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Product Verification System

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Abstract - Counterfeit products continue to pose significant challenges for manufacturers, distribu- tors, and consumers worldwide. They contribute to revenue losses, erode customer trust, create safety hazards, and cause long- term brand damage. According to global trade reports, coun- terfeit goods account for billions of dollars in annual losses across industries, with pharmaceu- ticals, electronics, and consumer goods among the most affected sectors. Traditional methods of product authentication, including holograms, barcodes, and RFID tags, either lack robust security or remain too costly for large-scale deployment. To overcome these limitations, this study proposes a Product Verification System that inte- grates QR codes with a MongoDB-based backend for efficient product traceability. The system architecture employs ReactJS for a user-friendly and modular frontend, Node.js with Express for secure API management, and MongoDB as a centralized, scalable database. At the point of manufacture, each product is assigned a unique QR code linked to its database record. Con- sumers can verify authenticity instantly by scanning the code with a smartphone, while manu- facturers and sellers gain real-time visibility into the supply chain.s Unlike conventional approaches, the proposed framework not only ensures authenticity but also supports analytics and reporting features, enabling stakeholders to monitor product dis- tribution, detect anomalies, and analyze consumer interaction patterns. This capability makes the solution adaptable for diverse sectors, including pharmaceuticals, electronics, and cosmet- ics, where transparency and safety are critical. The proposed system is cost-effective, scalable, and reliable, offering a practical balance between security and affordability. By leveraging accessible technologies such as QR codes and a flexible NoSQL database, it provides an imple- mentation pathway that is both technically feasible and industry-ready, making it suitable for mass adoption across global markets.In addition, the system introduces role-based access control (RBAC), ensuring that only authorized users such as administrators, manufacturers, and sellers can access or modify sen- sitive product information. The Admin Dashboard provides centralized control for managing users, viewing verification statistics, generating audit logs, and detecting counterfeit attempts through anomaly tracking. The Seller Module enables sellers to register genuine products and upload production details, while the Consumer The platform is further enhanced with real-time data synchronization, secure authentica- tion (JWT-based login system), and RESTful APIs, which maintain seamless communication between the client and server. Data integrity is preserved through encrypted QR code gen- eration and verification processes, while reporting and analytics tools assist manufacturers in monitoring sales regions, scanning frequency, and product lifecycle performance. Future scalability options include integration with blockchain networks to achieve im- mutable product records, AI-based anomaly detection for identifying suspicious activities, and cloud deployment for handling high- volume data operations. By combining robust backend design with modern frontend usability, this system delivers a holistic solution that bridges the gap between product authenticity, supply chain visibility, and consumer trust.

Keywords - Product Registration, QR Code- Based Verification, Real-Time Verification, Role- Based Access Control, Secure Authentication, User-Friendly Interface, Scalability & Performance,MongoDB,Node JS Integration, Data Integrity, Cloud Deployment, Supply Chain Transparency, Analytics & Reporting.

INTRODUCTION

The proliferation of counterfeit goods has emerged as a critical global issue, undermining indus- tries such as pharmaceuticals, automotive, electronics, and luxury merchandise. International trade studies estimate that counterfeit products represent nearly 3.3% of global commerce annu- ally, translating into billions of dollars in economic losses. Beyond financial repercussions, the risks extend to public safety and health: counterfeit automobile parts compromise road safety, while fake drugs endanger patients' lives and weaken trust in healthcare systems. The growing sophistication of counterfeiters, aided by advancements in printing, replication, and digital forgery, continues to make it increasingly difficult to distinguish between genuine and fake products. According to the Organisation for Economic Co-operation and Development (OECD), counterfeit and pirated goods amount to over USD $500 billion in global trade annually. This persistent issue impacts not only large-scale manufacturers but also small and medium- sized enterprises (SMEs), which often lack access to advanced anti-counterfeiting technologies.

Consequently, combating product falsification has become an essential priority for maintaining brand integrity, customer confidence, and fair market competition. Conventional anti-counterfeiting methods, including hologram stickers, serial

numbers, and watermarks, remain widely deployed but are easily imitated with modern reproduction technologies.

RFID-based solutions improve automation and tracking, yet their high cost limits scalability in mass-market applications. Blockchain technology, while promising in terms of immutability and transparency, presents challenges related to complexity, energy consumption, and deployment costs, making it impractical for most consumer product sectors.

Furthermore, traditional techniques often operate in isolation, lacking integration with digital ecosystems that enable real-time monitoring and analytics. In the absence of centralized an verifiable data, counterfeit products continue to infiltrate legitimate supply chains, damaging brand reputations and consumer confidence. These limitations highlight the urgent need for a cost-efficient, accessible, and technologically adaptive system that can be adopted across a range of industries and scales of production. To address these limitations, this study introduces a Product Verification System (PVS) that leverages QR codes for product identification and MongoDB as a centralized database for efficient traceability. The architecture integrates ReactJS for the frontend interface and Node.js for backend services, ensuring both scalability and accessibility. This hybrid approach emphasizes not only the importance of authentication but also seamless usability and cost- effectiveness. QR codes, being low- cost and universally scannable, eliminate the need for expensive hardware such as RFID readers, making the system deployable across both developing and developed markets.

MongoDB's NoSQL architecture provides a scalable and flexible data model capable of managing millions of product records while maintaining high performance and availability.

Unlike static authentication mechanisms, the proposed system enables consumers to instantly verify product authenticity through a simple QR code scan, while manufacturers and sellers gain real-time visibility into product distribution.

This approach provides a balanced solution that combines security, scalability, and affordability. By unifying manufacturers, sellers, and consumers within a single verification ecosystem, the system enhances transparency, fosters consumer trust, and establishes a practical framework for combating counterfeit goods across industries.
Moreover, the solution introduces modular components such as role-based access control (RBAC), JWT-secured authentication, and real-time analytics dashboards, making it adaptable to various business models. It supports product lifecycle management from manufacturing to end-user verification, ensuring every step of the process is digitally recorded and traceable.

In addition to its immediate benefits, the proposed framework also paves the way for future enhancements. Features such as blockchain integration for immutable product records, AI-based anomaly detection for identifying counterfeit trends, and cloud deployment for high- volume scalability are potential directions for extending the system's capabilities. This makes the Product Verification System a robust and future-ready solution for modern supply chain integrity and consumer protection.

By combining open-source technologies with practical design principles, this study aims to contribute to a more transparent, accountable, and secure global trade ecosystem. The proposed system's implementation demonstrates how digital transformation, when applied thoughtfully, can create measurable impact in minimizing counterfeiting risks while empowering both consumers and industries with real-time product authenticity insights.

Research Questions

- Integration of Technologies: How can QR codes, when combined with Mon- goDB, be effectively utilized to ensure secure, reliable, and real- time product verification?
- Database Advantage: What specific benefits does a centralized MongoDB database provide over blockchain-based systems in terms of cost, complexity, scalability, and operational efficiency for counterfeit detection?
- Scalability Across Industries: To what extent can the proposed Product Verifi- cation System (PVS) be scaled and adapted across diverse sectors such as pharmaceuticals, electronics, cosmetics, and luxury goods while maintaining performance and data integrity?
- Consumer Adoption Challenges: What potential barriers might consumers face in adopting a QR- based verification approach (e.g., accessibility, digital literacy, trust issues), and how can these challenges be effectively mitigated through design and awareness strategies?
- Analytics and Insights: Can the system provide actionable data for manufactur- ers and sellers to enhance supply chain transparency, detect anomalies, and support data-driven decision-making?
- System Security and Privacy: How
- can advanced encryption techniques and role-based access control (RBAC) mechanisms be implemented to ensure

data se- curity, prevent unauthorized access, and protect consumer privacy?

ER Diagram

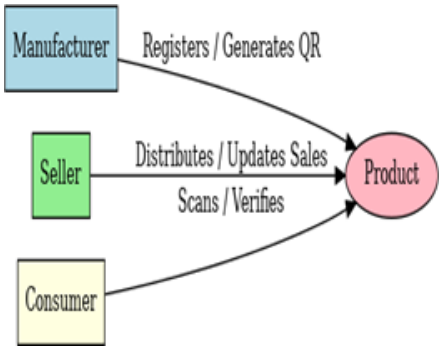


Fig 1.1 ER Diagram of the system

Implementation

Frontend (ReactJS)

The frontend of the Product Verification System is built using ReactJS, which allows the creation of modular and dynamic user interfaces. Its component-based architecture enables reusable elements such as dashboards, verification panels, and QR code scanners, enhancing maintainability and scalability. The interface is designed to be user-friendly and cross-platform responsive, allowing consumers, sellers, and manufacturers to access the system seamlessly on desktops, tablets, and mobile devices. ReactJS supports real- time updates, so any changes in product verification status or supply chain data are immediately reflected on the interface, improving usability and efficiency.

Backend (Node.js with Express)

The backend is developed using Node.js with the Express framework, providing a ro- bust and scalable environment for handling business logic and API requests. Node.js's event-driven, non-blocking architecture allows the system to handle multiple simultaneous requests efficiently, ensuring smooth performance even during high volumes of verification activities.

Express facilitates structured and secure RESTful APIs for communication between the frontend and the database. These APIs are protected using JWT-based authentication, ensuring that only authorized users, such as administrators, sellers, and manufacturers, can access or modify sensitive product data. The backend also sup- ports real-time processing, enabling instant updates on product verification activities and seamless integration with analytics dashboards.

Database (MongoDB)

All product data, seller information, and verification logs are stored in MongoDB, a NoSQL database that provides flexibility and high performance. Its schema-less architec- ture allows storing diverse product attributes across different industries without affecting database integrity. MongoDB supports fast read and write operations, which are essen- tial for real-time verification. The database can scale horizontally, efficiently handling millions of product records while maintaining high availability. It also provides audit trails, allowing stakeholders to monitor product movements, track verification events, and detect anomalies in the supply chain.

QR Code Generator

Each product is assigned a unique QR code, securely linked to its database record, which prevents duplication and forgery. QR codes are generated using libraries such as QRServer API or the qrcode.react library in ReactJS and can include encrypted data to enhance security. Consumers can verify product authenticity instantly by scanning the QR code with a smartphone. Manufacturers and sellers gain visibility into verification activity, allowing them to track scanning frequency, detect suspicious activity, and maintain transparency throughout the supply chain. This system ensures that product verification is both instant and reliable, bridging the gap between consumers, manufacturers, and sellers.

Figure : Login & Regester

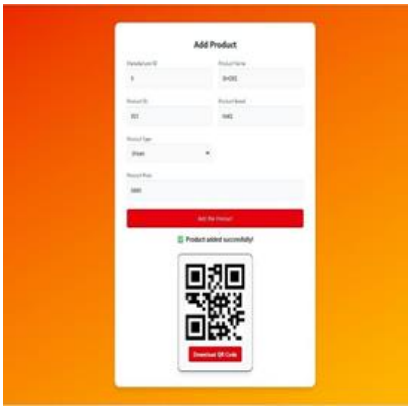


Figure :Add Product & QR Code Generate

Testing Procedures

Unit Testing

Unit testing focuses on validating the individual components of the Product Verification System. This includes ensuring that QR codes are generated correctly and are accurately linked to their corresponding database records. Backend API responses are also checked for correctness, including data retrieval, authentication, and error handling. Unit testing helps identify and fix issues at the component level before the system is integrated, ensuring that each module works as intended independently.

Integration Testing

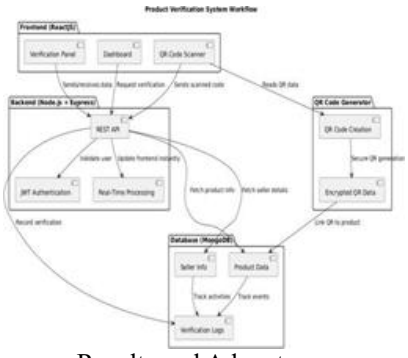
Integration testing ensures seamless communication between the frontend, backend, and database. It verifies that scanning a QR code triggers the correct API calls and retrieves accurate product information. This phase also tests the interaction of authentication mechanisms, role-based access controls, and real-time data updates. The goal is to con- firm that the system functions reliably when multiple modules work together, providing consistent and accurate product verification across all layers.

User Acceptance Testing (UAT)

User Acceptance Testing involves real users interacting with the system in practical sce- narios to validate its functionality. Consumers scan QR codes to check product authen- ticity and observe how the system responds in real-world usage. UAT evaluates usability, performance, and overall user experience, providing valuable feedback to improve inter- face design, verification speed, and system reliability.

This phase ensures that the system meets end-user expectations and is ready for deployment.

Workflow



Results and Advantages

Results

The Product Verification System (PVS) was evaluated using sample product datasets, and the results demonstrated its effectiveness in real- world scenarios. Consumers were able to instantly verify the authenticity of products by scanning QR codes using their smartphones, providing immediate confirmation of product legitimacy. Manufacturers and sellers benefited from transparent and accurate record- keeping, allowing them to track product distribution, monitor scanning activity, and identify potential anomalies in the supply chain. The system reliably detected counterfeit attempts and successfully blocked unauthorized access, showing its robustness and practical utility.

Advantages

Authenticity Assurance: Ensures that only genuine products reach consumers,
effectively preventing counterfeiting.
Consumer Confidence: Builds trust and strengthens overall brand reputation.
Scalability: Can be applied across diverse industries such as pharmaceuticals, electronics, cosmetics, and luxury goods.
Cost Efficiency: Provides an affordable alternative to expensive RFID-based sys- tems or blockchain platforms.
Instant Verification: Enables real-time product validation through QR code scan- ning using simple smartphones.
Data Insights: Supplies manufacturers with detailed analytics on sales trends, dis- tribution patterns, and product movement, supporting better supply chain decision- making.

II. CONCLUSION & FUTURESCOPE

The proposed Product Verification System (PVS), which integrates QR Codes and MongoDB, offers a practical, cost-effective, and secure solution to the growing problem of

counterfeit goods. By enabling real-time verifi- cation, the system allows consumers to immediately confirm the authentic- ity of products, which builds trust, reduces the risk of fraud, and safeguards brand reputation. Beyond consumer benefits,

manufacturers and sellers gain enhanced supply chain transparency, accurate record- keeping, and the ability to monitor product distribution, track verification events, and detect anomalies effectively. The system's architecture, designed for scalability, has demonstrated adaptability across multiple industries such as pharmaceuti- cals, electronics, cosmetics, and luxury goods, proving its reliability and po- tential for widespread adoption.

The PVS not only addresses counterfeit prevention but also bridges the gap between manufacturers, sellers, and consumers by providing a unified platform for authentication, monitoring, and analytics. Its combination of accessible technologies (QR codes) and a flexible backend (MongoDB) ensures both affordability and high performance, making it suitable for de- ployment in markets with varying technological maturity.
Future Scope

- Mobile Application: Developing a mobile app would allow users— both consumers and sellers—to access verification features on the go, improving convenience and adoption rates.
- AI-Powered Detection: Advanced algorithms could analyze scan- ning patterns and supply chain activity to identify suspicious behaviors,
- enabling proactive detection of counterfeit trends.
- IoT Integration: Real-time monitoring of products through con- nected devices (like smart sensors or trackers) can provide end-to-end visibility in the supply chain, improving operational efficiency and re- ducing fraud.
- Blockchain Integration (Optional): Implementing blockchain could create immutable, tamper-proof records of every product's journey, fur- ther strengthening trust, security, and auditability.
- Cloud-Based Deployment: Migrating the system to cloud platforms could provide high scalability, support large volumes of data, and en- sure faster access to verification services globally.
- Analytics Dashboard Enhancement: Enhanced reporting and vi- sualization tools could help manufacturers and sellers gain deeper in- sights into supply chain performance, product movement, and con- sumer behavior.
- Multi-Language Support: Adding support for multiple languages can improve accessibility for users in different regions, enhancing adop- tion in global markets.
- Integration with E- Commerce Platforms:
- Connecting the veri- fication system with online marketplaces can help ensure authenticity for products sold online, reducing the risk of counterfeits in digital commerce.
- User Education and Awareness Programs: Incorporating tuto- rials, notifications, or campaigns within the system can educate con- sumers on the importance of verification and encourage active partici- pation.
- Sustainability Tracking: Integrating environmental or sustainability metrics for products (e.g., eco-friendly production tracking) can provide added value and transparency for conscious consumers.

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Figure: Is Genuine or Fake

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