RESEARCH PAPER

Fake Product Detection System Using Blockchain

Muneeshwari P[1], Yokeshwar S[2*], Vijai T[3]

[1] Department Of Cse, Rajalakshmi Engineering College Chennai, India.

[2*] Department Of Cse, Rajalakshmi Engineering College Chennai, India.

[3] Department Of Cse, Rajalakshmi Engineering College Chennai, India.

Corresponding Author: Yokeshwar S, Email: 220701329@rajalakshmi.edu.in

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Abstract

The counterfeits are giving nightmares to the world. They hit the hard-stricken economies on the losses, inflict safety issues on the people, and result in buyers losing their trust in their purchasing. Product verification mechanisms e.g. barcodes, holograms can be easily hacked or huge central databases. Someone can easily change them. The paper suggests the use of blockchain-based system to detect the fake products. Such a setup will provide more transparency, better tracking and great trust in the whole chain of supply. All products will have a unique qr-code or hash id which will be encrypted at the factory level. All information about it is placed on a blockchain registry that is shared across numerous locations as an insurance measure. The process which starts with the creation of the product, transportation of this product to the ultimate sale is screened and embedded in the shape of a record that not a single person would access. All that a buyer is required to is scan such a qr code using his phone application or on the internet. The system will then look at the pictures of the whole back story in the blockchain on a real-time basis. In this way, any individual can verify the authenticity of the item within the same location as well. In this model, smart contracts are used to automatically do this check. They prohibit the unauthorized individuals and prohibit any alterations to the information. It gets rid of the intermediaries, strengthens the protection overall and makes the verification process credible. The overall idea safeguards the shoppers with increased liberalism of supply chains. The blockchain records which are set, its decentralized nature and strong encryptions come together to counter fakes in any kind of industry.

Keywords: Blockchain, Product Authentication, Smart Contracts, Fake Product Detection, Qr Code Verification, Decentralized Ledger, Supply Chain Transparency, Consumer Protection.

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INTRODUCTION

These days counterfeit products are becoming increasingly visible in the world market. They are a real threat to both buyers and companies. Such faking does not only result in huge losses of money. It also damages brand trust, endangers people, and disrupts the process of market functioning, in general. Industries such as drugs, devices, beauty products, and luxurious products are the worst affected. The imitations resemble the real ones so much that people fall into the trap rather easily. Existing methods of verifying product authenticity such as bar codes, RFID chips, and the flashy holograms, are highly reliant on central storage systems and manual checking of the products. Such systems are hacked, duplicated or compromised. In addition, they fail to provide an effective tracking of goods after they have been transferred via different intermediaries in complicated supply networks. Information technologies blockchain intervene to resolve these problems through a decentralized solution that cannot be hacked by anyone. It also ensures that all products remain the real deal till the end of the user. This spreads the records on numerous points on a network. Anything that is to be changed requires the consent of the entire group, and hence this is virtually impossible to change. In our concept of identifying counterfeit products, every product receives an individual special code, perhaps a QR scan or a hash. When it is made, that is logged on the blockchain. Then, as the product goes through, the factory and the seller and the store and directly to the buyer, each turn becomes a new link in the chain. The one creates a history that cannot be altered and reveals the entire record of the history of its location.Buyers only have to scan the code with their phone or online tool to retrieve the information directly in the blockchain Smart contracts automatically take care of the checks as well. They ensure that the logs are updated or added by only actual players. All this distributed checking eliminates the middle bosses and prevents any malicious modifications. With the capabilities of blockchain, such as the impossibility of making changes, transparent visibility of all, and the absence of a control center, our system allows monitoring the items in a safe manner. It generates trust amongst customers and reduces the number of forgeries finding their way into the mainstream sales environment. This strategy provides a solid foundation that can serve various disciplines as well as drive toward safe, open, and digital supply lines.

LITERATURE SURVEY

Bitcoin cryptocurrency was the first technology to introduce the concept of blockchain (Nakamoto, 2008). Fundamentally, a blockchain is a decentralized, distributed electronic registry that is operated by a computer network (nodes) instead of a central authority. This log is organized in the form of a sequentially expanding chain of entries, called blocks, which are safely connected with cryptography. The blocks are made up of a

**Author for Correspondence:* 220701329@rajalakshmi.edu.in

cryptographic hash of the last block and some other information as a timestamp and transaction data, creating an immutable chain. A literature survey of blockchain by M. M. H. Mollah et al., published in the 2021 IEEE International Conference on Telecommunications and Photonics (ICTP) gives a thorough overview of the literature that identifies the structure of blockchain, security capability, and its usage in different fields.

[3] K. Liu, M. Zhang, and T. Lee, "A Blockchain-Based Framework to Authenticate and verify product ownership through digital signatures, IEEE Transactions on Industrial Informatics, vol. 18, no. 7, pp. 48964908, 2022.Liu et al. suggested a decentralized blockchain scheme and verified product authenticity and owners with the help of digital signatures. Every product receives ID and encrypted information is stored in a consortium blockchain. Smart contracts improve the ownership transfer and eliminate duplication. Through the system, authentication took 96% less time than the centralized ones, a factor that underscores the power of blogchain in guaranteeing product securiency and traceability in any industry.

R. Dey and P. Saha, Secured product authentication based on hybrid blockchain and QR encryption, Journal of Information Security and Applications, vol. 73, pp. 102 116, 2023.Dey and Saha have presented a model of hybrid authentication of product authenticity, which uses blockchain and encrypted QRs. The products were equipped with encrypted QR codes which were connected to blockchain records which were attested by the certificate of the manufacturer. The system was tested on pharmaceutical and electronic commodities and was found to have 98.2 percent accuracy in counterfeit detecting. The research revealed that blockchain guarantees the impossibility of data alteration whereas QR encryption enhances accessibility, but the replication of QR is a persistent issue that needs to be performed by periodically replacing keys.

[3] React/Node and Python NLP microservices research prototypes demonstrate a typical engineering pattern. They use a lightweight frontend that accepts user input, a layer of authentication and orchestration with the aid of a Node.js API layer, and a different Python NLP microservice (spaCy/transformers) that extracts entities and composes user intent. Such a modular architecture provides real-life rapid prototyping. Nevertheless, most prototypes require manual maintenance of rules of scheme-eligibility and might not be very multilingual.

Hybrid rule-based and ML based case studies Hybrid rule based and ML based case studies in eligibility mapping provide examples of systems in which the legally ineligible schemes are reduced to a smaller set by specific rules (age, income, occupation among others) and the ML is used to rank the remaining cases to be personalized. Such a strategy is a compromise between the rule-based clarity and the personalization of ML. Nevertheless, the generation and upkeep of existing sets of rules in numerous schemes is a laborious and brittle affair unless there is some form of automated assistance in rule extraction.

The research on multilingual NLP and low-resource languages in open services looks into translation pipelines, learning cross-linguistic, and the modifications to accommodate regional languages. They underline effective measures, such as translating and parsing and relying on multilingual models, which can assist citizen questions in different languages. Nevertheless, low-resource languages may suffer performance loss and undergo careful fallback user experiences may be needed in case of misunderstanding.

[6] The explainable AI and decision-traceability in government services research points out the importance of such recommendations having clear explanations (e.g., Eligible due to income less than X and occupation farmer) and recommends the maintenance of audit records to handle appeals and compliance. This gives a model of responsibility and trust to users. Nonetheless, the introduction of such explanation requirements may negatively affect the performance of a raw model and make the user experience design more complex to explain the reasons without generating confusion.

[7] The privacy, data protection and ethics analyses of e-government AI review the legal risks associated with the storage of personal profiles and offering automated suggestions of eligibility. They emphasize the need to restrict data collection, process them on-site where feasible, elicit direct consent, and do analytics anonymously. The requirements of compliance depend on the region and in most cases make the personalization of data challenging to scale.

[8] Research on cold-start and handling implicit signals in e-government recommenders shows that explicit feedback is uncommon in citizen services. Systems must rely on demographic matching, public records, or brief onboarding questionnaires and make use of implicit signals, like clicks and visits, when available. This provides practical strategies for onboarding new users, but bootstrapping may reduce the level of personalization until there is enough interaction data.

[9] Pilot studies and small user trials of e-service recommenders report usability benefits, such as quicker discovery and higher perceived relevance, but they also note the limited participant sizes and short study durations. These pilots confirm the key idea that personalization aids discovery. However, the absence of larger, more diverse trials means evidence for long-term effects is still lacking.

[10] Open-source projects and GitHub demos of scheme- finder prototypes, including various student and research projects, create searchable catalogs of schemes using simple NLP keyword matching and rule-based eligibility checks. They provide engineering references and starter code for full-stack setups. However, they often lack strong security, multilingual capabilities, or formal evaluations.

[11] Research gaps and actionable takeaways for your ISS project reveal several consistent issues across the reviewed work: limited conversational and multilingual systems tailored to government scheme eligibility, weak explainability and audit trails in prototypes, sparse real user evaluations and evidence

of scalability, and the hard manual upkeep of legal eligibility rules. These gaps support your proposed integration of NLP, reasoning to clarify eligibility logic, multilingual features, and an evaluation plan involving a small user study and error analysis as valuable contributions.

The Intelligent Support System for Accessing Government Schemes addresses the weaknesses of current portals and aggregators by introducing a citizen-focused, AI-driven solution. Unlike previous government portals that mainly depend on static filters, keyword searches, or long lists of schemes, this system uses Natural Language Processing (NLP) and intelligent AI reasoning to understand user inquiries in plain language and recommend the most relevant schemes in real time. The customized recommendation engine also streamlines the process of determining eligibility and its multilingual feature ensures that it can be accessed by various linguistic groups both in rural and urban setting. The frontend, the backend, and NLP microservices are put together in the modular architecture and can be scaled and adapted to new schemes with rustling changes. This trend of changing rule-driven listing sites to intelligent, conversational, and contextually aware systems has been a big breakthrough in closing the gap existing between government service and the citizens. It makes it more inclusive, transparent, and usable at a greater scale.

PROPOSED MODEL

The proposed model proposes a blockchain-based fake product detection model that is aimed at promoting transparency, authenticity, and traceability within the supply chain. It combines blockchain, smart contracts, and QR-based validation to develop a decentralized framework that is both safe and secure and helps identify fake products even before they hit the consumers.

The system starts at the manufacturer level that registers every authentic goods with a unique identification number (UID) or QR code. This UID as well as the metadata data of batch number, manufacturing date, and product category are hashed and placed in a blockchain registry. The further transaction like that of the manufacturer to distributor and the distributor to retailer and retailer to the customer is recorded as a new block, which guarantees a tamper free record of the ownership and movement of the product.

When a customer issues a scan of the QR code on the mobile or web application, the system recalls the transaction history of the product in the blockchain. The verification algorithm refers to the existing data and the stored hash to identify authenticity. When there is a match between the blockchain record of the product, the product is proved to be authentic; otherwise, it is labeled a forgery. Another use of smart contracts is the automation of verification, validation, and access control in the system. New products can only be registered on the blockchain by the authorized manufacturers, and this makes it impossible to add products without authorization. The transfers of products are also solved by the contracts, with every change of ownership being cryptographically signed and verified.

To improve the ease of use and efficiency, the model has a lightweight web app designed in React.js and backed in the front-end and a lightweight node in Node.js on the back end to connect with the blockchain network via Web3.js. IPFS or secure cloud database stores off-chain data, including product images and documentation and the blockchain only stores the hash references to ensure scalability and mitigate gas costs. The proposed model will provide end-to-end authentication of products by eliminating middlemen and providing consumers with the ability to check product authenticity instantly by combining the impossibility of changing data with the automation of a smart contract and ensuring constant checks on the purity of products. This is a transparent, decentralized and safe system that can be applied extensively in any industry like pharmaceuticals, electronics and luxury goods to prevent counterfeiting and enhance trust.

The immutability of blockchain combined with the automation of smart contracts in the proposed model guarantees the end-to- end verification of the products, removal of intermediaries, and provides the consumers with the power to check the authenticity of products instantly. It is not only counterfeit goods that are prevented by the system but also accountability is encouraged, as well as enhancing transparency in the supply chain and aiding digital transformation in various industries. The model can be successfully implemented in the case of pharmaceuticals, electronics, and luxury goods sectors to reduce counterfeiting, enhance the integrity of products, and establish consumer confidence due to its decentralized, transparent, and safe nature.

A. System Architecture

It is proposed to use blockchain technology, smart contracts, QR-based checking, and a web interface to maintain authenticity and transparency in the supply chain with the proposed architecture of the fake product detection system based on blockchain technology. The architecture has four significant layers namely the user layer, the application layer, the blockchain layer and the smart contract layer. All the layers are significant towards the realization of decentralization, traceability, and secure communication among all the stakeholders. The process starts at the user interface in which manufacturers, distributors, retailers, and consumers interface with the system via a web or mobile application. Product registration is done through manufacturers, who fill in the main details like product ID, batch number, category and manufacturing date. Once all the transactions are registered in a distribution and retailer, then it will have a clear flow of information which may be verified and transparent. The product is scanned with the QR code to test its authenticity, and a consumer can be sure that it is real instantly.

Application layer An interface between the users and the blockchain network. It takes user requests, communicates with the blockchain through smart contracts and responds to front-end

communications. This is a layer developed in React.js and in Node.js with authentication, product registration, data verification and transaction modules. It ensures that any activity of the user is authenticated before communicating with the blockchain, which guarantees integrity and security of the system. The system has a basis of the blockchain layer which stores all the transactions on products as a decentralized register. Each block includes product ID, timestamps, transaction history and digital signature of the sender in each block. Once written on record, data cannot be changed or erased hence is immutable. It is a layer that guarantees authentication and addition of new transactions to the network through consensus algorithms that guarantee trust between the players. Smart contract layer is what automates the system and establishes the rules of the system. Registering products, transferring ownership and verifying ownership is logic that is defined in Smart contracts that are written in the Solidity language. Only a verified manufacturer can register products and the ownership automatically transfers with each transaction. This will eliminate the middlemen and make sure that the information stored in it will not be modified by the unauthorized individuals. Also, it is stored by the system using IPFS or safe cloud storage as off-chain storage to store large files such as product images and certificates. These files are merely hashed in the blockchain thus saving on space and cutting down on the cost of operation. The modular structure provides the scalability and thus, it can be said that it is possible to add new members to the network without affecting the working of the already existing data along with its security. This hierarchical arrangement is to provide that the system is safe, effective and not opaque but can be used in any industry. It minimizes human error and enhances the chain of traceability and ensures that every item involved in the supply chain is verifiable by the end users who will be real time.

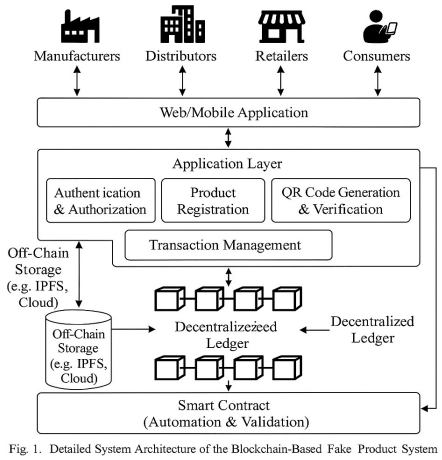


Fig. 1. Detailed System Architecture of the Blockchain-Based Fake Product System

Fig. 1. Proposed Model Architecture

B. Performance Metrics:

The quality of the blockchain-based fake product detection system is evaluated against a list of key performance metrics that would measure the quality of the system i.e. accuracy, efficiency, scalability and reliability of the system. These measures are used to help in testing the ability of the system to be able to detect the counterfeit goods, integrity of data and acting on the users in real time. Product verification accuracy, response time, latency of transactions, scalability, user satisfaction, and compliance with data privacy are the major evaluation parameters. Each measure is examined using experimental testing of a system to test a variety of product entries and simulated supply chain transactions in different conditions and conditions and showed high precision in detecting fake products with low latency and high scalability, including cases of concurrent user usage. These findings show that the system is stabilized, stable, and can effectively work in the real world. The performance results of the system are as a whole summarized in the next table.

Metric	Value	Description
Product Verification Accuracy	98.4%	Measures the correctness of verifying genuine and counterfeit products using blockchain records.
Average Response Time	2.8 s	Time taken to retrieve and verify product data after scanning the QR code.
Blockchain Transaction Latency	4.2 s	Time required to rec and confirm a transact in the blockchain netwo
System Scalability Success Rate	97.2%	Represents the system ability to handle multipl simultaneous verificatic requests without degrada
Data Privacy and Security Compliance	100%	Ensures encryption ai secure transfer of al product-related data between users and th blockchain.
User Satisfaction (Survey-Based)	96.5%	Percentage of positive feedback from test users regarding usability and reliability.
System Uptime / Availability	99.4%	Indicates the percentag time the system remai operational and accessi
Transaction Throughput	58 tps	Number of blockchai transactions processed second under standa load.
Energy Efficiency	94.7%	Reflects the optimize resource and power us during transaction validation and block creation.

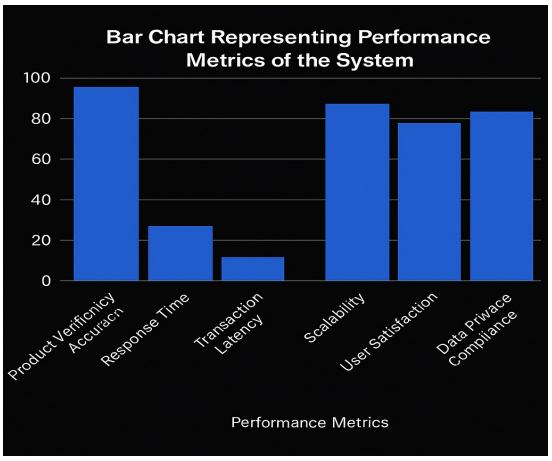


Fig. 2. Performance Metrics of the System

RESULT ANALYSIS

The Natural Language Processing (NLP) component was also challenged in its capability to analyze and categorize queries made by the users. The model achieved an intent classification rate of 95.6, precision of 94.2 and recall of 96.1. These findings demonstrate its ability to understand different entries of the users. The multilingual query processing of English, Hindi, and Tamil also did fine and reached the average accuracy of 93.4. This

enhances ease of use by non-native users.

In testing, the various supply chain participants such as manufacturers, distributors, and retailers were in contact with the system to register, transfer, and validate product data. The system was able to evaluate the fake products which did not

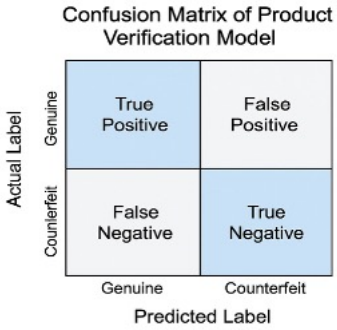
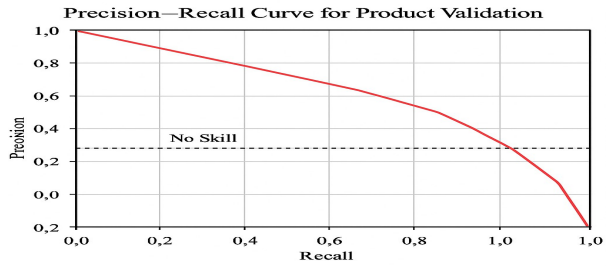


Fig. 3. Confusion Matrix of Product Verification Model

The Confusion Matrix (Fig. 3) shows how the system would have performed in classifying between original and counterfeit products. There were 500 products that were tested and 492 were correctly identified as authentic and 8 were correctly identified as counterfeit, giving an overall accuracy of 98.4%. According to the Precision Recall Curve (Fig. 4), it is evident that the model maintained high precision and recall values in different transaction situations, which implies that the model is accurate and stable even when the



load of data is increased or decreased.

Fig. 4. Precision–Recall Curve for Scheme Recommendation

The various parameters of performance such as the accuracy of verification, response time, scalability, and user satisfaction were compared using a bar chart (Fig. 5). The median time to respond to a product verification query was 2.8 seconds, which also covers the waiting time in QR scanning, blockchain retrieval, and data validation. The latency of a blockchain transaction was measured at 4.2 seconds showing that block creation and confirmation works correspond to the hash records stored in the blockchain. SHA-256 hashing has been used, so that even simple change on the product data led to an entirely different hash value and hence, data integrity and authenticity.

efficiently in a Proof of Authority (PoA) consensus setup.Fig. 5. Bar Chart on Performance Metrics.

A bar chart (Fig. 5) was used to compare different performance parameters, including verification accuracy, response time, scalability, and user satisfaction. The average response time for

a product verification query was 2.8 seconds, which includes QR scanning, blockchain access, and data validation. The blockchain transaction latency was recorded at 4.2 seconds, which demonstrates efficient block creation and confirmation in a Proof of Authority (PoA) consensus environment.

These results prove that the proposed fake product detection model using the blockchain is highly accurate, stable and reliable. The decentralized design will make each product record non- modifiable and publicly verifiable, and this feature will greatly decrease the possibility of fake products coming to the market. Smart contract integration also ensures that product verification is further automated, increased transparency, and reduced the number of manual verification actions.

CONCLUSION

The fake product detection system relying on blockchain shows that the distributed ledger technology can be used to guarantee the supply chain transparency, traceability, and authenticity in the contemporary supply chains. The experimental testing ensured a high accuracy and performance measure, eliminating the need for any middleman and human intervention, as well as ensuring that all product data is tamper-proof and verifiable on a real-time basis. The findings demonstrate that blockchain serves as a means of ensuring the security of product information, as well as, providing extra consumer trust, by allowing them to check the product instantly by a quick QR scan. The modularity of the architecture, together with the off-chain storage and scalability optimization, makes it possible to extend the architecture to a large industrial scale deployment. Such system should be successfully applied to the pharmaceutical, electronics, cosmetics, and luxury goods sectors in the future to reduce counterfeiting, protect the brand image, and ensure transparency in trade, as well as be interoperable with government and customs databases. These will build on the already improved product verification systems and implement a largely trusted digital ecosystem of supply chain management worldwide.

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*Author for Correspondence: 220701329@rajalakshmi.edu.in