Blockchain-Powered QR Code System for Product Validation

[1] Atharv Dhande, [2]Jay Kadam, [3]Rohit Maity, [4]Soham Masurkar, [5] Seema Bhuravane

[1,2,3,4] U.G. Student, Department of Information Technology, K.C College Of Engineering, Maharashtra.

[5]Assistant Professor Department of Information Technology, K.C College Of Engineering, Maharashtra

ABSTRACT : ***The increasing presence of counterfeit products in supply chains poses risks to both consumers and manufacturers, highlighting the need for reliable validation mechanisms. This paper proposes a Blockchain-Powered QR Code System for Product Validation, where each product is assigned a unique QR code linked to data stored on a blockchain. By scanning the code, users can verify product authenticity through an immutable and tamper-resistant ledger. The system also records scan-related metadata, such as time and location, to identify suspicious or duplicate verification attempts. By combining the transparency of blockchain with the simplicity of QR code technology, the proposed solution enhances product traceability and provides an efficient approach to detecting and preventing counterfeit goods***

KEY WORDS: Blockchain, QR Code, Product Validation, Anti-Counterfeiting, Supply Chain Security, Smart Contracts, Ethereum, Product Authentication, Traceability, Decentralized System

I. INTRODUCTION

The rapid expansion of global trade and e-commerce has significantly increased the circulation of counterfeit products across various industries, including pharmaceuticals, electronics, and luxury goods. These counterfeit items not only lead to substantial financial losses for manufacturers but also pose serious risks to consumer safety and brand reputation. Conventional product verification techniques, such as holograms, barcodes, and serial numbers, are becoming less effective, as they can be easily replicated or tampered with. As a result, there is a growing demand for a more secure, transparent, and tamper-resistant system that can ensure reliable product validation across the supply chain.

In recent years, blockchain technology has gained attention as a potential solution for addressing challenges related to data security, integrity, and trust in distributed environments. Its decentralized architecture and immutable ledger ensure that once information is recorded, it cannot be modified without proper consensus, making it highly reliable for secure record-keeping. By combining blockchain with QR code technology, which offers a simple and widely accessible method for retrieving information, it becomes possible to build a system that balances both usability and security for product verification.

This paper presents a **Blockchain-Powered QR Code System for Product Validation**, designed to provide a dependable mechanism for verifying product authenticity throughout its lifecycle. In the proposed system, each product is assigned a unique QR code that is directly linked to its corresponding record stored on the blockchain. Users can scan the QR code using a mobile or web interface to instantly access and validate product details in real time. Furthermore, the system records scan-related metadata, such as timestamp and location, to detect unusual patterns or repeated scans that may indicate counterfeit activity.

The proposed approach not only improves transparency and traceability within the supply chain but also minimizes reliance on centralized verification authorities. By leveraging the combined capabilities of blockchain and QR code technology, the system offers a practical, scalable, and efficient solution to address the growing challenge of counterfeit products in modern markets while enhancing trust among consumers and stakeholders

II. LITERATURE SURVEY

Detection of Counterfeit Products using Blockchain:

Counterfeit detection in supply chains is critical to ensure product authenticity and consumer trust. A blockchain-based system was developed to track product history across the supply chain. The decentralized ledger ensures immutability, multi-party access, and consumer-level verification, enhancing transparency and reducing counterfeit infiltration risks across multiple stages of distribution.

Blockchain to Prevent Counterfeit Products:

Blockchain and advanced cryptography offer a robust framework for preventing counterfeit products across industries. This study proposed a blockchain ledger integrated with IoT devices, NFTs for digital twins, and zero-knowledge proofs for privacy-preserving verification. The system balances transparency with confidentiality, making it suitable for sensitive sectors like pharmaceuticals.

Blockchain-Based Counterfeit Product Detection:

To strengthen counterfeit detection, a blockchain system was designed using Ethereum and Hyperledger platforms. AES-encrypted QR codes were integrated for tamper-proof traceability. The system ensures both security and scalability, enabling manufacturers and consumers to verify product authenticity with high confidence.

Federated Learning for Counterfeit Detection:

Collaborative counterfeit detection across global supply chains can be achieved using federated learning. This approach trains distributed machine learning models across multiple stakeholders without sharing raw data. It preserves privacy while enabling shared intelligence, allowing global partners to detect counterfeits without compromising sensitive business information.

QR Code-Based Product Authentication System:

A QR code-based system was developed to provide end users with transparent product verification. Each product is enrolled at manufacture, tracked through distribution, and verified at retail. Scanning the QR code reveals product details and transaction history, ensuring transparency and consumer trust.

III. EXISTING SYSTEM

Traditional product validation systems primarily rely on centralized architectures and physical identification methods such as barcodes, QR codes, holograms, and serial numbers. In these systems, product information is stored and managed within a central database controlled by manufacturers or third-party organizations. Verification is typically carried out by scanning a code or matching product details with stored records. Although these methods are easy to implement and widely used, they depend heavily on a single authority, which limits transparency and flexibility.

However, these systems face several limitations in effectively preventing counterfeit products. Physical identifiers like QR codes and barcodes can be easily copied, duplicated, or replaced, allowing fake products to appear authentic. Centralized databases are also vulnerable to cyberattacks, unauthorized modifications, and system failures, which can compromise data reliability. Additionally, these systems do not provide complete visibility of the product journey, making it difficult to track items across different stages of the supply chain.

Another major drawback is the lack of intelligent monitoring mechanisms. Existing systems often fail to detect suspicious activities such as repeated scans of the same product or verification attempts from different locations, which are strong indicators of counterfeit behaviour. This reduces the overall effectiveness of traditional approaches in real-world scenarios.

> **Key Limitation:**

- **Lack of Tamper-Proof Verification:** Existing systems do not ensure data immutability, making it possible to alter or duplicate product information, which weakens the reliability of authentication and increases the risk of counterfeit products entering the market.

Due to these challenges, there is a clear need for a more secure, transparent, and decentralized system that can provide reliable product validation and enhanced supply chain traceability.

IV. PROPOSED SYSTEM

The proposed **Blockchain-Powered QR Code System for Product Validation** provides a secure and decentralized method for verifying product authenticity. Each product is assigned a unique QR code linked to its record stored on the blockchain, ensuring that the data is immutable and cannot be altered. This eliminates the risks associated with centralized systems and improves trust in the verification process.

Users can scan the QR code to instantly access product details and validate authenticity in real time. The system also tracks scan information such as time and location to detect suspicious activities like repeated or unusual scans. By combining blockchain security with QR code accessibility, the proposed system enhances transparency, traceability, and protection against counterfeit products.

Additionally, the system supports end-to-end visibility across the supply chain by allowing manufacturers, distributors, and retailers to update product status at each stage. This continuous tracking ensures that any unauthorized changes or inconsistencies can be quickly identified, further strengthening the reliability and effectiveness of the product validation process.

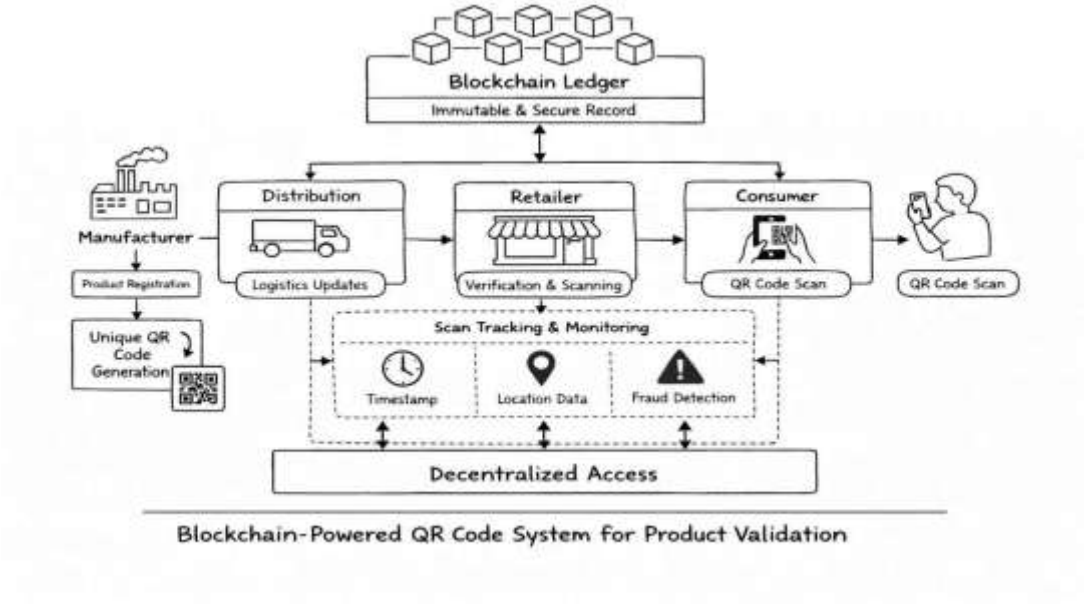

Figure 4.1: Block Diagram for Proposed System

V. RESULTS:-

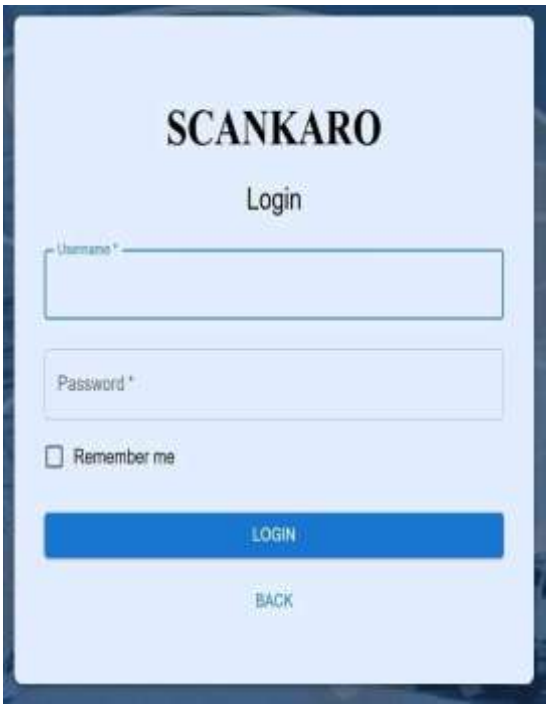

Fig 5.1: Login Page

The **login page** serves as a primary interface which provide Admin , manufacturer , supplier and retailer Dashboard. Here Admin can only assign roles to every Incoming entities

Fig5.2: Manufacturer Dashboard

Fig 5.3: Supplier Dashboard

The system provides dedicated dashboards for both **manufacturer** and **supplier** to manage and track products efficiently within the blockchain network. The **manufacturer dashboard** is used to register new products, generate unique QR codes, and store product details on the blockchain, ensuring secure and tamper-proof records from the initial stage. The **supplier dashboard** allows suppliers to update product status during distribution, including location and transfer details, which are recorded on the blockchain for real-time tracking. Together, these dashboards enable seamless coordination, improve transparency across the supply chain, and ensure accurate product validation at every stage.

Fig 5.4: Retailer Dashboard

Fig 5.5: Scan QR

The system also includes a **retailer dashboard** and a **QR code scanning module** to ensure final-stage verification and consumer interaction. The **retailer dashboard** allows retailers to verify incoming products by scanning the QR code and checking their authenticity against blockchain records before sale. It also enables updating the product status as "sold," ensuring accurate tracking in the supply chain. The **QR code scanning module** is used by consumers or stakeholders to instantly access product details such as origin, history, and authenticity. This real-time verification enhances transparency, builds consumer trust, and helps in identifying counterfeit products effectively.

Fig 5.6: – Check Authenticity

The first screen displays the successful authentication of the product Nike Men's Quest 6 Running Shoes. The system confirms that the product is authentic and shows details such as serial number, brand Nike, manufacturing date, warranty status, and product description. It also presents a timeline of the product's movement through the supply chain (manufacturer, supplier, and retailer) with location details. The second screen shows the failure case where the system displays "Product Authentication Failed". This indicates that the scanned product could not be verified and may be counterfeit. The system warns the user not to use the product and suggests contacting the manufacturer for further assistance.

VI. CONCLUSION

The proposed blockchain-powered QR code for product validation system provides a secure, transparent, and scalable solution to the growing problem of fake goods in global supply chains. By assigning unique digital identities to products and recording their lifecycle events on an immutable ledger, the system ensures authenticity verification at every stage.

Consumers benefit from instant product validation through QR or RFID scanning, while manufacturers and retailers gain traceability and protection against counterfeit infiltration. Compared to traditional methods, blockchain integration offers superior transparency, immutability, and trust, making it a reliable approach to safeguard brand reputation and enhance consumer confidence.

Furthermore, the system demonstrates strong potential for future expansion by supporting advanced features such as real-time analytics, integration with IoT devices, and large-scale deployment across industries. Its decentralized nature reduces dependency on intermediaries and enhances data security, making it a robust and adaptable solution for modern supply chain management.

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VII FUTURE SCOPE

The proposed system offers significant opportunities for future development and enhancement. One potential direction is the incorporation of Artificial Intelligence, which can intelligently analyze product patterns, manufacturing attributes, and transaction histories to identify counterfeit items with greater precision. In addition, integrating Internet of Things devices can enable continuous monitoring of products as they move across the supply chain, providing real-time updates regarding their location and condition.

The system can also be expanded to operate on a global scale by connecting all stakeholders, including manufacturers, distributors, retailers, and consumers, within a unified and secure blockchain network. Developing a user-friendly mobile application would further improve accessibility, allowing customers to instantly verify product authenticity before making a purchase. Moreover, advanced smart contracts can be implemented to automate critical operations such as product registration, ownership transfer, and validation processes, thereby reducing manual intervention and increasing efficiency.

Another important area of expansion is the adoption of this system across multiple industries such as healthcare, electronics, fashion, and food, where counterfeit products are a major concern. Integration with e-commerce platforms can provide an additional layer of trust by enabling real-time product verification during online transactions. Finally, the use of advanced analytics on blockchain data can help identify trends, detect unusual activities, and support better decision-making in supply chain management, making the system more intelligent and proactive.

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