and updates
- Lower execution risk
- Lower cost
- Accuracy
- New business or operational models • Fewer intermediaries [14]

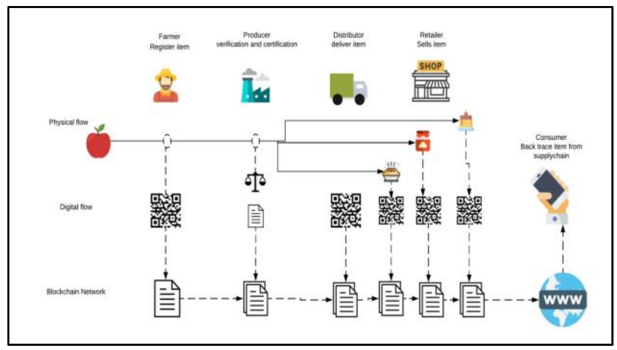

Fig. 3. Architecture/Flow of Food Supply Chain

III. 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

IV. RESULTS

The following are the screenshots of the user interface which represents the result:

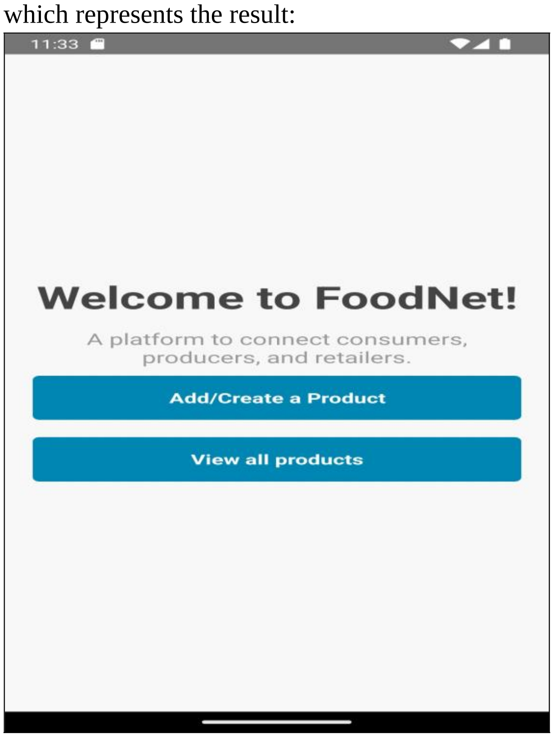

Fig. 4. Landing Page of the Application

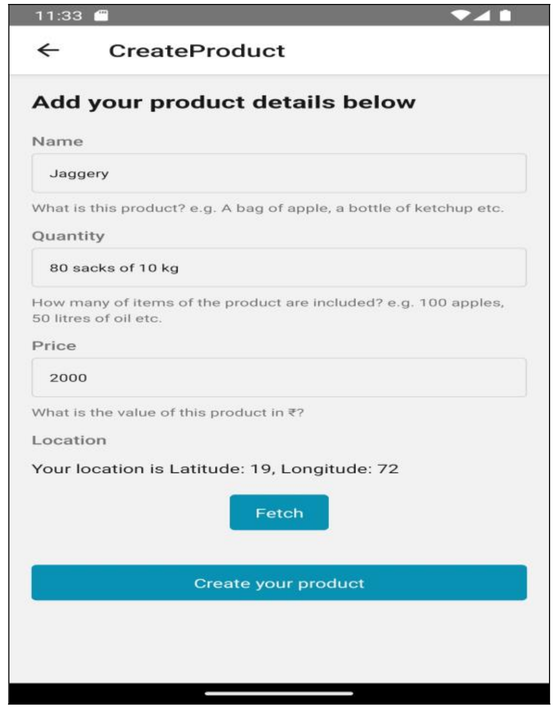

Fig. 5. Creating a new product and adding its details

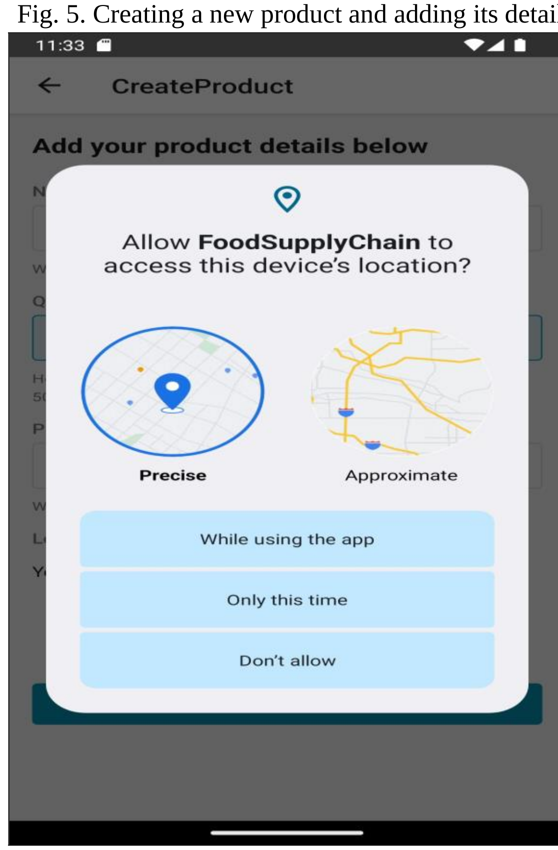

Fig. 6. Asking for User's permission for location access

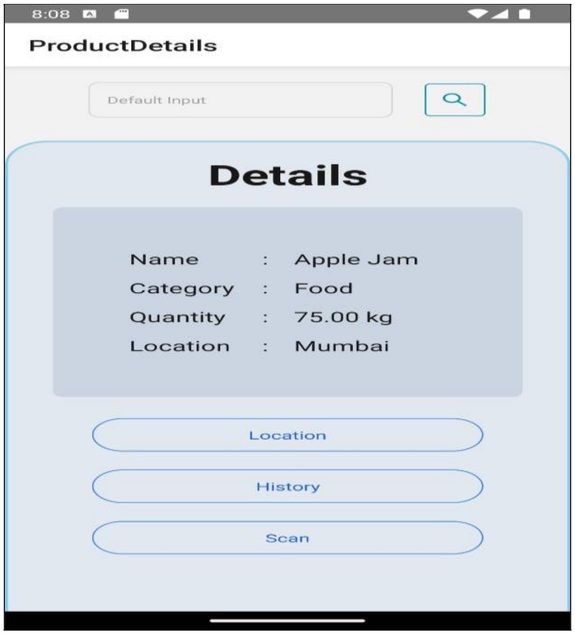

Fig. 7. Getting the details for product requested by user

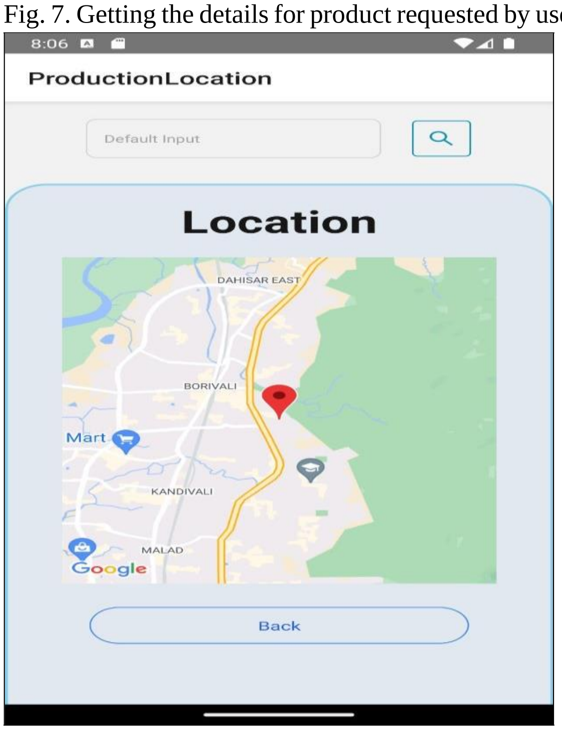

Fig. 8. Getting the current location of the product

V. 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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