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Enhancing Supply Chain Transparency and Traceability through a Blockchain-based Product Origins Tracking System

Srinivasan Shanmugam, Sriraman Shanmugam, Merlinsuganya K

UG Student, Department of CSE., Velalar College of Engineering and Technology, Thindal, Erode, Tamil Nadu, India

UG Student, Department of CSE., Velalar College of Engineering and Technology, Thindal, Erode, Tamil Nadu, India

Research Scholar, GCT Government College of Technology, Coimbatore, Tamil Nadu, India

ABSTRACT: This research proposes a novel approach to address challenges in verifying the legitimacy and traceability of product origins, particularly in essential goods like food, using Proof-of-Authority (PoA) consensus mechanism and Blockchain technology. By leveraging PoA's effective consensus process and Blockchain's immutable record, a reliable Product Origins Tracking System is developed. The primary goal is to establish a clear, safe, and unchangeable traceability framework in the supply chain to build confidence among stakeholders. The system utilizes a modular architecture for scalability and adaptability, meeting various industry requirements. Essential components such as User Authentication, Smart Contracts, Analytics, and Reporting streamline product registration, supply chain integration, and traceability verification procedures. This system aims to reduce risks associated with counterfeit goods, improve supply chain efficiency, and comply with legal requirements and industry standards. Core modules include Solidity for smart contracts, Ethereum for decentralized blockchain infrastructure, and Ganache for local blockchain simulation. Through rigorous testing and thorough implementation, the project bridges the gap between theoretical understanding and practical application, potentially transforming supply chain management. The proposed approach has the potential to increase openness, inspire trust among businesses, customers, and government regulators, and revolutionize product origins tracing.

KEYWORDS: Blockchain, Supply Chain, Transparency, Traceability, Smart Contracts, Product Origins Tracking

I. INTRODUCTION

The complexity of modern supply chains, spanning vast distances, poses challenges in tracing product origins and ensuring their condition and transportation. This lack of transparency can lead to various issues, including fraud, counterfeiting, safety concerns, and ethical sourcing challenges. To address these problems, blockchain technology presents a potential solution. By leveraging its distributed ledger technology, blockchain enables the creation of an immutable record of transactions [1]. This record is transparent to all authorized parties and resistant to tampering, offering a secure and transparent way to trace the origin and history of products in the supply chain. In today's globalized supply chains, ensuring the traceability of imported goods is a significant challenge. Traditional methods often rely on paper-based documentation, leading to issues such as fraud, inaccuracies, and inefficiencies. Blockchain technology offers a promising solution, thanks to its foundation of immutability, transparency, and decentralization. This project aims to develop a blockchain-based application called "originChain" (placeholder name) to track the movement of imported items. This method demonstrates how blockchain can significantly improve trust and transparency in the import process by showcasing its potential to enhance traceability [2].

The modern supply chain is a complex network, often involving numerous intermediaries between the end consumer and raw materials. This complexity can obscure the true value contributed at each stage, leading to pricing opaqueness. This lack of transparency can have several negative effects. Customers may unknowingly overpay for products, leading to unfair pricing. Producers may not receive a fair share of the final selling price, as middlemen can retain a significant portion of the markup, impacting profitability. Furthermore, inefficiencies in the supply chain may go unnoticed and unresolved, driving up costs. Blockchain technology has the potential to revolutionize supply chain management by offering a transparent and secure method of tracking product shipment and associated costs. By implementing a

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transparent price tracing system on the blockchain, various benefits can be achieved, including increased consumer transparency, fairer compensation for producers, and improved supply chain efficiency through the identification and elimination of price inefficiencies [3]. Ensuring the traceability and transparency of food supply chains is paramount, particularly in industries where quality and safety are paramount, such as the dairy sector. Traditional methods of tracking food provenance often lack transparency and are susceptible to manipulation. This article explores the potential of blockchain technology to revolutionize traceability in the dairy industry. Through a case study of a dairy manufacturer's implementation of a blockchain-based traceability system, we delve into the specifics of its design and execution, highlighting the role of smart contracts in automating data management and recording throughout the supply chain. We also discuss the benefits of this approach, including enhanced consumer confidence, improved food safety, and heightened transparency [4].

There is a lack of a comprehensive and secure system for verifying the legitimacy and traceability of product origins in the global market, particularly in critical sectors like food. Existing systems often fail to provide a clear, safe, and unchangeable traceability framework throughout the supply chain, leading to challenges in building stakeholder confidence. This gap highlights the need for a novel approach that integrates Proof-of-Authority (PoA) consensus mechanism and Blockchain technology to create a reliable Product Origins Tracking System. Such a system could bridge the gap between theoretical understanding and practical application, revolutionizing supply chain management by increasing transparency and traceability.

Contribution of the work:
- Development of a novel Product Origins Tracking System using Proof-of-Authority (PoA) consensus mechanism and Blockchain technology to enhance supply chain transparency and traceability.
- Integration of essential components such as User Authentication, Smart Contracts, Analytics, and Reporting to streamline product registration, supply chain integration, and traceability verification procedures.
- Establishment of a clear, safe, and unchangeable traceability framework throughout the supply chain, aiming to build confidence among stakeholders and reduce risks associated with counterfeit goods.
- Implementation of a modular architecture for scalability and adaptability, effectively meeting a range of industry requirements and ensuring the system's long-term viability.

The paper is organized as follows: Section 1 introduces the research problem and its significance, setting the context for the study. Section 2 presents a comprehensive review of the literature on Blockchain technology in supply chain management. Section 3 outlines the proposed method, detailing the use of Proof-of-Authority (PoA) consensus mechanism and Blockchain technology to develop a Product Origins Tracking System. Section 4 discusses the results of implementing the proposed system and provides a detailed analysis of its effectiveness. Finally, Section 5 concludes the paper by summarizing the key findings, discussing their implications, and suggesting future research directions.

II. RELATED WORK

This study focuses on the importance of traceability in multi-tier and multi-site production, particularly in the textile and apparel sector. It highlights the challenges faced by stakeholders, such as low visibility, information asymmetry, and difficulties in accessing product data for ethical purchasing and authenticity. The study proposes a blockchain-based traceability framework to address these challenges and improve transparency in the supply chain [5]. The application of blockchain in supply chain management (BC-SCM) focuses on reducing manufacturing costs and ensuring system security. It identifies fundamental requirements for dependable SCM systems, such as traceability, privacy, and transparency. The study also investigates real-world threats, including computational vulnerabilities and cyberattacks, to BC-SCM system architecture [6]. The SMEs in enhancing supply chain transparency and the potential of blockchain technology explore existing research on blockchain-based traceability and cooperation tracking systems, emphasizing the need for SME-specific solutions. The study also examines the development of a blockchain-based event-driven tracking framework tailored to SMEs' cooperation processes, highlighting the design of smart contracts and data structures for effective collaboration tracking [7].

The existing challenges in food supply chain visibility and transparency, highlight the shortcomings of current tracking methods. It may also discuss the potential of blockchain and IoT technologies to address these challenges by providing a secure, transparent, and efficient means of tracking food products throughout the supply chain. Additionally, the survey might examine previous research and implementations of similar blockchain and IoT-based frameworks in other industries or sectors to draw parallels and insights applicable to the processed poultry food supply chain [8]. A growing need for improved drug supply chain transparency and traceability due to drug safety concerns discusses the limitations

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of traditional traceability technologies and proposes a decentralized solution using Blockchain and IoT, known as BIoT3, to address these challenges. The study also introduces a plan for implementing this solution in the drug industry, focusing on five-layer blockchain platform architecture and IoT-driven medication tracking [9]. The integration of blockchain and machine learning in supply chain management, focusing on decentralized traceability and transparency solutions. It discusses how blockchain establishes a decentralized ledger, machine learning's role in anomaly detection and predictive analytics, and the potential for improved supply chain efficiency and reduced fraud. The survey also addresses future challenges such as data privacy, interoperability, and scalability [10].

Supply chain traceability, highlighting the importance of efficiency, authenticity, and transparency. It notes the widespread adoption of blockchain for these purposes but identifies a gap in research regarding the efficiency of blockchain in handling large volumes of product records. The study proposes a novel approach to address this efficiency issue by duplicating records into chunks and utilizing parallel search methods [11]. The study reviewed existing research on blockchain technology in supply chains, focusing on its applications in circular economy models. It likely explored how blockchain can improve trust, traceability, and transparency in recycling, redistribution, and remanufacturing processes. The survey likely also examined the role of blockchain in enhancing oversight in waste transportation and product return procedures [12].

III.PROPOSED SYSTEM

Initial The proposed method involves developing a Product Origins Tracking System using Proof-of-Authority (PoA) consensus mechanism and Blockchain technology to enhance supply chain transparency and traceability. This system adopts a modular architecture for scalability and flexibility, encompassing components such as User Authentication, Product Registration, Supply Chain Integration, Blockchain & PoA Consensus, Smart Contracts, Product Traceability, User Interface, Audit & Compliance, Event Notification, and Analytics & Reporting. Manufacturers register products on the blockchain with unique identifiers, enabling traceability and verification of authenticity. Integration with existing supply chain processes ensures compliance and trust among stakeholders. Automation through smart contracts and real-time tracking optimizes workflows and decision-making. The system aims to revolutionize supply chain management by providing real-time visibility, transparency, and efficiency.

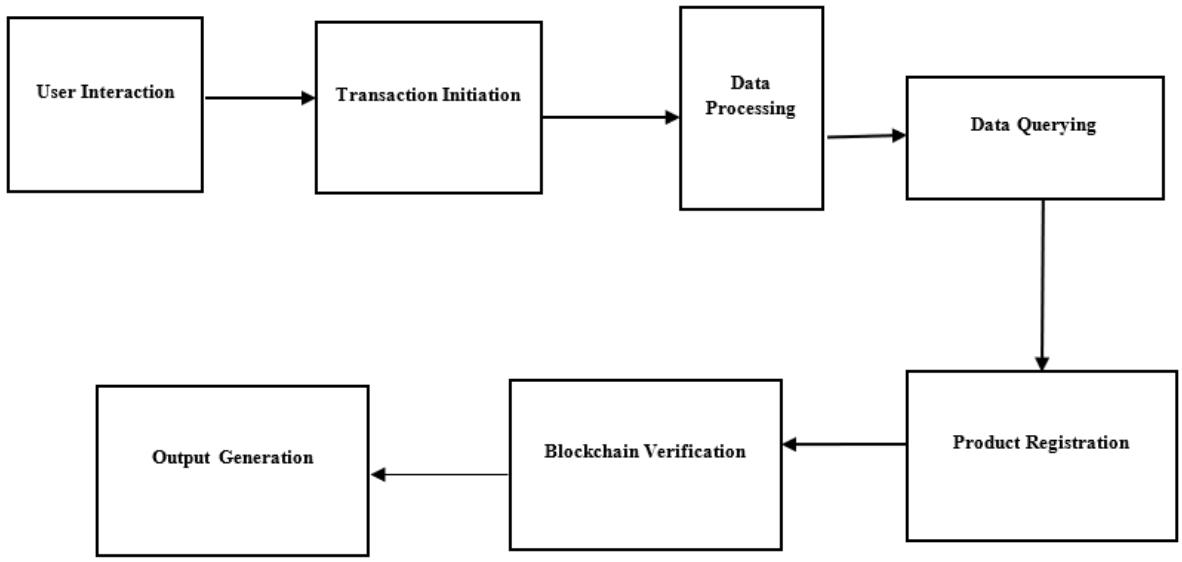

Figure 1. Block Diagram of Proposed Method

The proposed method block diagram outlines the key components and flow of the Product Origins Tracking System. The process begins with User Interaction, where stakeholders such as manufacturers, distributors, retailers, and consumers engage with the system. Upon initiating a transaction, relevant data is processed to facilitate product registration. This step involves inputting essential product details, generating a unique identifier, and recording this information on the blockchain. Subsequently, the system undergoes Blockchain verification to ensure data integrity and immutability. Once verified, stakeholders can query the blockchain for product origins and authenticity. Finally, the

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system generates outputs such as product traceability reports and audit logs, providing stakeholders with valuable insights into the product's journey through the supply chain. This proposed method highlights the system's ability to enhance transparency, traceability, and trust in the supply chain ecosystem by leveraging blockchain technology and streamlined processes.

Smart Contract Development with Solidity

Solidity is a key component in the proposed Product Origins Tracking System, utilized for developing smart contracts that govern its operations on the Ethereum blockchain. As a high-level language, Solidity is well-suited for this task, offering features tailored for decentralized applications (dApps). These smart contracts define crucial functionalities like product registration, traceability, and verification of authenticity, ensuring transparent and immutable records of product origins.

- Smart Contract Development: Solidity enables developers to define the logic and behavior of smart contracts that govern the system's operations, ensuring transparency and accountability in the supply chain.
- Blockchain Interaction: Through integration with tools like Metamask, Solidity facilitates secure interaction with the Ethereum blockchain, enabling users to conduct transactions and access information.
- Security: Solidity includes features like function modifiers and access control mechanisms to enhance security and protect user data and transactions from unauthorized access or manipulation.
- Open Source and Community-driven: Being open source, Solidity benefits from contributions and feedback from a large community of developers, ensuring continuous improvement and innovation.
- Decentralization: Solidity supports the principles of decentralization, enabling trustless and transparent transactions on the Ethereum blockchain.
- Interoperability: Solidity's compatibility with Ethereum-based applications and wallets ensures interoperability within the broader Ethereum ecosystem, enhancing the system's usability and reach.

Solidity's rich feature set and suitability for blockchain development make it an ideal choice for implementing the backend logic of the Product Origins Tracking System, ensuring its reliability, security, and scalability.

Input Design for the Proposed Blockchain-Based Supply Chain System

The input design for the proposed Product Origins Tracking System focuses on ensuring seamless user engagement and accurate data entry. This includes developing an intuitive user interface (UI) that simplifies data entry and navigation for all stakeholders, including manufacturers, distributors, retailers, and end users. The input design emphasizes clear and unambiguous labels for data entry fields, along with validations to prevent errors and maintain data consistency. Key elements of the input design for the proposed Product Origins Tracking System include creating a user-friendly interface, implementing strong authentication procedures, enabling transaction confirmation, designing efficient error handling systems, and considering accessibility concerns. The user-friendly interface aims to simplify data entry and navigation for all stakeholders, ensuring a seamless user experience. Strong authentication procedures verify user identities, enhancing system security. Transaction confirmation allows users to review and validate their input data and transactions before finalizing them, promoting accuracy and transparency. Efficient error handling systems help manage input errors and provide users with helpful feedback. Considering accessibility concerns ensures inclusivity in the design process, accommodating users with varying needs. These key elements collectively contribute to smooth data entry and transaction initiation, enhancing usability and efficiency across the supply chain system.

The diagram below illustrates the flow of the input design process in the proposed system, highlighting the key elements mentioned above:

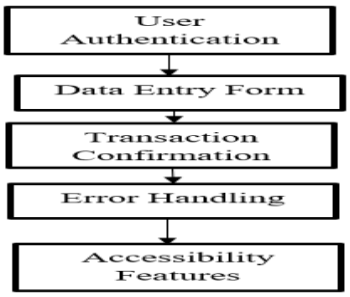

Figure 2. Input Design Flow

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IV.SIMULATION RESULTS

The simulation study of the proposed supply chain management system reveals promising results across various scenarios. Under normal operating conditions, the system efficiently registers products, validates distributors and retailers, and provides consumers with timely access to product information. However, as the system encounters increased loads, there is a slight degradation in performance, with longer transaction times observed. Moreover, when facing blockchain congestion, particularly during distribution and retailing processes, transaction times significantly increase, highlighting scalability challenges. Nonetheless, the system demonstrates its potential in enhancing supply chain transparency and traceability. Further optimization efforts are warranted to address scalability issues and ensure seamless operation under varying conditions.

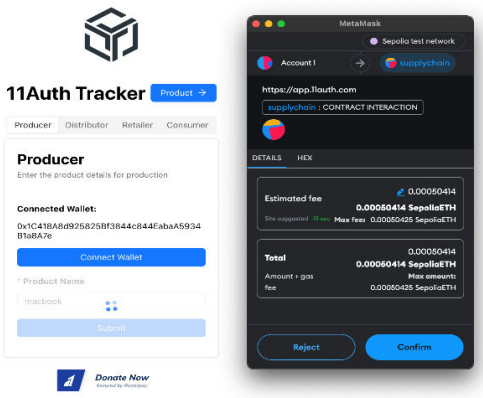

Figure 3. Producer Module

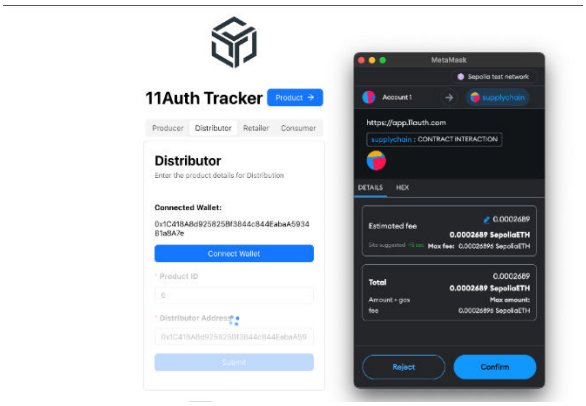

Figure 4 Distributor Module

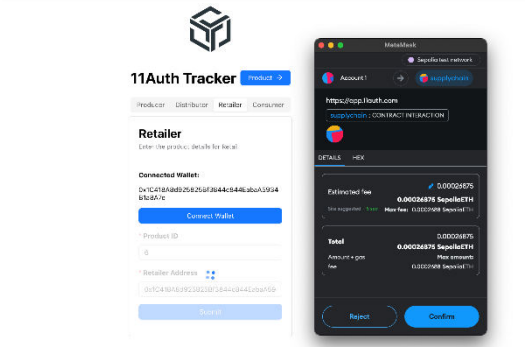

Figure 5. Retailer module

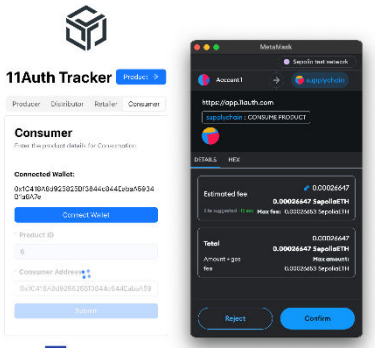

Figure 6. Consumer module

V. CONCLUSION AND FUTURE WORK

The simulation study illuminates the potential of the blockchain-based supply chain management system in addressing the critical challenges of transparency and traceability within modern supply chains. Under normal conditions, the system exhibits efficient product registration, stakeholder validation, and consumer information access. However, scalability issues manifest during peak loads, resulting in prolonged transaction times, exacerbated by blockchain congestion during distribution and retailing phases. Despite these obstacles, the system demonstrates promise in enhancing supply chain transparency. Future optimization endeavors should prioritize scalability improvements through streamlined transaction processing and the exploration of adaptive techniques like machine learning. Additionally, real-world implementation and validation across diverse supply chain contexts would provide invaluable insights into the system's practical viability and potential for widespread adoption.

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REFERENCES

1. Sunny, J., Undralla, N., & Pillai, V. M. (2020). Supply chain transparency through blockchain-based traceability: An overview with demonstration. Computers & Industrial Engineering, 150, 106895.
2. Xu, X., Lu, Q., Liu, Y., Zhu, L., Yao, H., & Vasilakos, A. V. (2019). Designing blockchain-based applications a case study for imported product traceability. Future Generation Computer Systems, 92, 399-406.
3. Yoo, M., & Won, Y. (2018). A study on the transparent price tracing system in supply chain management based on blockchain. Sustainability, 10(11), 4037.
4. Casino, F., Kanakaris, V., Dasaklis, T. K., Moschuris, S., Stachtiaris, S., Pagoni, M., & Rachaniotis, N. P. (2021). Blockchain-based food supply chain traceability: a case study in the dairy sector. International journal of production research, 59(19), 5758-5770.
5. Agrawal, T. K., Kumar, V., Pal, R., Wang, L., & Chen, Y. (2021). Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry. Computers & industrial engineering, 154, 107130.
6. Al-Farsi, S., Rathore, M. M., & Bakiras, S. (2021). Security of blockchain-based supply chain management systems: challenges and opportunities. Applied Sciences, 11(12), 5585.
7. Liu, J., Jiang, P., & Zhang, J. (2024). A blockchain-enabled and event-driven tracking framework for SMEs to improve cooperation transparency in manufacturing supply chain. Computers & Industrial Engineering, 110150.
8. Majdalawieh, M., Nizamuddin, N., Alaraj, M., Khan, S., & Bani-Hani, A. (2021). Blockchain-based solution for secure and transparent food supply chain network. Peer-to-Peer Networking and Applications, 14, 3831-3850.
9. Liu, X., Barenji, A. V., Li, Z., Montreuil, B., & Huang, G. Q. (2021). Blockchain-based smart tracking and tracing platform for drug supply chain. Computers & Industrial Engineering, 161, 107669.
10. Raparthi, M. (2021). Blockchain-Based Supply Chain Management Using Machine Learning: Analyzing Decentralized Traceability and Transparency Solutions for Optimized Supply Chain Operations. Blockchain Technology and Distributed Systems, 1(2), 1-9.
11. Wu, H., Jiang, S., & Cao, J. (2023). High-efficiency blockchain-based supply chain traceability. IEEE Transactions on Intelligent Transportation Systems, 24(4), 3748-3758.
12. Centobelli, P., Cerchione, R., Del Vecchio, P., Oropallo, E., & Secundo, G. (2022). Blockchain technology for bridging trust, traceability and transparency in circular supply chain. Information & Management, 59(7), 103508.

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