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Decentralized Supply Chain Tracking System

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Abstract - In order to enhance security traceability and transparency throughout product lifecycles this paper proposes a decentralized supply chain tracking system. The suggested solution records supply chain transactions in an unchangeable and tamper-resistant way using blockchain technology and smart contracts. To guarantee safe and regulated interactions producers distributors retailers and consumers are given role-based access. Users can easily communicate with the blockchain network via cryptographic wallets thanks to a web- based interface. Stakeholders can effectively track the movement and status of products thanks to real-time event-driven updates. Additionally the system gives users a visual timeline to track the history of the product. The suggested strategy improves accountability and trust by doing away with centralized control. This project illustrates how blockchain technology can be used practically in contemporary supply chain management systems.

Keywords - blockchain Technology, Decentralized Supply Chain, Smart Contracts, Product Traceability, Ethereum, Supply Chain Transparency, Web3 Applications, Distributed Ledger Systems.

INTRODUCTION

In order to guarantee the smooth flow of goods from producers to final consumers supply chain management is essential. Due to their high degree of centralization conventional supply chain systems are susceptible to data manipulation low transparency and single points of failure. These restrictions have grown in importance due to the rising need for reliable and traceable product information. Blockchain technology provides a decentralized method that guarantees data integrity via immutability and cryptographic validation. Supply chain procedures can be automated and safely enforced without the need for middlemen by utilizing smart contracts. A decentralized supply chain tracking system that keeps track of each product transaction on the blockchain is proposed in this paper. For manufacturers distributors retailers and consumers the system allows role-based participation. The suggested strategy improves supply chain network visibility accountability and trust.

LITERATURE SURVEY

1. **Desai, S., Menon, R., and Nair, P. Block chain-Enabled Supply Chain Transparency**

   This study explains how supply chain transactions are stored on immutable ledgers using block chain technology which increases transparency. I discovered from this work that decentralized record-keeping greatly lowers data manipulation and boosts stakeholder trust in the supply chain.

2. **Gupta, A. and Sharma, N. Smart Contracts for Automated Supply Chain Operations**

   The authors demonstrate how smart contracts automate product creation, transfer, and delivery processes. This research helped me understand how event-driven automation minimizes manual intervention and enables real-time synchronization in supply chains.

3. **Thomas, R., Agarwal, L., and Bhosale, M. Decentralized Logistics Tracking Using IoT and Block chain**

   This paper explores combining IoT sensors with block chain for tracking shipment conditions. From this study, I learned how recording sensor data on-chain improves reliability and prevents manipulation during logistics operations.

4. **Verma, P. and Rao, S. Role-Based Access Models in Block chain Supply Chains**

   Smart contracts allow chain procedures to be automated and securely enforced without the need for middlemen. This paper proposes a decentralized supply chain tracking system that monitors every product transaction on the block chain. The system permits role-based participation for producers distributors retailers and consumers. The recommended approach increases supply chain network trust accountability and visibility.

5. **Five. Banerjee K. Shetty T. and V. Raghav. Decentralized Platforms with Visual Product Tracking Interfaces.**

   In this paper product journeys are visualized through timelines created using blockchain events. I learned from

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this work that decentralized tracking system adoption and user comprehension are significantly increased by user-friendly web-based interfaces.

METHODLOGY

PROPOSED METHODOLOGY

1. **User Role Selection and Authentication**:

   By choosing a predetermined role such as producer distributor retailer or customer users can access the system. Wallet-based authentication provides safe decentralized identity verification through a blockchain provider. For each subsequent action role-specific permissions are granted in this step.

2. **Product Registration on Blockchain:**

   By entering product details like name batch number and quantity the manufacturer starts the supply chain process. A smart contract receives these details verifies them and permanently stores them on the blockchain. A successful registration triggers a blockchain event that verifies the creation of the product.

3. **Ownership Transfer Mechanism**:

   Once a product is registered smart contract functions allow supply chain participants to share ownership of it. To verify every transfer the authorized role must employ cryptographic signatures. This guarantees that only individuals with authorization can modify product ownership records.

4. **Shipment Status Update Process:**

   Distributors monitor the location and handling status of shipments while they are in transit. The blockchain records these modifications as transaction records resulting in an unchangeable and transparent shipment history. To inform the system of changes in state event logs are made public.

5. **Retail Availability Confirmation:**

   The retailer uses a smart contract feature to confirm the products availability after receiving it. This stage keeps an unchangeable delivery confirmation record on the blockchain and signifies that the product is prepared for consumer access.

6. **Event-Driven Data Synchronization:**

   When smart contracts emit blockchain events the front-end application listens to them. The local application state is immediately updated by the system whenever something changes in the supply chain. This technique ensures that the data on the chain and the user interface are consistent.

7. **Customer Tracking and Visualization:**

Customers can view product history via a tracking interface that creates a visual timeline using lifecycle data. The system provides comprehensible product movement and status updates. This leads to increased transparency and the ability to verify customers.

DATA FLOW DIAGRAM

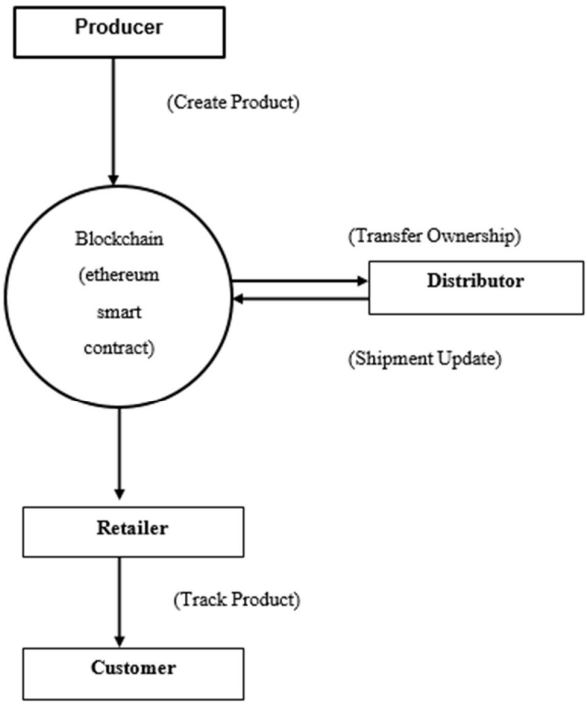

fig 1. DFD diagram

Mathematical Formulation

The supply chain can be represented as a **directed network** where each product moves through nodes (roles) and edges (transfers). Let:

- $P[k]$= Product k
- R = {Producer, Distributor, Retailer, Customer}= Set of roles
- $T^{(k)}$= Transfer of product $k$from role $i$to role j

A producer $rp \in R$creates a product $[k]$at time t_c:

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$[k]$ = {id$_k$, name$_k$, batch$_k$, quantity$_k$, t_C}

- id$_k$= Unique product identifier
- t_C= Creation timestamp (block timestamp)

Transfer of product $[k]$from role $r_i$to role $r_j$is represented as:

$$(k)_{(t)} = \begin{cases} 1, & \text{if transfer occurred at time } t \\ 0, & \text{otherwise} \end{cases}$$

i,j

The **current owner** of product $k$is:

$$\text{Owner}(P[k], t) = r \text{ if} T^{(k)}(t) = 1$$

i i,j

For each product $[k]$in transit:

$$S(t) = \{\text{location}(t), \text{temperature}(t), \text{status}(t)\}$$

Where:

- location(t)= GPS coordinates of shipment
- temperature(t)= Current temperature
- status(t)= Enum {In Transit, Delivered, Available}

Retailer marks product $[k]$as available for customers:

$$A_k\ (t) = \begin{cases} 1, & \text{if product is available} \\ 0, & \text{otherwise} \end{cases}$$

The **timeline** of product $[k]$is:

$$\text{Timeline}(P[k]) = \sum_{(i,j)\in R} T^{(k)} \cdot \delta(t - t^{(k)})_j$$

Where:

- $\delta(t - t^{(k)})$= Indicator function marking the time of transfer from r to r

i,j

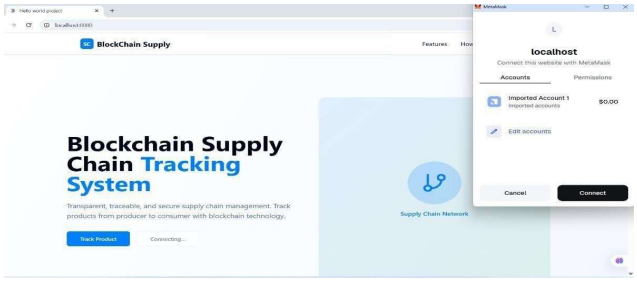
The timeline allows reconstructing the full journey of the product from producer to customer.

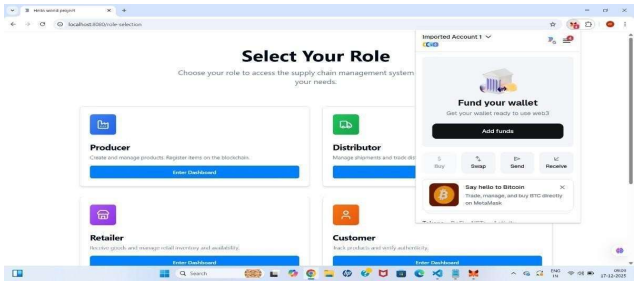
Let $E(t)$be the blockchain event for product $k$at time t:

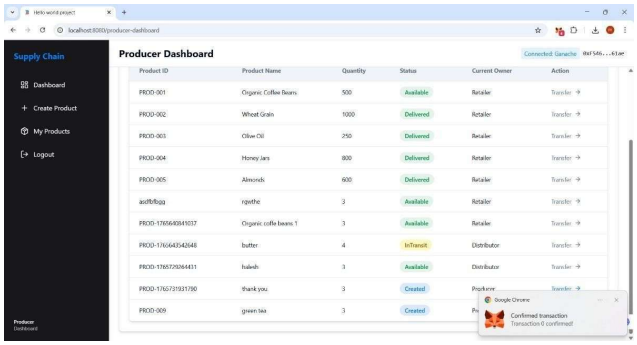
$$E(t) = \{\text{event\_type}, P[k], ri, rj, t\}$$

When $E_k(t)$occurs, frontend updates local

EXPERIMENTAL RESULT







CONCLUSION

This project successfully demonstrates how blockchain technology can be applied to build a transparent and trustworthy supply chain management system. By using role-based dashboards, each participant in the supply chain is given clear responsibilities and controlled access to product operations. The integration of smart contracts ensures that product data remains immutable and tamper-proof throughout its lifecycle. Real-time event- driven updates improve visibility

and keep the user interface synchronized with on-chain activities. The use of React and a modular frontend design enhances usability and scalability. Local storage support ensures smooth operation even during temporary network limitations. MetaMask and Ganache integration simplify blockchain interaction during development and testing. Overall, the system reduces dependency on centralized authorities and increases accountability among stakeholders. This project provides a strong foundation for future enhancements such as IoT integration, advanced analytics, and enterprise- level deployment.

FUTURE ENHANCEMENT

Future versions of Auto Jam with AI can expand its capabilities by supporting additional instruments such as piano, bass, and guitar. Integrating real-time MIDI input will allow musicians to connect external hardware directly to the system. Exporting music to WAV or MIDI formats can make the tool more useful for professional workflows. More advanced AI models—especially Transformers—can generate richer, more complex melodies and rhythms. Customization options like new sound packs, themes, and visual layouts will enhance user experience. Cloud saving and sharing features can encourage collaboration among musicians.

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