

Enhancing Traceability in Agricultural Supply Chain Using Blockchain Technology

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Abstract: The work highlights exploring the usage of blockchain technology for enhancing traceability in agricultural supply chain management. The aim is to develop a secure and transparent system, which improves the easy tracking and tracing of agricultural products from the point of origin until it reaches the end consumer. Currently, Blockchain is a technology, which provides security in various fields of transactions. The work utilizes to improve supply chain efficiency, increase transparency and accountability, and enhance consumer trust in the agricultural products. The system will utilize smart contracts to automate processes and ensure compliance with regulations and standards, which improves supply chain efficiency. Smart contracts enable agreement between two parties present in the supply chain. Further, the financial transactions can be improved with the help of block chain. Additional, the work will also provide recommendations for companies and organizations looking to implement blockchain-based results in their supply chain management. The work implements an application using ganache, solidity and truffle. Ethereum block chain is used as primary infrastructure for the application. Smart contracts generated using solidity is deployed into Ethereum network using truffle. The deployment of the application in agricultural sectors improves the accountability in the field of the supply chain. The deployment in a wider range will avoid manipulation of the data.

Agricultural supply chain tracing website involves the use of several tools and technologies, including Ganache, Solidity, and Truffle. The system uses the Ethereum blockchain as the underlying infrastructure to store and manage supply chain data securely and transparently. The smart contracts in the supply chain tracing system are generated using Solidity and deployed to the Ethereum network using Truffle.

Index Terms: Blockchain, Agriculture, Traceability, Transparency, Supply chain management

1. Introduction

The challenges faced by the agriculture industry in the past, include a lack of traceability and transparency in the supply chain. These challenges have made it difficult for consumers to have assurance regarding the quality and safety of their food. However, Blockchain technology can help address these challenges by providing a secure and transparent method of monitoring the complete supply chain from farm to table. Supply chain management (SCM) is a critical component of the agriculture industry, since it has to coordinate and plan the activities in the production, processing, and distribution of food products. SCM can be enhanced by blockchain technology by providing a decentralized and immutable ledger that can track all transactions and data associated with the supply chain (SC).

Blockchain technology in agriculture can offer a number of advantages. First, it can improve supply chain traceability and transparency. Given that they can follow a product’s shipping details starting from source to destination, farmers and consumers can feel confident in the safety and quality of the food goods they purchase. Second, blockchain can aid in lowering the likelihood of supply chain fraud and corruption. This is due to the immutability of all transactions and data stored on the blockchain, which prevents their alteration or deletion. Third, by cutting the time and expenses associated with manual operations, blockchain technology helps in assisting improvement in supply chain efficiency.

Several companies and organizations have already begun to explore the use of blockchain technology in agriculture. For example, Walmart adopted a blockchain-based food traceability system that allows it to track the origin and journey of its leafy green vegetables. This system has already proven to be successful in reducing the time it takes to trace the origin of a food product from several days to just a few seconds. Additionally, the World Wildlife Fund (WWF) is exploring the use of blockchain technology to track the origin of sustainable seafood products.

When applying blockchain technology in agriculture, there are obstacles that must be overcome. The requirement for compatibility between various blockchain platforms presents one difficulty. This is due to the possibility that various blockchain platforms used by supply chain participants may prevent seamless communication between them. Additionally, there is a need for standardization of data and processes across the entire supply chain to ensure consistency and accuracy of data.

Blockchain technology has the ability to completely change how agriculture supply chain management is carried out in the present implementation. Blockchain can help promote transparency and traceability, lessen fraud and corruption, and boost efficiency by giving a safe and transparent mechanism to follow the full supply chain from farm to table as shown in Figure 1. While there are challenges that must be addressed when implementing blockchain in agriculture, the benefits are clear. As more companies and organizations begin to explore the use of blockchain technology in agriculture, significant improvements can be observed in the quality, safety, and sustainability of food products.

The paper is organized by explaining the survey carried out in section 2 followed by implementation of the work. The implementation explains how Ethereum block chain is implemented and integrated with smart contracts. Section 3 includes results and discussions, where the activity diagram and screenshots of the application results included. Further, a conclusion and future scope is summarized.

2. Related Work

A literature review is carried out with recent papers to provide a decentralized and immutable ledger for recording transactions and data related to the supply chain process. The global economy’s agriculture sector is essential, and supply chain management is essential to the effective production and distribution of food goods. However, the agricultural supply chain confronts a number of difficulties, including a lack of transparency and traceability, which has raised questions about the reliability and caliber of food items.

Blockchain technology has become a viable answer to these problems in recent years. These literature reviews attempt to present a summary of the current status of research on blockchain-based SCM in agriculture. Lack of transparency and traceability in the supply chain is one of the biggest problems facing the agriculture sector. Numerous research that addresses this issue shows how blockchain technology provides a secure and transparent solution to track the whole supply chain. Fig 1 shows the network of blockchain in the supply chain.

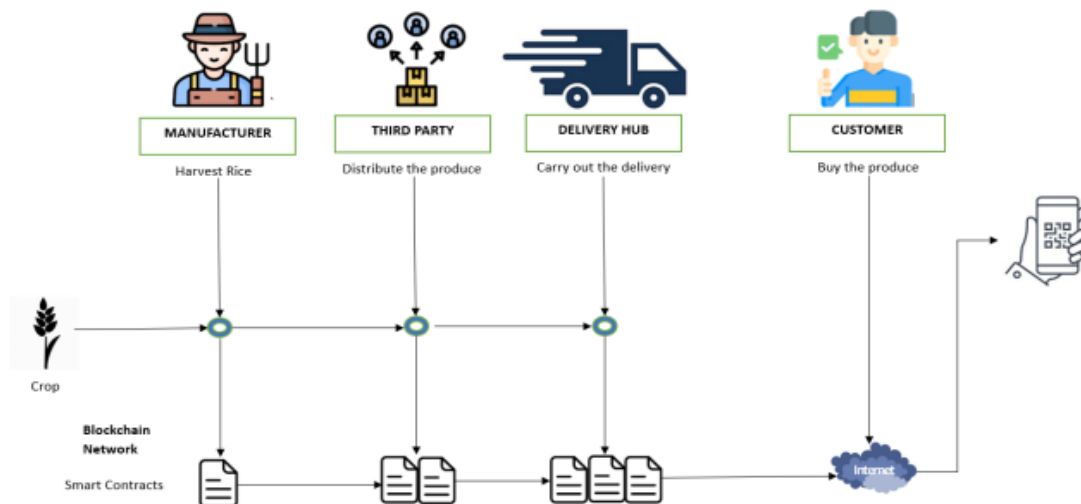


Fig.1. Diagram showing the Blockchain network in the supply chain

In order to achieve traceability in the hemp business, this study suggests a methodology that integrates agricultural specialist knowledge, value chain planning, and digital technology. The integration of embedded systems and the Internet of Things (IoT), offers optimization opportunities in agronomic processes. The model aims to address the challenges related to traceability in the industry while leveraging the benefits of these technologies. The author proposed a permissioned blockchain that considers various actors in the value chain. It ensures the tamper-proof, transparency, and secure traceability of products and activities. Additionally, the model integrates a range of services, going beyond the partial integration seen in other proposals. It not only focuses on blockchain implementation but also emphasizes the use of human-machine interfaces and IoT protocols. Model is validated using a proof-of-concept implementation in a realistic scenario. A network of IoT devices with control algorithms is deployed to provide traceability services. These devices have automated access to the blockchain, enabling seamless integration of digital systems and human tasks [1].

The passage of agricultural products from producers to buyers is tracked through an arming supply chain. The author introduces blockchain for farming as a transparent system that allows members of the organization to collaborate effectively. By doing away with the requirement for a central trusted authority and middlemen, this strategy increases output while improving security, integrity, accountability, and safety. Smart contracts are used to coordinate and control various interactions and exchanges between the various supply chain network players. The blockchain-based traceability solution AgriBlock IoT is advertised as incorporating data from IoT devices used in the SC. It offers a comprehensive view of the product journey from the farm to the branch, including the evaluation of Ethereum and Hyperledger implementations. By leveraging blockchain technology, this approach aims to enhance transparency, trust, and efficiency in the farming supply chain [2].

Author focuses on exploring the advantages of blockchain technology in agricultural SC during the COVID-19 pandemic. It specifically aims to identify the benefits and solutions offered by blockchain for the efficient running of agricultural supply systems during this difficult time. The findings of the study reveal the most commonly mentioned benefits of implementing blockchain technology in agricultural SC during COVID-19. These benefits include data retrieval and management, tracking shipments, combating transaction and product fraud, and addressing the inflexibility of international supply chains. Promising solutions are proposed to overcome these challenges. By leveraging blockchain, the study suggests that agricultural companies can enhance supply chain transparency, data management, fraud prevention, and adaptability to overcome the unique challenges posed by the pandemic [3, 21].

The author addresses the concerns surrounding food safety in the grain supply chain and the need for effective information management. To overcome the issues such as inadequate hazardous-material information management, data tampering, low traceability efficiency throughout, and isolated information islands the study explores the application of blockchain technology, known for its decentralization, network-wide recording, security, and reliability [4].

The blockchain-based system offers improved data security and reliability, enhanced information communication and interconnection, real-time sharing of hazardous-material information, and dynamic and trustworthy process tracing [4].

The author focuses on the evaluation of blockchain technology's maturity in the agricultural SC. Blockchain is recognized as a disruptive technology that has the potential to revolutionize business and supply chain models by enabling secure and transparent information exchange. The objective of this research is to develop a model for assessing blockchain technology specifically in the context of the agricultural SC. The study is conducted in three phases. In the first phase, agricultural experts rank the dimensions of blockchain technology using the SWARA method, which involves a group of 13 faculty members specialized in technology methods in agriculture.

In the second phase, a model is further enhanced to evaluate the maturity of blockchain technology by considering each dimension of blockchain and maturity. In the final phase, the model is tested using a questionnaire data operating in the agricultural sector. The findings of the research highlight that among the dimensions of blockchain, smart contracts, the Internet of Things (IoT), and transaction records are deemed of the highest importance in the agricultural supply chain. Additionally, the study reveals that the supply chain under examination demonstrates a good level of digital document management [5].

The author addresses the limitations and challenges faced by existing blockchain-based traceability systems in the agricultural sector. While these systems provide customers with online access to data, transparency issues, privacy concerns, and security challenges still persist. To overcome the challenges and to enhance the credibility of traceability data, the researchers propose a prototype called the Trusted Auditing (TA) Chain. The TA leverages the unique attributes of blockchain technology, including security hash cryptography, tamper-evident properties, and a distributed ledger. It aims to provide a reliable and secure storage solution for traceability data while ensuring privacy and scalability. The prototype incorporates a Zero-knowledge proof mechanism using Schnorr-style non-interactive Zero-knowledge proof mechanism. This supports automatic privacy augmentation and enhance data security [6].

The main advantages of the TA chain are its ability to perform audits efficiently. It can audit over 1000 transactions within 1ms, with an error rate stabilizing below 250 μ s. This demonstrates the system's reliability and efficiency in ensuring data distribution, reliability, and provable auditing. By proposing the TA chain, this study presents a flexible solution that addresses the challenges associated with existing blockchain-based traceability systems. It offers enhanced data security, privacy preservation, scalability, and auditing capabilities. The research contributes to the development of a secure and fair traceability system in the agricultural sector, inculcating trust in the distributed and audited nature of the traceability data [7].

The author explores the interest and applications of blockchain technology in the agricultural sector. The blockchain in agriculture can address various needs, including improving transparency in food safety, applying IoT-based quality control, ensuring provenance traceability, improving contract exchanges, and increasing transaction efficiency. It starts by explaining the technical elements such as data structure, cryptographic methods, and consensus mechanisms associated with blockchain. It then categorizes and reviews existing blockchain applications in agriculture, highlighting the platforms and smart contracts utilized by practitioners in developing these applications [8].

Furthermore, the study identifies key challenges faced by prospective agricultural systems and discusses potential solutions. It recognizes the need to address these challenges to fully leverage the benefits of blockchain in agriculture [8]. The article addresses the pressing issue of food safety in China and its implications for public health, quality of life, and overall societal well-being. To tackle the problem of inadequate food management, many countries and regions have invested in researching, developing, and implementing traceability systems as a means of ensuring product quality and safety. In response, the article introduces the concept of Blockchain technology as a potential solution. Blockchain technology is proposed as a promising approach to address the shortcomings of conventional traceability systems. By leveraging its inherent characteristics, such as decentralization, immutability, and transparency [9].

This study focuses on the adoption of Blockchain Technology (BT) in agriculture SC (ASC) to enhance their sustainable performance. BT has emerged as a disruptive technology that addresses trust-related issues in supply chains, and its potential benefits are being explored worldwide. The author aims to identify and establish the relationships between the enablers of BT adoption in ASC. Through literature review and validated by experts, thirteen enablers were identified. To understand the complex causal relationships between these enablers, a combined Interpretive Structural Modelling (ISM) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) methodology was applied [9].

The study addresses the limits of traditional traceability systems in the SC of agricultural products and proposes a traceability system on blockchain technology as a solution. The proposed system aims to enhance the transparency and credibility of traceability information by utilizing blockchain technology. The study also introduces the use of cryptography to ensure the secure sharing of private information within the blockchain network. The contract design encourages active participation and data contribution from network nodes, enhancing the overall reliability of the system. The researchers provide performance analysis and practical application scenarios to demonstrate the effectiveness of the proposed system. Further, blockchain technology can enhance the transparency and traceability of the supply chain, reduce the risk of fraud and corruption, improve the efficiency of SCM, and facilitate interoperability and standardization [10,19].

The paper highlights the challenges faced by traditional SC systems and the benefits that blockchain can offer in terms of transparency, efficiency, and traceability. The transparency provided by blockchain helps in reducing code of conduct violations throughout the supply chain. The immutability property of blockchain allows stakeholders to trace products throughout the network, ensuring authenticity and accountability [11, 20].

This paper explores the use of blockchain technology in SCM to overcome limitations in traditional supply chains. By employing unique tags like RFID, NFC, or QR codes, the proposed solution enhances trust and transparency by ensuring unalterable product information. Leveraging blockchain's secure and decentralized nature, the system improves the overall supply chain life cycle. This approach addresses the disadvantages of conventional supply chains and provides a reliable and efficient solution for participants. Ultimately, the paper showcases how blockchain and special tags can enhance traceability and transparency, benefiting various industries' supply chain management [12,16].

This study focuses on the integration of Internet of Things (IoT) technology with blockchain to enhance transparency and trust in the food supply chain (FSC). The author suggests replacing the traditional third-party intermediaries with a blockchain-enabled IoT platform to authorize and ensure the legitimacy of product data. This platform would involve all relevant parties in the FSC and enforce agreed-upon terms. The case study presented illustrates the feasibility of implementing an accessible IoT technology-based data network and explores various IoT technologies that can be utilized in the proposed architecture [13].

The author highlights the potential of using blockchain in conjunction with IoT to modernize and optimize the standard FSC, improving transparency and efficiency [13].

The author addresses the challenges present in the centralized agricultural supply chain, such as integrity issues, tracking difficulties, and lack of trust and transparency. These issues lead to doubts about food quality and payment frauds. To overcome these challenges, the paper proposes a model for an agricultural supply chain system using the Ethereum blockchain platform. Smart contracts are developed for each stage of the supply chain to ensure that predetermined conditions are met before transactions take place. By leveraging the transparency, immutability, and traceability of the public blockchain, the proposed system aims to reduce irregularities and frauds. It offers enhanced security, reliability, trust, and openness. The system streamlines transactions and administrative processes, benefiting all participants. Additionally, the use of smart contracts provides fair opportunities for farmers to quote prices.

Author discusses the potential of integrating blockchain with the Internet of Things (IoT) framework in supply chain management. It highlights the challenges faced by traditional supply chain systems and the benefits that blockchain can offer in terms of transparency, efficiency, and traceability. The immutability of blockchain records allows stakeholders to trace products throughout the network, ensuring authenticity and accountability [15]. Incorporating Industry 4.0 into the elements of supply chain management builds a more responsive supply chain [16,17].

3. Implementation

3.1. Blockchain Implementation

The implementation of blockchain is as shown in Fig. 2, where the agricultural supply chain tracing website involves the use of several tools and technologies, including Ganache, Solidity, and Truffle. The system uses the Ethereum blockchain as the underlying infrastructure to store and manage supply chain data securely and transparently. The smart contracts in the supply chain tracing system are created using Solidity and deployed to the Ethereum network using Truffle.

Ganache is a personal blockchain for Ethereum development that enables us to create decentralized apps (dApps), test smart contracts, and replicate the operation of the Ethereum network in a local setting before deploying them to the main net. It provides a virtual blockchain environment that developers can use to simulate the behavior of the Ethereum network and test their code in a safe and controlled environment. The smart contracts that control how the system behaves are created using the programming language Solidity.

The Ethereum Virtual Machine (EVM) can execute complicated and secure smart contracts that are written in this contract-oriented language. For creating decentralized apps (DApps) on the Ethereum blockchain, the truffle development framework is used. It offers a set of tools and frameworks that programmers may use to create, test, and launch their applications and smart contracts.

The smart contracts are designed to capture the key events and transactions in the supply chain, including the production of the product, purchase by the third party, shipping by the manufacturer, processing by the third party, and delivery to the customer.

They are also designed to ensure that the supply chain data is immutable and transparent, ensuring that all parties can access and verify the data at any time. Smart contracts use cryptographic algorithms to ensure the authenticity and integrity of the data, making it resistant to tampering or modification. Smart contracts also provide a mechanism for automated payments and settlements, ensuring that all parties are compensated for their role in the supply chain. This helps to eliminate the need for intermediaries and reduce the overall cost and complexity of the supply chain.

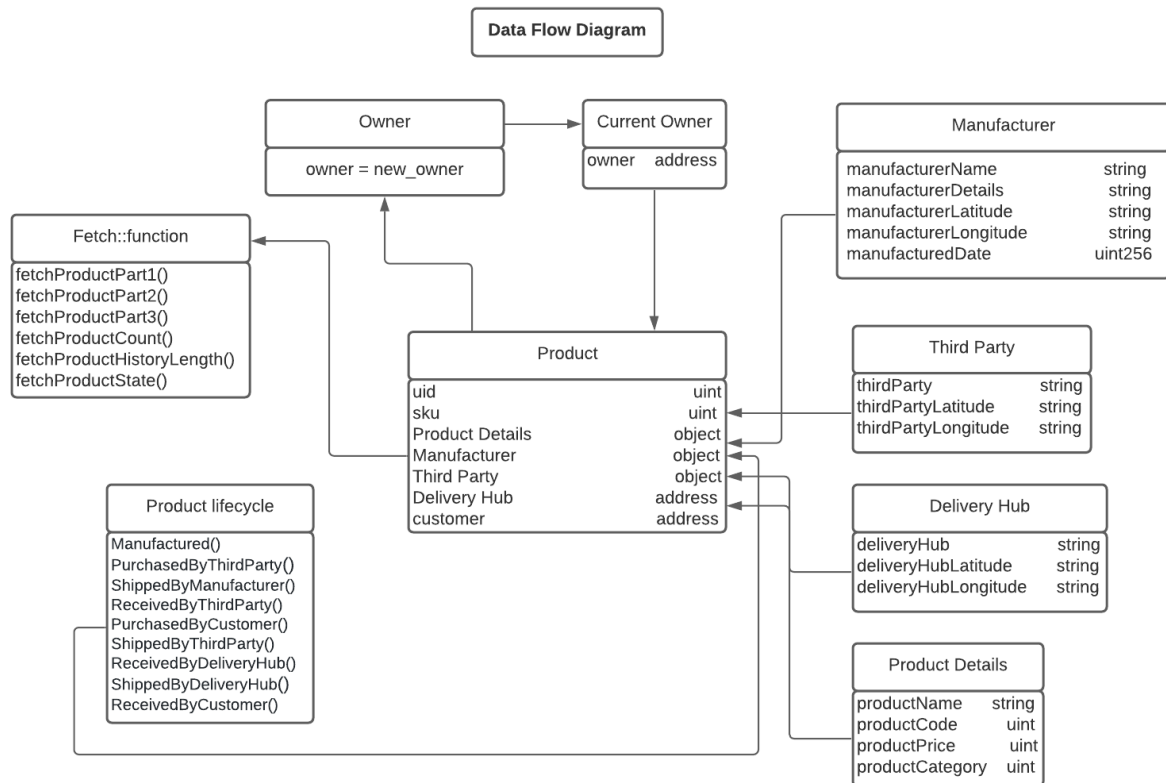


Fig. 2. Class diagram representing the flow of data.

3.2. Integration of Blockchain

In the website, blockchain is integrated using the Web3.js library. Web3.js allows the website to communicate with the Ethereum blockchain and interact with the smart contracts deployed on it. To integrate the blockchain, the website developers first create smart contracts using the Solidity programming language and Truffle framework. These smart contracts contain the rules and logic for the supply chain process and are deployed on the Ethereum network. Once the smart contracts are deployed, the website uses the Web3.js library to interact with them. The architecture diagram is as shown in figure 3.

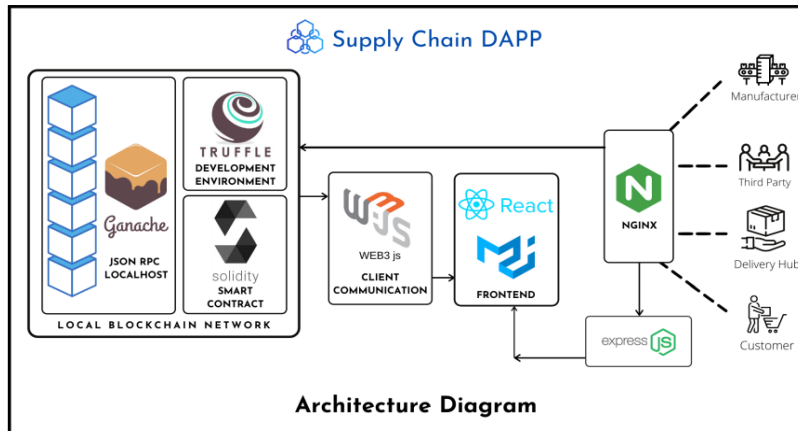
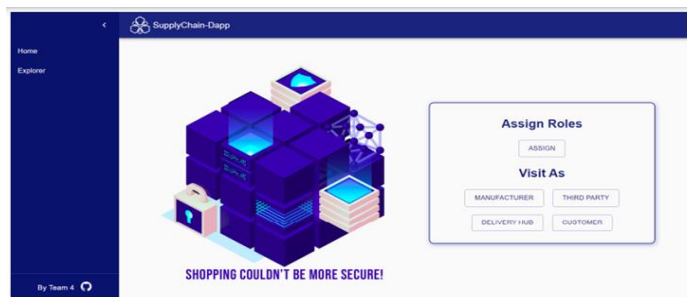


Fig. 3. Architecture diagram of proposed work

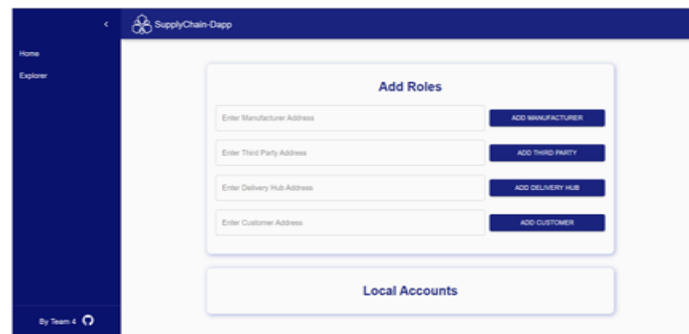
3.3. Application design

This includes sending and receiving transactions, retrieving data from the blockchain, and listening for events emitted by smart contracts. For example, when a farmer produces a product, the website sends a transaction to the smart contract to record the production details on the blockchain. When a third party purchases the product, the smart contract updates the ownership and sends a transaction to record the transaction details. Web3.js also provides a secure and easy-to-use interface for users to connect their Ethereum wallets to the website. This allows users to securely purchase products and track their supply chain journey on the blockchain.

The front end of the agricultural supply chain tracing website is implemented using the React.js library, which provides a simple and intuitive way to create reusable UI components. The user interface is designed to be responsive and user-friendly, with a modern and clean look. The main page of the website displays a search bar where the user can enter the product code to track its supply chain. Once the user enters the code, the website fetches the data from the Ethereum blockchain using the Web3.js library and displays it in a simple and intuitive way. The user can see the origin of the product, the farmer who produced it, the third party who purchased it, the manufacturer who shipped it, and so on, all the way to the delivery hub and the customer who received it.



(a)



(b)

Fig. 4a). Home page of User Interface designed. Fig.4b). Addition of role as manufacturer, third party, customer or delivery hub.

To make the supply chain tracing even more convenient, a QR code is provided that can be scanned using a smartphone to see the entire supply chain in one place. The QR code is generated using the product code and the Web3.js library, and it provides a convenient way for customers to verify the authenticity and quality of the product they have purchased.

The UI is designed to be seamless and intuitive, with clear and concise information presented in an easily digestible format. The use of React.js allows for a modular and flexible approach to building the user interface, with reusable components that can be easily customized and updated as needed. The website is responsive and works equally well on desktop and mobile devices, providing a seamless user experience.

4. Results and Discussions

The implementation of a blockchain-based agricultural supply chain tracing website represents a significant advancement in the field of supply chain management. This innovative solution leverages the power of blockchain technology to provide users with an immutable and transparent record of the entire supply chain process, from farm to consumer. By utilizing this platform, users can easily track the origin of their products, ensuring that they are ethically sourced and of the highest quality. In order to evaluate the effectiveness of this solution, several experiments were conducted, focusing on various aspects of the website's functionality.

These experiments aimed to assess the performance of the system, as well as the user experience provided by the website's front-end. The website's ability to accurately track the movement of products through the supply chain was tested. This was achieved by using a series of test transactions to simulate the movement of products through the system. The results of this experiment were highly promising, demonstrating the ability of the blockchain to provide an accurate and tamperproof record of product movements.

User testing was conducted to evaluate the overall user experience provided by the website's front-end. Participants were asked to perform a series of tasks, such as tracking the origin of a particular product, and providing feedback on the ease of use and overall effectiveness of the system. The results of this testing were highly positive, with participants reporting that the website was easy to use and provided a seamless and intuitive user experience.

It demonstrates the effectiveness of the blockchain-based agricultural supply chain tracing website. By leveraging the power of blockchain technology, this system offers users a precise, clear, and effective way to follow the progress of goods through the supply chain tracing website.

Blockchain technology can significantly increase transparency and reduce inefficiencies in the supply chain. The website's user interface listed from figure 4 is highly intuitive and user-friendly, making it easy for users to access the information they need. The use of React ensures that the website is highly responsive and can handle a large number of users simultaneously, providing a seamless user experience. With the incorporation of Internet of Things (IoT) devices can provide real-time data on the location, temperature, and other environmental factors affecting the products in transit. This data could be recorded on the blockchain to provide an immutable record of the product's journey, increasing trust and confidence in the supply chain. Figure 5 gives the activity diagram showing the work flow beginning from manufacturer to customer.

Figure 6 and 7 shows the screenshots of the webpage. Smart contracts could be programmed to trigger automatic payments when certain milestones are reached or to automatically block the release of funds if certain quality standards are not met. The website's front end provides a seamless and intuitive user experience, making it easy for users to access and interact with the system. Power of blockchain technology offers users a precise, clear and effective way to follow the progress of goods through the supply chain tracing website. Figure 8 gives the screenshots of the part of source code implemented in the work.

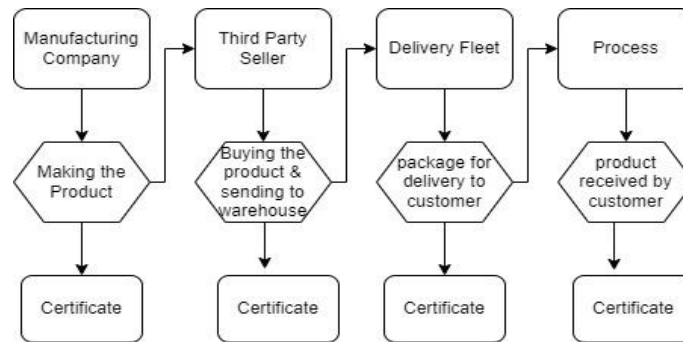
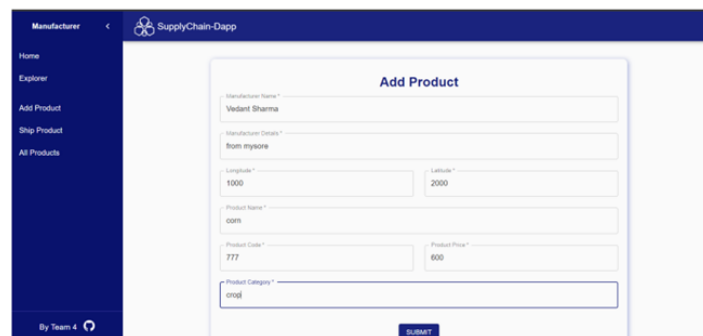


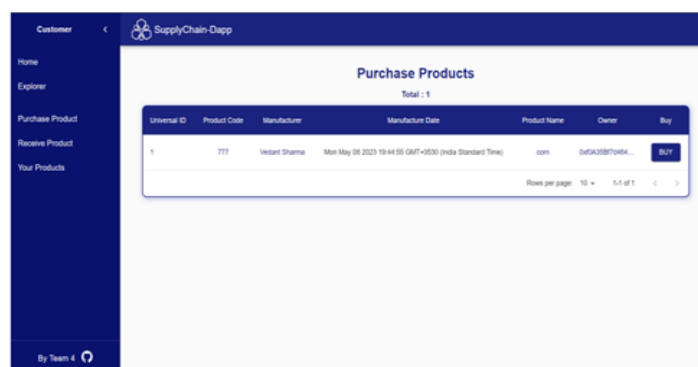
Fig. 5. Activity diagram of the implemented work.



Fig. 6. Screenshots of list of products appearing in the webpage



(a)



(b)

Fig.7 (a). Screenshot of adding products to the webpage; (b). Screenshot of purchasing products.

4.1 Link for the implemented code: The following URL provides the link for the implemented work

<https://github.com/TrascibleVortex/SCM>


```

pragma solidity ^0.8.0;
///@title Library to add, remove and verify role.
///@author Rishav Raj Kumar, Ramiz Mollah.
///@notice You can use this as helper functions for contracts making use of Roles.
///@dev All internal functions from use by contracts internally only.
library Roles{
    struct Role {
        mapping (address => bool) list;
    }
    ///@notice Checks is the given account has the given role.
    function hasRole(Role storage role, address _account)
        internal
        view
        returns (bool)
    {
        require(_account != address(0));
        return role.list[_account];
    }
    ///@notice Adds the given role to the given account.
    function addRole(Role storage role, address _account)
        internal
    {
        require(_account != address(0));
        require(!hasRole(role, _account));
        role.list[_account] = true;
    }

    ///@notice Removes the given role from the given account.
    function removeRole(Role storage role, address _account)
        internal
    {
        require(_account != address(0));
        require(hasRole(role, _account));
        role.list[_account] = false;
    }
}

pragma solidity ^0.8.0;
import "./Roles.sol";
contract DeliveryHub {
    using Roles for Roles.Role;
    event DeliveryHubAdded(address indexed _account);
    event DeliveryHubRemoved(address indexed _account);
    Roles.Role private deliveryHubsList;
    constructor() {
        deliveryHubsList.addRole(msg.sender);
        emit DeliveryHubAdded(msg.sender);
    }
    ///@dev Modifiers for DeliveryHub.
    modifier onlyDeliveryHub() {
        require(isDeliveryHub(msg.sender));
    }
    /*-----*/
    ///@dev DeliveryHub Utility functions.
    function isDeliveryHub(address _account) public view returns (bool) {
        return deliveryHubsList.hasRole(_account);
    }
    function addDeliveryHub(address _account) public onlyDeliveryHub {
        deliveryHubsList.addRole(_account);
        emit DeliveryHubAdded(_account);
    }
    function removeDeliveryHub() public {
        deliveryHubsList.removeRole(msg.sender);
        emit DeliveryHubRemoved(msg.sender);
    }
    /*-----*/
}

```

Fig. 8a). Screenshot of source code implemented for delivery hub 8b). Screenshot of source code for addition of role.

5. Conclusion & Future Work

The present work of agricultural supply chain tracing using React, Node.js, and Ethereum has proven to be a highly effective solution for the agricultural supply chain. The use of blockchain technology ensures that every step in the supply chain is recorded in an immutable and tamper-proof ledger, providing complete transparency and accountability.

The website provides a seamless user experience, allowing users to easily trace the origin and journey of their food products. The use of QR codes provides an efficient and convenient way for users to access the supply chain information of their products, making the entire process highly accessible to the general public.

The integration of the Web3.js library and the use of smart contracts written in Solidity ensure that the transactions are secure and executed in a decentralized manner. The user interface is highly intuitive and user-friendly, making it easy for users to access the information they need. The use of React ensures that the website is highly responsive and can handle a large number of users simultaneously, providing a seamless user experience. With a better understanding of the product’s quality and sustainability.

Furthermore, there is a need for greater collaboration between all parties involved in the supply chain, including farmers, manufacturers, third-party purchasers, and delivery hubs, to ensure that the supply chain is truly transparent and efficient. As technology continues to evolve and improve, there are several possible future directions for this website and similar projects. One potential future direction is the integration of more advanced features, which leads to the development of more sophisticated smart contracts that can automatically enforce certain conditions and requirements. This would reduce the need for manual oversight and intervention and increase efficiency and accuracy in the supply chain. Additionally, the use of blockchain technology could be extended beyond just supply chain tracing to other areas of the agricultural industry, such as crop insurance and financing.

Limitations of the current work are the integration of existing agricultural system with blockchain with respect to hardware and software. Further, if the inaccurate data is entered, then block chain is unable to verify at the source.

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