

Blockchain-Based Product Authentication and Supply Chain Traceability Using QR Code

RANGINI M¹, VINODHINI S², SAMEEHA FARIDHA S³, DHUSHITHA M⁴
^{1,2} Assistant Professor – IT, Velammal Engineering College, Chennai, Tamilnadu.
^{3,4} UG Scholar – IT, Velammal Engineering College, Chennai, Tamilnadu

Abstract- Counterfeit products are popping up in the supply chain faster than ever, putting both consumer safety and brand reputations on the line. Traditional verification systems just aren't cutting it—they're slow, need outside help, and you can't really see what's going on behind the scenes. That's why this project focuses on building a blockchain-based system for product authentication and supply chain traceability, all powered by QR codes. Here's how it works: we use a private blockchain to lock in the data so everything's transparent, secure, and can't be changed after the fact. Every product gets its own QR code, which links directly to its details on the blockchain. We store info like the product name, batch number, and when it was made. As products move through the supply chain, distributors and retailers add more details by creating new blocks, each one tied securely to the last using SHA-256 hashing. This way, you get a complete, tamper-proof history from manufacturer to distributor to retailer. The whole system runs on Java and Spring Boot, with MySQL for the backend and local QR code generation. In the end, this setup helps spot counterfeit goods and keeps the entire supply chain open and honest for everyone involved.

I. INTRODUCTION

Counterfeit products are a real challenge for every manufacturer lose money, brands take a hit, and, worst of all, people end up with unsafe goods. Right now, most ways to check if a product's legit depend on central systems or third-party authorities. That's risky. It leaves room for data tampering and keeps things a bit murky. Blockchain shakes things up. It's decentralized, secure, and doesn't let anyone mess with the data once it's there. With this Blockchain-Based Product Authentication and Supply Chain Traceability System, every product gets registered by the manufacturer, tied to a unique QR code, and all the details land safely on a private blockchain. We use SHA-256 hashing here, so the data stays solid and untouched. As the product moves along from manufacturer to distributor to retailer each handoff gets logged.

II. RELATED WORK

Blockchain's faced a lot of issues lately because it lets people store data in a way that's decentralized, secure, and really tough to mess with. The whole idea got its start with Satoshi Nakamoto and the original Bitcoin paper, which explained how things like cryptographic hashing, linking blocks together, and getting everyone to agree on the same data all work. Sure, it started as a way to handle digital money, but those ideas are now the backbone for all sorts of authentication and traceability systems built on blockchain.

Melanie Swan expanded on these concepts by categorizing blockchain applications into financial and non-financial domains [2]. Her work highlighted the potential of blockchain in supply chain management, emphasizing transparency, immutability, and trustless verification. This research laid the groundwork for using private and consortium blockchains in enterprise-level product authentication systems. The Hyperledger Foundation provided an industry-backed framework for implementing permissioned blockchains in supply chain management. Hyperledger-based systems enable controlled access. For system implementation, backend technologies such as Spring Boot play a crucial role. The Spring Boot Reference provides comprehensive support for developing scalable backend services, handling business logic, and integrating blockchain simulations with web applications. These studies collectively demonstrate the growing importance of blockchain in improving transparency, security, and traceability across different domains. Building on these foundations, the proposed system aims to utilize blockchain-based principles to enhance product authentication and ensure data integrity within the supply chain. By integrating QR code technology with blockchain, the system provides a reliable method for tracking products.

III. PROPOSED WORK

The proposed system aims to provide a secure, transparent, and tamper-proof product authentication and supply chain traceability solution using blockchain technology integrated with QR codes. The system is designed to eliminate counterfeit products and improve trust among manufacturers, distributors, retailers, and customers. The customer can scan the QR code using a web or mobile interface to verify product authenticity and view the complete supply chain history in real time. This enables customers to easily identify genuine products and avoid counterfeit goods. An admin module is included for user management, system monitoring, and maintaining blockchain integrity.

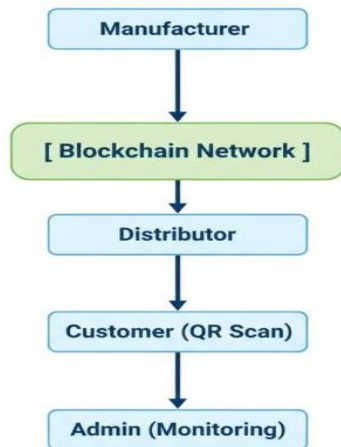


Fig. 1. SYSTEM ARCHITECTURE

In this system, the manufacturer initiates the product lifecycle by registering product details such as product ID, name, batch number, and manufacturing date. A unique QR code is generated for each product and linked to the first block in the blockchain, establishing product authenticity at the source. As the product moves through the supply chain, distributors and retailers update shipment and transaction details. Each update is recorded as a new block, cryptographically linked to the previous block, ensuring immutability and data integrity. This chained structure prevents unauthorized modifications and provides a transparent record of the product's journey across all stages of the supply chain. Customers can scan the QR code to

verify product authenticity and view the complete transaction history stored in the blockchain. This

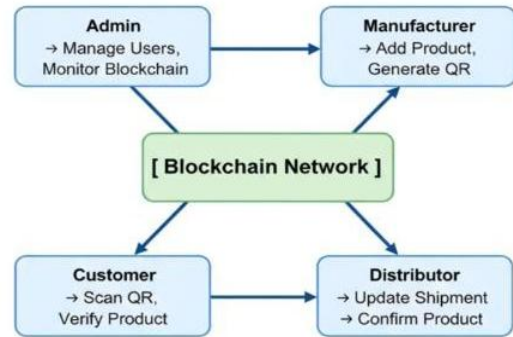


Fig. 2. USE CASE DIAGRAM

3.1 MANUFACTURER

The manufacturer drives the whole blockchain-based product authentication and supply chain traceability system. They start by registering and logging in securely—that's how they unlock all the manufacturing tools they're allowed to use. Once they're in, they create new product entries with all the key info: product name, product ID, batch number, manufacturing and expiry dates, and anything else that matters. For each product, the system spits out a unique QR code. That code is the product's digital fingerprint, making it easy to track or verify instantly at any point in the supply chain. Right from the start, the manufacturer locks this product data into the very first block of the blockchain, complete with timestamps. That way, everything's set up for transparent, tamper-proof tracking.

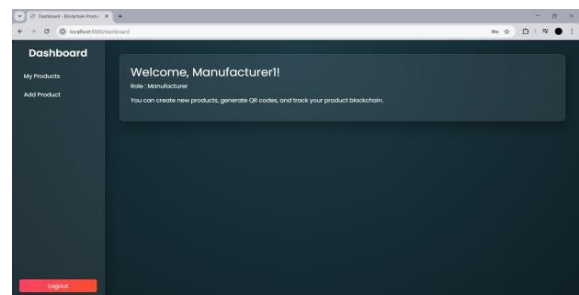


Fig. 3.1.1 Manufacturer Dashboard Interface

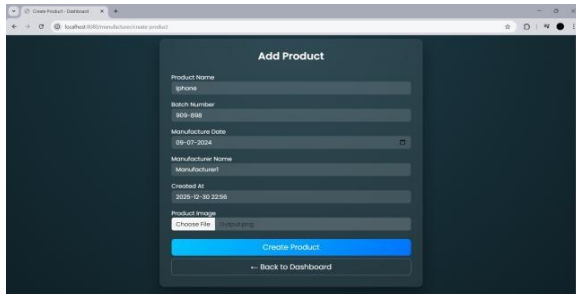


Fig. 3.1.2 Manufacturer Interface for Adding

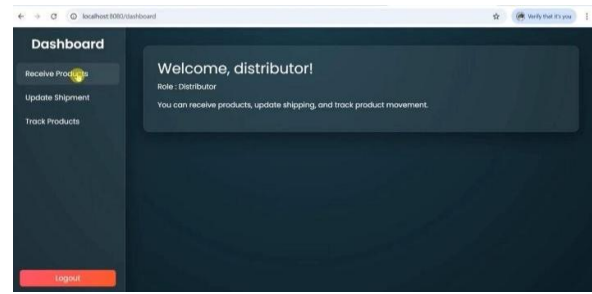


Fig. 3.2.1 Distributor Dashboard

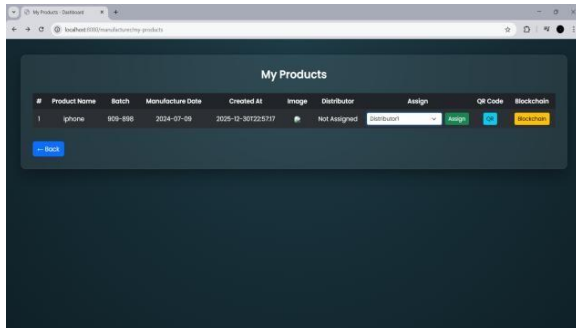


Fig. 3.1.3 Assigning Product To Distributor

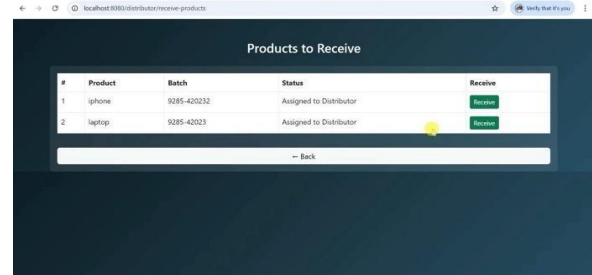


Fig. 3.2.2 Products To Receive Distributor Interface

3.2 DISTRIBUTOR

Distributors keep the supply chain system secure. They log in with their credentials and accept shipments straight from the manufacturer. Once they've got the products, they jump in and update all the important details when the shipment left, which vehicle or courier's handling it, where it's stored, and how delivery's going. Every time they update a location or movement, the system creates a fresh block on the blockchain, locking in the details with a timestamp and a cryptographic hash. That means every step gets tracked for good. Because of this constant blockchain logging, everyone can see exactly where products are at any moment. Distributors can pull up the entire product history during transit, so they can watch and double-check things in real time. The blockchain's immutability keeps those records safe, nobody can mess with them, period. That's how the system stops unauthorized changes and builds real trust between every player in the supply chain.

3.3 RETAILER

The retailer stands right at the end of the supply chain, making sure products actually reach customers and that everything's legit. They log in with secure credentials and receive shipments straight from the distributor. Once the products arrive, the retailer scans each QR code and pulls up the full blockchain-backed history: manufacturing details, distribution steps, the whole journey. After checking everything matches up, the retailer updates retail-level information like shelf location or sales status right in the system. Each time they verify or update something, the system creates a new block on the blockchain, stamping it with the time.

This setup lets retailers see exactly where any product's been, from the factory floor to the store shelf. It makes inventory tracking and authenticity checks much simpler. And because blockchain records can't be changed or faked, the risk of counterfeit goods drops to almost zero. Customers get real products, and trust in the supply chain gets a solid boost. The retailer is the final and most customer-facing node in the supply chain. Operating through a secure, role-based login portal, the retailer receives incoming shipments from authorized distributors and immediately begins the verification process using blockchain-backed tools built into the system. For the customer, it means the

product on the shelf has a verified, auditable trail stretching back to its point of manufacture. In addition, retailers can integrate blockchain insights with analytics tools to predict demand patterns, optimize shelf layouts, and improve sales strategies. They become not only the endpoint of the supply chain but also an intelligent feedback node, providing data that can inform production planning, distribution efficiency, and overall supply chain improvement.

Ultimately, the retailer serves as the critical interface between the product and the consumer. By leveraging blockchain technology, they ensure that every product on the shelf is authentic, fully traceable, and delivered with confidence strengthening both operational reliability and brand reputation.

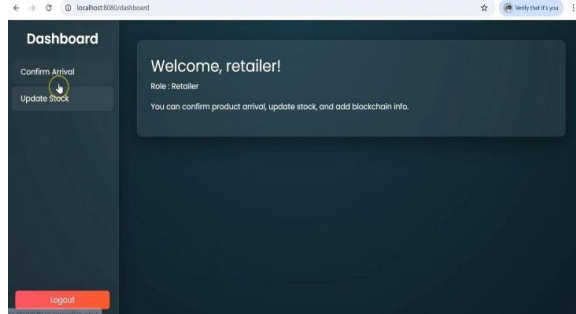


Fig. 3.3.1 Retailer Dashboard

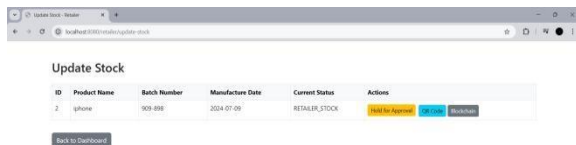


Fig. 3.3.2 Update Stock Interface

3.4 ADMIN

The admin runs the show when it comes to the blockchain-based supply chain system. They log in with top-level credentials no regular user stuff here and keep an eye on everything. It's up to the admin to decide who gets access, which means they register and approve manufacturers, distributors, and retailers. Only verified players make it in. Every product registration, transfer, and status update runs past the

admin, who checks that everything sticks to the rules. If someone needs to audit a product's journey, the admin can pull up the entire history, start to finish manufacturing to final sale. Thanks to the blockchain, every step comes with a timestamp and a cryptographic hash, so nothing slips through the cracks. This centralized system ensures that only authorized participants can interact with the system, maintaining security and operational integrity.

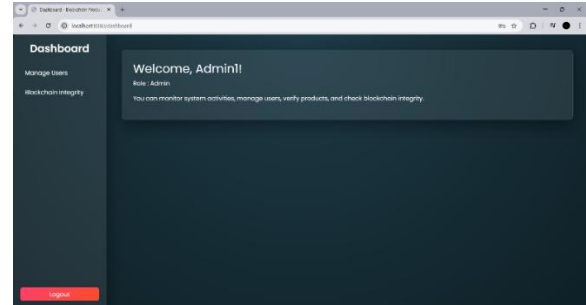


Fig. 3.4.1 Admin Dashboard

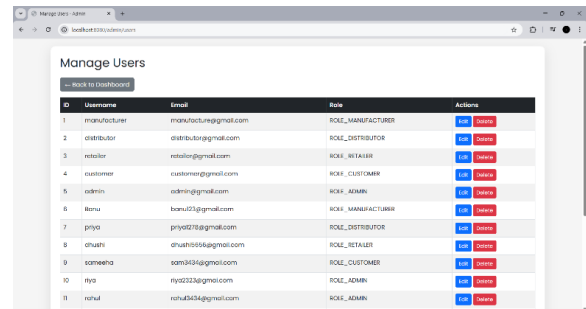


Fig. 3.4.2 User Management Module

3.5 CUSTOMER

The customer module is designed to provide end users with a simple and reliable way to verify the authenticity of products before making a purchase. In this system, customers are allowed to register and log in using their credentials, which ensures secure access to product verification features. The main functionality available to the customer is the ability to scan the QR code attached to a product using a mobile device or a web-based camera interface. This QR code acts as a gateway to the product's digital record stored in the system.

Once the QR code is scanned, the application fetches the corresponding product details that have been recorded and maintained through the blockchain-based system. The customer can view important

almost impossible for anyone to sneak in fake updates or mess with the product's history. On the consumer side, the verification module lets anyone scan the QR code and instantly pull up everything about that item where it was made, who handled it, and every step it took to get there. It gives people real confidence in what they're buying and makes it much easier to spot fakes. The admin side keeps things running smoothly: it manages users, watches over transactions, and keeps the blockchain itself consistent. Performance tests show the system works fast QR code scans and data retrieval happen with barely any lag. By using a private blockchain, we cut down on the heavy computing power public chains need, QR code verification provides a reliable approach for product authentication, improved traceability, and enhanced trust among supply chain stakeholders and consumers. One of the key outcomes of the system is its ability to maintain a transparent and continuous record of product movement. At any given point, the complete history of a product can be retrieved without any data loss. This traceability feature proved to be highly useful, especially in identifying delays, verifying product origin, and ensuring that the product passed through authorized entities only. Any attempt to alter previous records resulted in a mismatch in hash values, clearly indicating data tampering.

V. CONCLUSION

The project "Blockchain-Based Product Authentication and Supply Chain Traceability Using QR Code" effectively addresses the problems of counterfeit products and lack of transparency in traditional supply chains. By combining blockchain technology with QR codes, the system ensures secure, tamper-proof, and traceable product records from manufacturing to the end customer. Each supply chain transaction is stored as an immutable blockchain entry, improving data integrity and accountability. The solution enhances consumer trust and demonstrates the practical use of blockchain in real-world supply chain management, with strong potential for future enhancements and scalability. Beyond its technical merits, this project highlights a broader shift in how industries can approach trust and verification in the digital age. Traditional supply chains have long relied on paper trails, manual audits, and centralized databases — all of which are vulnerable to human

error, fraud, and data tampering. In contrast, the proposed system introduces a more reliable and transparent framework where information is shared across all stakeholders in a consistent and verifiable manner. By decentralizing the storage of transaction data and linking each stage through cryptographic mechanisms, the system reduces dependency on a single controlling authority while still maintaining structured oversight through the admin module. This balance between decentralization and control makes the solution both practical and adaptable to real-world environments. Furthermore, incorporating analytics and reporting tools can help organizations gain deeper insights into supply chain performance and identify potential inefficiencies. In conclusion, the proposed system not only provides a technical solution to product authentication but also contributes to building a more transparent, accountable, and trust-driven supply chain ecosystem. Its adaptability and scalability make it a promising approach for addressing current and future challenges in supply chain management across various industries.

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