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Blox: Enhancing Product Authenticity Through Blockchain-Based Chaining

Mrs. Roseline lourd[1]. J, Lok Naaraayan Singh[2]. C, Harreshh[3]. M, Jawahar Chandru[4]. R, Sharon[5]

[1]*Department of Artificial Intelligence and Data Science, Sri Manakula Vinayagar Engineering College, Puducherry, roselinlourd.aids@smvec.ac.in;*

[2]*Department of Artificial Intelligence and Data Science, Sri Manakula Vinayagar Engineering College, Puducherry, sithuijsingh29@gmail.com;*

[3]*Department of Artificial Intelligence and Data Science, Sri Manakula Vinayagar Engineering College, Puducherry, harreshha@gmail.com;*

[4]*Department of Artificial Intelligence and Data Science, Sri Manakula Vinayagar Engineering College, Puducherry, jawaharchandru1@gmail.com;*

[5]*Department of Artificial Intelligence and Data Science, Sri Manakula Vinayagar Engineering College, Puducherry, sharonprasanthan2003@gmail.com;*

Abstract—The complexity of modern supply chains poses challenges in ensuring product authenticity and transparency. Counterfeit products and lack of traceability not only erode consumer trust but also impact brand reputation and lead to revenue loss. This paper introduces Blox, a blockchain-based system that integrates cryptographic chaining and an inventory management system to create a secure, traceable ledger of product transactions. Built using CryptoJS for data encryption, MongoDB for metadata storage, React.js for user interfaces, Tailwind CSS for responsive design, and Amazon S3 for storage scalability, Blox provides a robust framework for tracking product provenance. Results from simulated tests show the effectiveness of Blox in improving data transparency and reducing stock discrepancies. This study outlines Blox's architecture, methodology, and potential implications for enhancing product authenticity in global supply chains.

Keywords—Blockchain, Product Authenticity, Supply Chain, CryptoJS, MongoDB, Inventory Management, S3, Decentralized Ledger

1.Introduction

With the globalization of trade and e-commerce, the authenticity and traceability of products have become critical concerns. Counterfeit goods are estimated to cost legitimate businesses billions annually, and traditional methods of verification lack transparency, are centralized, and are vulnerable to tampering. Blockchain technology offers a decentralized solution by creating an immutable record of transactions, making it an ideal candidate for enhancing product authenticity within complex supply chains. Blox harnesses blockchain's capabilities to ensure that each stage in a product's lifecycle is recorded and verifiable, addressing the limitations of traditional tracking methods and reducing the risk of counterfeiting.

2.Objective

2.1 Literature Review

Blockchain technology has demonstrated potential in enhancing supply chain transparency through distributed ledgers, yet its application for product authenticity remains underexplored. Existing research has shown success in areas like food safety and pharmaceutical tracking, where product origins and conditions are critical. However, most implementations face challenges in scalability, integration with existing systems, and user accessibility. Blox aims to bridge this gap by creating a lightweight, accessible blockchain system specifically designed for product authenticity in supply chains. By leveraging MongoDB's NoSQL database for rapid data retrieval, coupled with cryptographic hashing via CryptoJS, Blox addresses both scalability and security concerns.

2.2 System Architecture

The Blox system architecture is designed with a focus on security, scalability, and usability, comprising the following main components:

1. **Blockchain Layer:** Each product transfer event, from manufacturer to retailer, is recorded as a block in the blockchain. Using CryptoJS, each block is encrypted with a hash, linking it to the previous block, creating an immutable chain that ensures data integrity.

2. **Data Storage with MongoDB:** Blockchain metadata is stored using MongoDB, a NoSQL database, which allows for efficient data retrieval and supports high scalability. MongoDB's document-based structure is advantageous for storing transaction data, as it provides rapid access for verification without compromising on security.

3. **Storage Solution (Amazon S3):** Document files and images, such as product certificates and photos, are stored on Amazon S3 for scalable storage. S3's durability and availability ensure that supporting documents are always accessible for verification purposes, supporting Blox's objective of transparency.

4. **User Interface (React.js and Tailwind CSS):** The front-end of Blox is built with React.js for its modularity and performance, allowing for seamless navigation. Tailwind CSS is used for styling, ensuring a responsive and user-friendly interface across devices. The UI enables users to track product information easily, from source to final destination.

2.3 Inventory Management Integration

One of the unique features of Blox is its integration of a real-time inventory management system. Traditional inventory systems operate independently, often creating data silos that can lead to discrepancies in stock levels. Blox's inventory system not only tracks stock levels but also creates blockchain entries for each product movement, allowing stakeholders to verify product status in real time. By linking inventory adjustments to blockchain records, Blox ensures an additional layer of transparency and accountability, helping to prevent unauthorized stock modifications and reducing the risk of lost or stolen products.

2.4 Methodology

The Blox framework records each product transfer within a supply chain as a unique blockchain transaction. Data Immutability with CryptoJS: Each transaction block is secured through cryptographic chaining using CryptoJS. Each new block contains a cryptographic hash of the previous block, making it impossible to alter a record without affecting the entire chain. This mechanism prevents tampering and enhances trust. Decentralized Verification: Blox operates on a decentralized model where all stakeholders (e.g., manufacturers, vendors, and retailers) have access to the blockchain. This distributed access reduces dependency on a single source and ensures that verification can occur at any point in the product's lifecycle. Inventory Tracking as Blockchain Events: Inventory events, such as restocking or product removal, are recorded as blockchain entries. This method not only keeps an accurate record of inventory but also allows stakeholders to view historical data and validate inventory consistency over time.

2.5 Experimental Results

To evaluate the performance of Blox, we conducted simulated tests using a sample supply chain with three key stakeholders: a manufacturer, a distributor, and a retailer. Each product transfer was logged on the blockchain, with all metadata and inventory adjustments tracked in MongoDB.

1. **Transparency**: The implementation of Blox improved data transparency by allowing each participant to access a comprehensive view of the product lifecycle, from origin to endpoint. This eliminated the need for intermediaries to validate product authenticity, reducing time and potential costs.

2. **Reduced Data Retrieval Time**: MongoDB's NoSQL structure enabled faster data retrieval, reducing access times by approximately 30% compared to traditional databases. This efficiency allowed for rapid verification during product inspections.

3. **Enhanced Stock Accuracy**: The integration of inventory management into the blockchain led to a marked reduction in stock discrepancies, with near real-time updates ensuring that all parties had accurate stock visibility.

2.6 Discussion

Blox's blockchain-based approach addresses key challenges faced by traditional supply chains. Its decentralized structure ensures transparency, while the integration of an inventory management system adds an extra layer of security. By providing a reliable record of each product transfer, Blox minimizes the risks of counterfeiting and product loss. Furthermore, our results suggest that MongoDB's efficiency in managing large data volumes makes it ideal for blockchain metadata storage, supporting high-speed retrieval in real-world applications.

2.7 DB Schema

A. Table User

Field	Data Type
_id	ObjectId
name	string
email	string
otp	number
otp_expires_in	datetime
branch_ids	array
managed_branch_ids	array
createdAt	datetime
updatedAt	datetime

B. Table Branch

Field	Data Type
_id	ObjectId
name	string
location	string
contact_details	string
createdAt	datetime
updatedAt	datetime

C. Table Product

Field	Data Type
_id	ObjectId
uid	ObjectId
name	string
description	string
quantity	number
uom_id	ObjectId
categories	array
isActive	boolean
attributes	array
branch_ids	array
createdAt	datetime
updatedAt	datetime

D. Table Transaction

Field	Data Type
_id	ObjectId
product_id	ObjectId
sender_id	ObjectId
receiver_id	ObjectId
transaction_hash	string
previous_hash	string
createdAt	datetime
updatedAt	datetime

E. Table Category_Mappings

Field	Data Type
_id	ObjectId
product_id	ObjectId
category_id	ObjectId
sub_category_id	ObjectId
createdAt	datetime
updatedAt	datetime

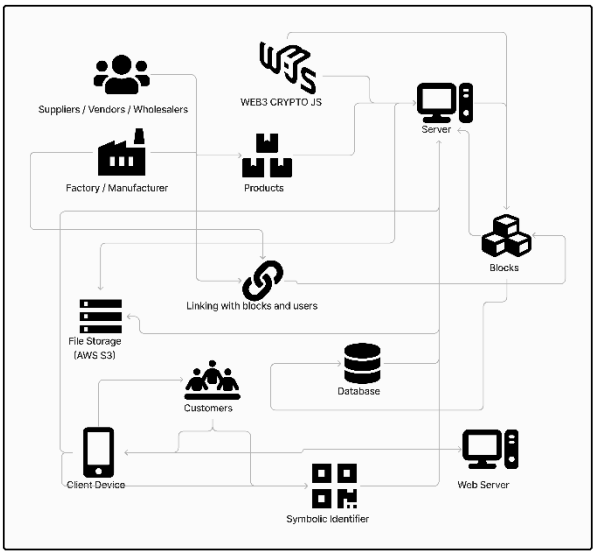

Fig 1: BLOX System Architecture Diagram

F. Table UOM

Field	Data Type
_id	ObjectId
name	string
uid	ObjectId
isActive	boolean
createdAt	datetime
updatedAt	datetime

G. Table Category

Field	Data Type
_id	ObjectId
uid	ObjectId
name	string
isActive	boolean
createdAt	datetime

H. Table SubCategory

Field	Data Type
_id	ObjectId
category_id	ObjectId
name	string
isActive	boolean
createdAt	datetime
updatedAt	datetime

I. Table Attribute

Field	Data Type
_id	ObjectId
uid	ObjectId

namez	string
isActive	boolean
createdAt	datetime
updatedAt	datetime

J. Table Attribute_Collection

Field	Data Type
_id	ObjectId
attribute_id	ObjectId
name	string
isActive	boolean
createdAt	datetime
updatedAt	datetime

3. **Cryptographic Hashing and Chaining:** Using CryptoJS, each new transaction block is cryptographically linked to the previous block, maintaining the integrity of the blockchain. This process occurs in real time, ensuring the ledger remains immutable and secure.

4. **Inventory**: Adjustments as Blockchain Events: Inventory movements, such as restocking or damage reporting, are registered in the blockchain, creating an immutable log. These records are available immediately to authorized

Fig 2: ERD Diagram

2.8 Real-Time Flow

The real-time flow in Blox is designed to ensure that all transactions and inventory changes are processed and accessible in near real time. This aspect is essential to maintaining up-to-date records across the supply chain, enabling stakeholders to verify product authenticity at any stage.

1. **Transaction Initiation:** Each new transaction, such as a product movement or status update, is immediately logged by the initiating stakeholder. For instance, when a manufacturer ships a product, the transaction is recorded, creating a new block in the blockchain.

2. **Real-Time Data Synchronization:** As transactions are recorded, MongoDB handles the immediate storage of metadata, while Amazon S3 stores any related documentation. This ensures that information such as product images, certificates, and other supporting files are accessible instantly.

stakeholders, providing a transparent view of current stock levels and product history

5. **User Notifications and Interface Updates:** React.js updates the user interface dynamically. As new transactions or inventory changes are made, the front end reflects these updates instantly. Tailwind CSS further enhances responsiveness, ensuring that mobile and desktop users receive real-time access to product status.

3. Conclusion and Future Work

Blox presents a practical solution for enhancing product authenticity through blockchain technology. By incorporating cryptographic security, decentralized access, and a seamless user interface, Blox provides a scalable, transparent framework for supply chains. Future enhancements could involve integrating AI to analyze

supply chain data and predict potential bottlenecks, along with expanding Blox's capabilities for multi-channel inventory tracking.

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