International Journal of Computer Science & Communication (ISSN: 0973-7391)
Volume 17 • Issue 2 pp. 99-118 March 2026-Sept 2026 www.csjournals.com

Blockchain for Product Authenticity Checker: Barcode scanning links items to Blockchain for Anti-counterfeit verification.

Neha, Dr. Sneha, Dr. Anupam Bhatia
[1]MCA Student, [3]Asst. Prof., [2]Associate Professor
Deptt. of Comp. Sc. and Application, Chaudhary Ranbir Singh University, Jind, Haryana, India

Abstract: As businesses and consumers have begun to rely increasingly on the convenience of technology in conjunction with online marketplaces, obtaining authentic products has become increasingly challenging due to increasing counterfeiting activities. Traditional approaches to product verification are usually slow, centralized, and susceptible to manipulation; however, this research presents a solution in the form of using a blockchain-based mechanism for verifying product authenticity via a unique identifier, i.e. a barcode.

The system uses blockchain technology for storing and validating product information and the use of smart contracts to enable verification of products in a trustless environment. Each product is assigned a unique barcode that is linked to a corresponding record on the blockchain, thereby allowing consumers to verify the authenticity of a product in an instant via a barcode scanner. Additionally, the use of cryptographic hash functions together with digital signatures ensures that data integrity has not been compromised through tampering.

The proposed system improves transparency, security, trustworthiness and anti-counterfeiting protection in addition to providing a fast and effective information verification mechanism, through the combination of blockchain technology and smart contracts to provide a way to verify within a decentralized, distributed model..

Index Term: Blockchain Technology, Product Authenticity Checker, Barcode Scanning, Smart Contracts, Anti-Counterfeit Verification.

1. Introduction

Counterfeit products are a global issue and have negatively impacted manufacturers, retailers, and consumers worldwide. As e-commerce continues to grow and develop advances in packaging technologies, it has become easier to duplicate the appearance and characteristics of real products, resulting in revenue losses, damaged brand identity, and an erosion of consumer confidence. The use of counterfeit products poses health and safety risks to consumers within the pharmaceutical, electronics, cosmetics, and luxury goods industries. Traditional methods of product verification, such as holograms, serial numbers, and manual inspection, are often insecure, expensive, and easy to duplicate. They typically rely on a central database and human input, making them less reliable and time-consuming for authentication. Therefore, businesses require an automated, secure, and transparent method of combating counterfeiting. The decentralized, secure, and tamper-proof nature of Blockchain is an ideal technology for this purpose. Blockchain is a database that enables organizations to keep track of products with very high levels of transparency, security and trust. The "Blockchain for Product Authenticity Checker" means that every product will have a unique identifier (like a barcode or QR code) assigned to it by the time it is finished being manufactured. When consumers or retailers scan that product using either a web-based application or mobile application, the application will connect to the blockchain in order to find out information about that specific product and determine whether it is real or counterfeit. Because all of the data within the blockchain has to be agreed upon by all of the members of the network in order for it to change, there is no way to change or forge data on the blockchain, thus making the authentication process very safe and reliable. Apart from digital currencies, such as Bitcoin (and many other digital currencies), business can use blockchain technologies within various industries including healthcare, banking, digital identity solutions, electronic voting, and tracking the supply chain of goods and services. By incorporating barcode scanning technology, and product tracking systems, counterfeit

goods will be minimized, thereby increasing the level of trust consumers have as they make purchases in today's global market.

1.1 Product Counterfeiting and Authenticity Issues: A Growing Problem

Counterfeiting has grown into a significant global problem for both businesses and consumers alike. More and more counterfeit products are appearing in both retail outlets and online sales systems, which results in loss of income to companies, damage to brand equity, and a decrease in consumer confidence. Traditional ways to confirm whether a product is legitimate are typically centralized and subject to manipulation and imitation. The result is that it may not be possible for many consumers to independently verify whether a product was manufactured as represented, creating significant difficulties in confirming the identity and authenticity of products and maintaining transparency within the supply chain. Therefore, there is an increased demand for a secure, verifiable means of proving product identity and authenticity. A combination of the two, utilizing blockchain technology with bar code scanning as a method for storing information generated about products, will allow for a higher level of accountability throughout the supply chain and ultimately reduce the impact on businesses and consumers due to counterfeit or fraudulent activity.

There are several frequent types of counterfeiting and data manipulation associated with the sale of products. These include:

1. **Fake Product Labeling** – Total fakes are copied brand names, packaging and/or bar codes made to look like real products;
2. **Altered Product Information** – Changing information on a legitimate product (i.e., manufacturing date, expiration, serial number, origin);
3. **Unauthorized Product Copies** – Unapproved by manufacturer duplicate copies of brands;

4. **Duplicate or Inconsistent Product Records** – Having multiple fake entries of the same product throughout supply chains causes confusion and reduces trust in those systems;
5. **Supply Chain Fraud** – Using manipulated product records to cover up counterfeits or low-quality items while in route.

When shopping for branded items, pharmaceuticals, electronic devices, or luxury products, consumers usually have to confirm the authenticity of the purchased items. If an item is purchased in a traditional marketplace scenario, the parties involved (the manufacturer or distributor who sold the item to the consumer) have a lengthy verification process that can be cumbersome, expensive, and inaccurate. Thus, the end result is a longer wait time and higher likelihood that the consumer will unknowingly buy counterfeit goods.

Blockchain can help address the issues associated with product authenticity by enabling companies to implement a secure and tamper-proof environment for validating products. A blockchain-based Product Authentication checker assigns each product a distinct barcode linked to its blockchain record. When scanned, the barcode will allow consumers to verify quickly whether a product is authentic or fake. The details regarding the product have been secured cryptographically, stored on the blockchain, and are therefore transparent and can be traced; this increases consumer confidence while reducing counterfeit fraud and enabling secure and efficient verification throughout the supply chain.

1.2 Limitations of Traditional Product Authentication Systems

The traditional practices of authentication and verification for products are faced with many challenges associated with counterfeit products and the ability of a method to effectively prevent their commercialization.

Most of the information relating to manufactured items has been stored in a centralized database or via other means such as paper records or proprietary systems; all methods of storing product information are subject to the problems related to:

1. Unauthorized alteration

2. Loss of data due to human error, system failure, etc.

3. Security vulnerabilities.

The limitations described above also impede consumers' ability, as well as the ability of companies, to authenticate manufactured items:

• **Ownership:** Product authenticaton information is primarily managed by the manufacturer, distributor, or retailer of the product. As a result, consumers typically do not have access to the product's history and are unable to verify if the purchased item is true or not.

• **Availability:** Centralized systems may lose access to product records due to server failure, database corruption, or issues on the part of the organization. Over time, paper-based records can be lost or damaged as well.

• **Dependence on Third Parties:** To determine whether a product is authentic, often consumers need to rely on either the manufacturer or retailer or third-party certification agencies, thus making it more complex and less transparent.

• **Risk of Counterfeiting:** Counterfeiters are able to imitate traditional barcode systems, making it increasingly complicated to identify authentic goods vs. counterfeit goods.

• **Time Consumption:** Using traditional methods for authenticating products can require additional time for consumers by necessitating contacting manufacturers and/or checking multiple database systems; thus, producing considerable amounts of delay and inconvenience.

A need exists for a more secure, transparent and distributed method for linking the information provided by trade marks on products to blockchain technology. By recording product data onto an un-changeable ledger via a blockchain system, consumers will be able to easily access real-time confirmations about the authenticity of a given product, as well as obtain information regarding its past history and cut down on the incidence of counterfeit products within the supply chain.

2. Need of Blockchain Technology

The use of blockchain technology provides for a safe, transparent, and immovable system to allow for the verification of authenticity within the product supply chain. In the past, many companies have utilized a centralized database system for authentication purposes. However, centralized databases suffer from the possibility of being hacked, altered, and/or counterfeited due to their vulnerability to malicious activities. Since blockchain uses a distributed and immutable ledger technology, there is no way that the data could be changed/modified without proper authorization. The Blockchain-based Product Authenticity Checker connects every product with an individual barcode that is recorded in a secure way on the blockchain. Consumers can check the authenticity of their products by scanning the barcode to see if they are indeed real or fake. The use of digital signatures, cryptographic hash functions, and Smart Contracts ensure that the data remains untampered with during the entire supply chain process. The traceability of products is enhanced via blockchain technology by creating a secure and shared record of each item's life cycle from the manufacturer through to the customer. The result is reduced opportunities for

counterfeits; increased customer satisfaction; and quicker, easier, and more dependable verification than traditional tracking methods provide.

2.1 Potential of Blockchain Technology

By creating a decentralised, secure and transparent mechanism in which to store and validate product details, blockchain technology could change the way many organisations authenticate their products and prevent counterfeiting.

As one cannot alter or erase any record in an unalterable way, manufacturers, retailers and consumers have greater confidence in the integrity of the product record through using blockchain. Blockchain technology can provide a secure way to store information about a product, such as its serial number, and link that information to an item through a unique barcode. Customers will be able to scan a barcode and view the information recorded in the blockchain instantly, allowing them to verify the product's authenticity. The use of cryptographic hashes and digital signatures ensures the integrity of this information and prevents duplication of records or changes to the information that was originally recorded. The transparency of supply chains has also been improved by the use of blockchain technology as blockchain can provide real-time product tracking between manufacturers and end users. Automated registration/verification of products through smart contracts can further assist with reducing the number of manual processes required and minimizing opportunities for fraud. With enhanced security, traceability and trust, blockchain has a large potential for providing an efficient and trustworthy solution for verifying anti-counterfeited products.

3. Related Work

Due to rapid advancements in technology, the product manufacture and supply chain sectors are transitioning from traditional to digital systems; which raises major challenges

regarding secure management and verification of product data. Another major concern for this industry is the increase in counterfeit products, the unauthorized reproduction of products, and changes made to a product's record. In today's digital environment, the widespread use of centralized databases and online platforms for the storage and dissemination of product information means that there is a potential for alterations, duplication, and unauthorized access to that information.

In the case of these problems blockchain technology provides a solution for securely verifying and managing product authenticity. Blockchain is like certificate verification systems (CCVS) in that it allows you to use cryptographic hashing and distributed consensus to validate both the original and the integrity of the information related to a product.

TABLE 1. A Thorough Analysis Of Previous Studies Based On Blockchain Technology Parameters

citations	Key contribution	R 1	R 2	R 3	R4	R5	R6
[1]	Patient-centric blockchain framework for secure EHR sharing using IPFS and hybrid encryption.	✓	---	✓	✓	✓	✓
[8]	PREHEALTH framework using Hyperledger Fabric for privacy-preserving EHR management.	✓	✓	✓	---	✓	✓
[9]	Blockchain and edge-node architecture with AES encryption and access control for health records.	✓	✓	✓	✓	✓	✓
[10]	Patient-owned EHR system for secure and interoperable data sharing across providers.						

		✓	---	✓	---	✓	✓
[11]	Hyperledger Fabric-based framework with usage control and time-limited access to health records.	✓	✓	✓	✓	✓	✓
[6]	Generic patient-centered EHR management system with full patient control over record access.	✓	---	✓	✓	✓	✓

There are many features of blockchain technology that are important in product verification systems for their ability to create a secure and trustworthy environment. Some of these features are as follows: (1) Transparency, (2) Integrity, (3) Auditable, (4) Public Verifiable, (5) Persistent, (6) Anonymity, and (7) Trust Anchoring. Each of the above-listed properties makes blockchain an excellent choice for product verification systems that require security and traceability in their processing and record-keeping operations. In contrast, product information in conventional product verification systems is typically stored in centralized databases which can be easily compromised by unauthorized access or modification and where there is potential for the creation of counterfeit products and modification of product information. The decentralized and immutable aspects of blockchain combined with various cryptographic algorithms, such as hashing and encryption, provide an environment that allows product verification records to be maintained securely and be verifiably accessed by consumers as proof of their authenticity.

Although blockchain has many benefits there are issues associated with its implementation; these include high costs, limited scalability, complex architecture, poor interoperability with existing systems on supply chains. Many scholars have shown that utilizing blockchain can provide benefits in both anti-counterfeit and supply chain

environments. Several researchers have developed blockchain-based solutions that utilize Quick Response (QR) codes, Radio Frequency Identification (RFID) tags, or barcodes to create secure and verifiable tracking capabilities for products. Many other researchers have also employed Hyperledger Fabric and Smart Contracts to enhance the level of transparency available within the supply chain and automate verification processes, in addition many researchers have developed combinations of Cryptographic Hashing and Consensus Mechanisms to guarantee that the registration of products is tamper-proof and provides traceability of products across Manufacturers, Distributors, Retailers and End Consumers.

4.Proposed Model For Product Authenticity Checker

Over time, both product manufacturing and the supply chain industry have experienced substantial growth in terms of the number of manufacturers, distributors, retailers, and consumers involved. Due to product data volume as well as the need for companies to verify the authenticity of products throughout the supply chain, handling large numbers of product data has posed significant operational challenges in terms of order fulfilment and product verification. This has caused a gradual loss of consumer confidence and subsequently contributed to the proliferation of counterfeit goods within the marketplace.

There are multiple reasons for the lack of effectiveness of existing verification systems. One of the main drawbacks of traditional verification systems is the means to securely store, track, and verify product and other data. In traditional verification systems, product information is stored in a centralised database that may be susceptible to a number of security issues such as hacking, unauthorised modifications, duplicate records, and even loss of data.

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Volume 17 • Issue 2 pp. 99-118 March 2026-Sept 2026 www.csjournals.com

The presented methodology to overcome these challenges is blockchain for product verification and product authentication as shown in Figure 1. Blockchain is a state-of-the-art technology which allows product information to be stored, tracked and verified in a secure way. The concept behind this technology allows a manufacturer, distributor, retailer or consumer to verify the authenticity of a product by using barcode scanning while providing transparency, security, traceability and protection against counterfeiting activities.

4. Proposed Model for Product Authenticity Verification

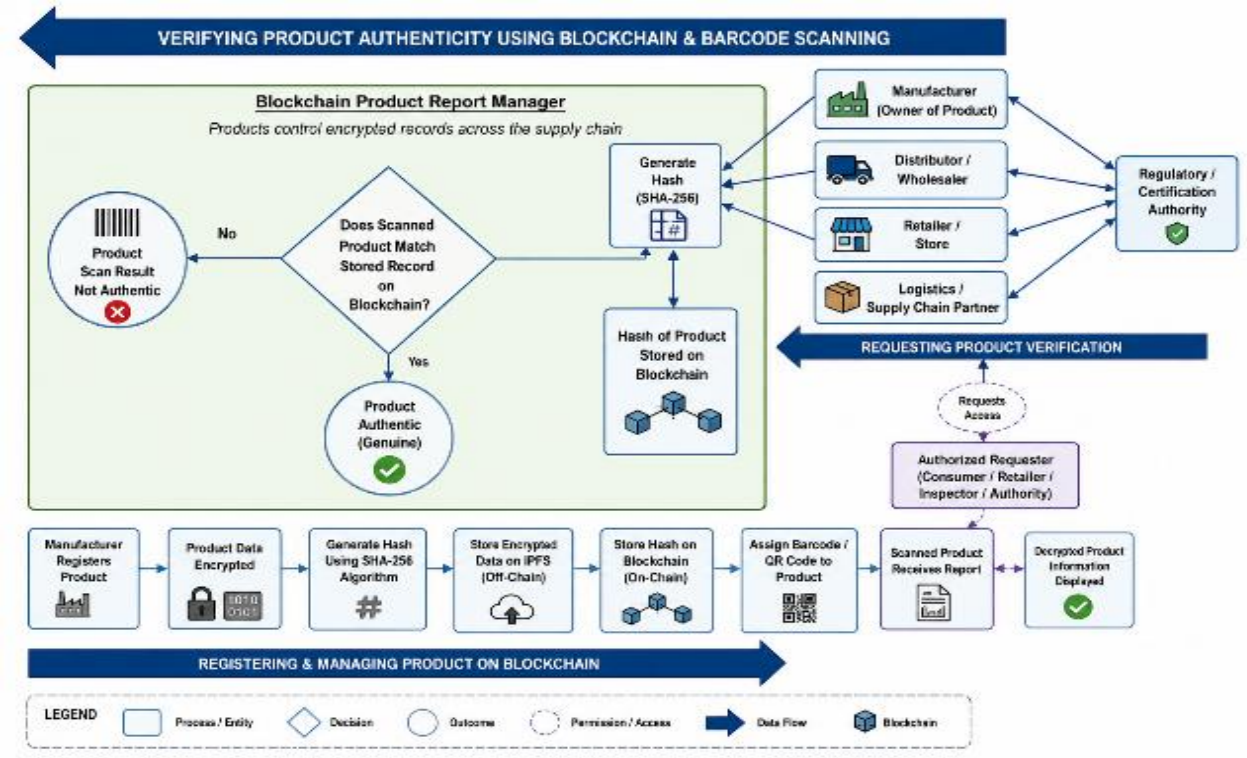

FIGURE 1: Blockchain-Based Model for Product Authenticity Verification and Anti-Counterfeit Management

4.1 Discussion

Accurate product information is essential for all stakeholders in a supply chain to accurately determine if a product is genuine or counterfeit. Each chain member (manufacturer, distributor/wholesaler, retailer) needs to be able to confirm that the products that they are selling and distributing are manufactured ethically. Manufacturers need to provide authenticated product data, including manufacturing date, batch number, bar code, and distribution records. A manufacturer must also keep up-to-date records of the verification and validation of this data to ensure the quality, safety and originality of the product throughout the supply chain from production to point-of-purchase. This can require a great deal of time and resources from the manufacturer to track the movement of product through the supply chain, and to provide assurance of a product's authenticity before it is sold or delivered to its final destination. As a result, many companies dedicate a lot of resources to working with their distributors and suppliers to validate product authenticity and prevent counterfeit products from entering the market. Manual verification of product data is a time consuming and challenging process, but is necessary to maintain consumer trust and preserve brand image. The use of blockchain technology can help to improve the ease with which products can be verified by manufacturers, retailers, and customers alike. With a combination of secured digital record-keeping capabilities and cryptographic keys, manufacturers will now have access to a secure way of storing and managing their product information on the blockchain, including product IDs, barcodes, manufacturing info, and transactions. Using these secured digital records will enhance supply chain transparency through improved traceability and trust for all partners in the supply chain.

Manufacturers will now have the ability to create a secured digital record of their products on the blockchain for any/all of their products. The products will be assigned a cryptographic hash that permanently relates to the specific item stored on the blockchain and can be accessed by any manufacturers, authorized retailers, distributors and consumers, as long as they have a barcode or QR code reader. By utilizing the Blockchain framework in this manner, verification times will be reduced; there is a

significantly lower risk of minute manipulation of product records; Supply Chain Security will be enhanced; and consumers will now be able to verify visually whether or not an item they are purchasing is an authentic product or counterfeit.

4.2 Analysis of the Proposed Solution

The blockchain is a decentralized and secure form of technology that has many features including hashing, encryption, peer-to-peer networking, timestamping and distributed storage. These elements work in unison to offer a dependable method for establishing product authenticity and protection against counterfeiting. The proposed Blockchain-Product Authenticity Checker combines these technologies to securely store, manage, monitor and verify product information throughout the supply chain. The theoretical model for the proposed system is presented in Figure 1.

❖ **Generating Product Information**

Digital product records are produced by manufacturers in the proposed system, which includes product IDS (such as barcodes or QR codes), manufacturing information (such as date of manufacture), batch numbers, expiration dates, and supply chain data. The product information is securely encrypted prior to being stored in order to ensure that only authorized personnel have access to the data and cannot alter it by tampering with it.

❖ **Hashing**

Digital product records are produced by manufacturers in the proposed system, which includes product IDS (such as barcodes or QR codes), manufacturing information (such as date of manufacture), batch numbers, expiration dates, and supply chain data. The product information is securely encrypted prior to being stored in order to ensure that only authorized personnel have access to the data and cannot alter it by tampering with it.

❖ **Timestamping**

A timestamp is assigned to each registration and transaction associated with the product, which indicates exactly when the product was created, shipped or validated. The use of timestamps allows for accurate tracking of the sequence of events and enhances the clarity and traceability of the supply chain.

❖ **Storage of Product Records**

Decentralized Storage Platforms, for example Interplanetary File System (IPFS), have been employed to store the encrypted records of products. Hence, there are cryptographic hashes and IPFS references for the product data on the blockchain, not the actual product data. With this approach, less blockchain storage is needed but the security, integrity, and authenticity of the product information is maintained.

❖ **Verification of Product Authenticity**

Retailers and consumers can scan product barcodes or QR codes via mobile app/web interface to check product details and authenticity. The product's hash, located in a blockchain network, is compared to the current hash of the barcode or QR code. If the hashes match, the product is legitimate and hasn't been tampered with, however if not, it could be a counterfeit product or tampered with.

❖ **Secure Tracking Across the Supply Chain**

This new technology facilitates secure and efficient tracking of products between manufacturers, distributors, warehouses, retailers, and consumers. Because of its decentralised and tamper-proof nature, a blockchain enabled supply chain can only be updated or accessed by approved entities and gives all participants transparency, traceability, and trust across the supply chain ecosystem.

By incorporating blockchain into the product verification ecosystem, the ability of current systems to store and verify product data with no central authority can be greatly enhanced. Information such as manufacturing documentation, bar code data, shipment history and ownership history can all be securely saved and protected through encryption when saved onto a blockchain. Additionally, this stored information can then be automatically verified against the original source, thus removing/reducing chance of error associated when verifying product info via other means while enabling instant access to that verified information for all authorized parties through the supply chain.

Table 2 : Workflow of Blockchain-Based Model for Product Authenticity Verification

Steps	Process	Description
1	Product Registration	Manufacturer registers the product and its details on the blockchain.
2	Barcode/QR Generation	A unique barcode or QR code is assigned to the product.
3	Blockchain Storage	Product information and hash value are securely stored on the blockchain.
4	Barcode Scanning	Retailer or consumer scans the barcode/QR code.
5	Verification	The system verifies the product by matching blockchain records.
6	Result Display	The system displays whether the product is **genuine** or **counterfeit**.

4.3 Benefit of Proposed Model

In this section we will look at how the proposed blockchain based authentication system will benefit manufacturers, retailers, distributors, and consumers. Below is a list of the benefits that the proposed blockchain based product verification model will provide to organizations who are part of the supply chain, as well as to end--users (consumers).

Benefits for Manufacturers, Retailers, and Supply Chain Authorities

• The sole type of proactive action by producers/distributors to validate the quality of their goods is through the use of blockchain networks, which provide an encrypted way to share and protect the authenticity of product data (barcode; how it was made/manufactured; transaction history on each product).

• All of the information related to products (barcodes, product details; mfg. (How the Product was Acquired) and TPH) is done securely and will be available for retrieval when needed. • There will be no additional effort by manufacturers/distributors when confirming the authenticity of products with the various systems being used.

• Organizations may securely register; store; track & share their authenticated product data & information.

• Product records are stored on a blockchain, which means they cannot be lost, deleted, or changed by an unauthorized user.

• The authorized participants in the supply chain (manufacturers, distributors, and retailers) can verify the authenticity of products at any time.

• There is no longer a need to maintain the same product information in several different databases/systems.

Advantages for Consumers and Retailers

- Barcode or QR code scanning allows consumers to quickly check whether the product is legitimate or fake.
- All details about a product; including manufacturing data, batch number, and supply chain history; can be tracked through One Digital Platform/Application - Manufacturers, Retailers, Distributors and Consumers can all securely take part in the verification process via the Internet.
- With blockchain technology in place, product record transactions are permanent and protection against future tampering exists.
- Users can check product information at any time using a device or authorized application.
- Supply chain partners can connect through integration of systems to check latest and greatest verifiable versions of product information.

5. Implication of The Findings

Using the context provided, this table provides information on how the use of blockchain technology can impact verification of product authenticity and management of counterfeits.

TABLE 2: Implications of Findings in Blockchain Technology for Product Authenticity Verification.

Implications	Explanation
Security	Blockchain technology offers a secure and trustworthy platform for storing and validating medical records, which minimizes the likelihood of hacking, data breaches

	and unauthorized changes.
Efficiency	With Blockchain, the process for sharing and verifying medical reports has become much more efficient and requires less time than before.
Decentralization	Decentralized storage of medical record decreases reliance on one central authority and therefore builds greater faith and trust between both the patient and their healthcare professionals.
Transparency	The visibility and traceability of every transaction or access activity provided by blockchain enhances the overall accountability and auditability of transactions and access activities.
Verification	Medical reports can be quickly verified for their authenticity and integrity before utilizing them for diagnostics and treatment options.
Interoperability	By providing a trustworthy way to transmit data, the blockchain facilitates the secure exchange of patient information among hospitals, laboratories, clinics, and health insurers.
Patient Control	The encrypted health records of patients are completely owned by the patients, who are able to authorize and de-authorize healthcare providers to access their records.

6. Conclusion and Future Work

To enhance the detection and verification process of counterfeit products, the study proposes a Product Authenticity Checker (PAC) based on Blockchain technology. The Product Authenticity Checker (PAC) will provide manufacturers, retailers, and consumers with the capacity to verify a product's originality using barcode scanning that

is integrated with Blockchain Technology. In addition, the proposed Product Authenticity Checker (PAC) will reduce exposure to counterfeit products through Unauthorized Product Duplication, as well as manipulation of Product Information, and improve Security, Transparency, Traceability, and Trust across the Supply Chain.

One significant advantage of the proposed model is that all information needed to Validate and Verify a product is stored in a secure manner on the Blockchain; encrypted records of Products are maintained Off-Chain when necessary. Thus, consumers, retailers, and distributors will no longer need to contact the manufacturer for confirmation of whether a Product is Authentic, because they will scan the barcode and verify that the generated Product Hash matches the Hash stored on the Blockchain. If the two values matches, a product can be regarded as unaltered and genuine. Initially, a proposed model will be implemented in various industry sectors (eg Pharmaceuticals, Electronics, Cosmetics, Luxury Goods) with the potential for a later rollout to include larger Global Supply Chain Networks. Future enhancements to the system could include the use of Smart Contract Automation, QR Code Integration, IoT-based Tracking, and AI Counterfeit Detection, all of which would further increase the Product's traceability, improve interoperability and support real-time monitoring and secure verification for multiple Stakeholders within the entire Supply Chain.

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