IDENTIFYING FAKE PRODUCTS THROUGH A BARCODE-BASED BLOCKCHAIN SYSTEM

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE AND ENGINEERING

Use Case Report

submitted by

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Kanuru, Vijayawada-520 007

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CERTIFICATE

This is to certify that the Use Case report entitled **"Identifying Fake Products Through A Barcode-Based Blockchain System"** that is being submitted by **Bhavitha Sri Kagitha (22501A0570)**, as part of Assignment-1 and Assignment-2 for the **Blockchain Technology**(**20CS4601C)** course in **3-2** during the academic year **2024-25**.

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MARKS

ASSIGNMENT-1: ____/5

ASSIGNMENT-2: ____/5

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1. INTRODUCTION

The rise of counterfeit products in global supply chains poses a significant challenge to manufacturers, retailers, and consumers. The Barcode-Based Blockchain System is a decentralized solution designed to verify product authenticity and prevent fraudulent goods from entering the market [1][2]. By integrating blockchain technology with barcode scanning, this system enables users to verify product details in a secure, transparent, and immutable manner. The platform utilizes React.js for the frontend and Ethereum smart contracts for the backend, ensuring a trust-less verification process [3].

The system functions by embedding a unique barcode identifier for each product, which is stored on the blockchain upon manufacturing. Consumers and retailers can scan the barcode using a mobile or web application, retrieving the product's history and verifying its legitimacy. This ensures that counterfeit items can be easily identified, as they will not have a corresponding blockchain record [4]. MetaMask is employed for user authentication, while Ethers.js facilitates blockchain interactions, enabling seamless retrieval of product data on the Ethereum network [5].

One of the primary advantages of this blockchain-based system is its tamper-proof nature. Once product details are recorded on the blockchain, they cannot be altered or deleted, ensuring a trustworthy record of ownership and authenticity [6]. Additionally, manufacturers can update product status, such as ownership transfer or recalls, in real time, providing an added layer of transparency. This eliminates the need for intermediaries and significantly reduces the risk of fraud in product distribution [7].

Security and efficiency are key highlights of this system. By leveraging Decentralized Ledger Technology (DLT), product information is permanently recorded, preventing data manipulation. Unlike traditional centralized databases, blockchain technology ensures that all transactions and modifications are publicly verifiable, further enhancing trustworthiness [8]. The adoption of this technology in the supply chain industry demonstrates how blockchain can revolutionize anti-counterfeiting efforts and promote a more secure trading environment [9].

This project showcases the potential of blockchain technology in combating counterfeiting by providing an immutable, decentralized, and transparent system for product authentication. As Web3 technologies continue to gain traction, integrating blockchain with barcode-based verification presents a promising approach to ensuring product authenticity, ultimately safeguarding consumers and businesses from fraudulent goods [10].

2. BACKGROUND

The Barcode-Based Blockchain System presents an innovative approach to combating counterfeit products by ensuring authenticity through blockchain verification. However, despite its advantages, several challenges must be addressed for widespread adoption in supply chains and consumer markets. Below are the key obstacles in this domain:

2.1 Integration with Existing Supply Chain Systems

Many manufacturers and retailers still rely on traditional centralized supply chain management systems. Transitioning to a blockchain-based verification system requires significant technical modifications, making integration complex and costly. Businesses may also resist adoption due to high initial investment costs, lack of technical expertise, and the need to modify operational models [3][6].

2.2 Transaction Costs and Scalability

Public blockchains often experience high transaction (gas) fees, which can make frequent product verification expensive, especially for low-cost items. Additionally, scalability issues arise as the number of recorded product verifications increases, leading to slower processing times and higher costs. Implementing Layer-2 scaling solutions or using private blockchain networks can help mitigate these challenges [2][8].

2.3 Smart Contract Security and Vulnerabilities

Smart contracts play a crucial role in verifying and recording product authenticity on the blockchain. However, vulnerabilities in smart contract code can lead to security breaches, such as unauthorized modifications or data manipulation. Conducting regular audits, following best coding practices, and implementing security-focused development approaches is necessary to mitigate these risks [5][7].

2.4 Regulatory and Legal Uncertainty

Blockchain-based product verification operates globally, but legal frameworks vary across jurisdictions. Issues such as data protection laws, taxation policies, and intellectual property regulations introduce compliance challenges. Additionally, lack of standardization can slow down adoption and create uncertainties for businesses implementing blockchain-based counterfeit detection systems [9].

2.5 User Experience and Adoption Barriers

For widespread adoption, both businesses and consumers must find the system easy to use. Managing crypto wallets, private keys, and gas fees can be complex for non-technical users. Additionally, requiring manufacturers to onboard blockchain-based verification may slow adoption. Simplified QR code/barcode scanning, gasless transactions, and seamless wallet integration can enhance usability [4][10].

2.6 Trust and Reputation Management

In centralized systems, brands and retailers act as intermediaries to verify product authenticity. However, in a decentralized verification system, trust is established through blockchain records and decentralized reputation mechanisms. Ensuring fair verification processes and preventing fraudulent barcode registrations remains a challenge that requires strong consensus mechanisms and identity verification tools [6].

2.7 Energy Consumption and Sustainability

Blockchain networks using Proof-of-Work (PoW) consensus mechanisms consume significant energy, raising concerns about the environmental impact of large-scale product verification. Transitioning to energy-efficient models like Proof-of-Stake (PoS) and integrating sustainable blockchain solutions can reduce these concerns while maintaining security [8].

2.8 Data Privacy and Transparency Balance

While blockchain provides public transparency, sensitive product details—such as ownership history, pricing strategies, and supply chain information—must be protected. Achieving a balance between public verification and private data protection through solutions like Zero-Knowledge Proofs (ZKPs) or permissioned blockchain networks is crucial for adoption [7].

2.9 Cross-Platform and Multi-Blockchain Compatibility

Different blockchain networks have varying token standards and data structures, making interoperability between them a challenge. A barcode-based authentication system must be compatible with multiple blockchains to maximize its reach. Implementing cross-chain functionality, decentralized oracles, and multi-blockchain support can enhance efficiency and adoption [9]

3. BLOCKCHAIN BASICS

Blockchain technology is transforming supply chain management by offering security, transparency, and decentralization. Traditional systems rely on intermediaries, which introduce inefficiencies, delays, and potential data manipulation. Integrating blockchain with barcode-based authentication eliminates the need for third-party oversight, ensuring a trustless and efficient verification system.

3.1 Decentralization

- Blockchain operates on a distributed ledger, meaning no single entity controls the data [1].
- In a barcode-based product verification system, decentralization ensures that product records cannot be altered by any single party, reducing fraud risks [2].
- Peer-to-peer (P2P) validation prevents system failures common in centralized verification models.

3.2 Immutability

- Data recorded on a blockchain is permanent and tamper-proof, preventing unauthorized alterations [3].
- Once a product's authenticity details are stored on the blockchain, they cannot be modified, ensuring that counterfeit products can be easily identified.
- Order histories, ownership transfers, and barcode registration remain verifiable and secure [2].

3.3 Smart Contracts

- Smart contracts are self-executing agreements stored on the blockchain, enabling automation without intermediaries [4].
- In barcode-based authentication, smart contracts can automatically verify product details, initiate recalls, or trigger ownership transfers.
- Example: A smart contract could verify whether a product's barcode matches its blockchain record before approving a transaction.

3.4 Key Components of Blockchain

1. **Blocks**: Each block contains transaction details, a timestamp, and a reference (hash) to the previous block, forming an immutable chain [1].
2. **Consensus Mechanisms**: Blockchain networks use consensus protocols to validate transactions and prevent fraud.
    - **Proof of Work (PoW)**: Used in Bitcoin but is energy-intensive.
    - **Proof of Stake (PoS)**: More efficient and widely used in Ethereum 2.0 [3].
    - **Byzantine Fault Tolerance (BFT)**: Ensures security even with some malicious network participants [2].
3. **Tokens**: Some blockchain-based supply chain solutions use tokens for transaction verification or incentivizing authenticity checks.

4. **Cryptographic Keys**: Public keys act as digital addresses for product authentication, while private keys secure ownership records [3].

3.5 Advantages of Blockchain in Supply Chain Authentication

1. **Trust & Transparency**: Immutable records prevent data manipulation [1].
2. **Reduced Costs**: Eliminates intermediaries, lowering verification costs [2].
3. **Security**: Decentralization and cryptographic hashing prevent unauthorized changes to product history [3].
4. **Real-time Updates**: Product statuses, recalls, and ownership transfers can be updated instantly.
5. **Cross-Border Verification**: Blockchain enables global product tracking, ensuring uniform standards across markets.
6. **Fraud Prevention**: Prevents counterfeiting by verifying product origins [4].

3.6 Use Cases of Blockchain in Product Authentication

- **E-commerce**: Ensures that products sold online are verified and not counterfeit [1].
- **Luxury Goods Authentication**: High-end brands use blockchain to verify genuine items.
- **Pharmaceuticals**: Prevents counterfeit drugs by tracking product origins and ensuring regulatory compliance [3].
- **Automobile Parts Tracking**: Helps verify the authenticity of vehicle parts and prevents fraud in the resale market.
- **Food Supply Chain**: Ensures food products are ethically sourced and free from contamination [4].
- **Electronics & Gadgets**: Prevents sales of duplicate or fake electronic devices.

By integrating blockchain into barcode-based authentication, businesses can strengthen supply chain security, reduce fraud, and enhance consumer trust. As blockchain technology continues to evolve, it will play a crucial role in securing product authenticity across industries

4. USE CASE OVERVIEW

The blockchain-based product authentication system leverages Hyperledger technology to ensure product authenticity by securely storing product details and verifying their legitimacy through QR code scanning. Manufacturers register products with unique identifiers, and customers can verify product authenticity in real-time using blockchain-based verification.

This case describes the implementation of a blockchain-based authentication system that enhances transparency, security, and trust in product verification by preventing counterfeit products.

4.1 Objectives

The primary objectives of this blockchain-based authentication system are:

1. **Prevent Counterfeit Products:** Ensure that only genuine products are verified and authenticated using blockchain.
2. **Enhance Security:** Utilize Hyperledger's secure and immutable ledger to store product details and prevent data manipulation.
3. **Increase Transparency:** Record all product details on the blockchain, making them verifiable and tamper-proof.
4. **Automate Verification:** Use digital signatures and QR codes to allow real-time product verification.
5. **Improve Consumer Trust:** Provide a reliable verification system to assure consumers of product authenticity.
6. **Data Integrity:** Store product-related information immutably on a distributed ledger to prevent unauthorized modifications.

4.2 Scope

The blockchain-based product authentication system covers the following functionalities:

- **Manufacturer Product Registration:** Manufacturers can log in and register products with essential details, including product ID, name, price, and manufacturing details.
- **QR Code Generation:** Each registered product is assigned a unique QR code linked to its blockchain entry.
- **Customer Verification:** Customers can scan QR codes using the system to check product authenticity.
- **Digital Signature Verification:** The system verifies the digital signature stored on the blockchain to confirm authenticity.
- **Access Control:** Manufacturers can add products, while customers can only verify product authenticity.
- **Hyperledger Database:** Stores product details securely, ensuring transparency and immutability.
- **Fake Product Detection:** If a scanned QR code does not match any registered product, it is flagged as counterfeit.

4.3 Stakeholders Involved

The key stakeholders in the blockchain-based authentication system include:

1. **Manufacturers**
    - o Can log in and register product details.
    - o Generate a unique QR code for each product.
    - o Store product details on the blockchain.
2. **Customers**
    - o Can scan QR codes to verify product authenticity.
    - o View product details from the blockchain.
    - o Detect counterfeit products if verification fails.
3. **Hyperledger Blockchain System**
    - o Acts as the decentralized ledger to store and manage product details.
    - o Verifies digital signatures to confirm authenticity.
    - o Ensures immutability and prevents fraud.
4. **Developers**
    - o Implement and maintain the blockchain-based authentication system.
    - o Ensure security protocols are properly enforced.

4.4 Architecture

The blockchain-based product authentication system follows a Hyperledger-based architecture with the following components:

a) Hyperledger Blockchain

- A decentralized ledger that securely stores product details.
- Ensures product authenticity using digital signatures.

b) Product Data Structure

- The system stores essential product details, including:
    - o id (unique product identifier)
    - o name (product name)
    - o price (product cost)
    - o manufacturer (entity registering the product)
    - o qr_code (unique QR code for verification)

c) QR Code Mechanism

- Each registered product receives a unique QR code.
- Customers scan the QR code to verify product authenticity.

d) Digital Signature Verification

- The system verifies stored digital signatures to validate product legitimacy.
- If verification fails, the product is flagged as counterfeit.

e) Access Control Layer

- **Manufacturers:** Can register and manage product details.
- **Customers:** Can only verify product authenticity.

f) Blockchain Storage

- All product information is immutably stored on the blockchain.
- Prevents unauthorized data manipulation.

g) Frontend Interface

- Users interact with the authentication system via a decentralized application (DApp).
- Customers scan QR codes, and the system fetches verification details from the blockchain.

Flow Chart Representation [Fig. 4.1]

As illustrated in **[Fig. 4.1]**, the system's flow begins with manufacturers logging in to register product details, including a unique QR code. This data is stored in the **Hyperledger blockchain**, ensuring security and immutability. Customers, after signing up and logging in, can scan the QR code to verify the product ID. The system then verifies the digital signature on the blockchain. If the product is genuine, details are displayed; otherwise, it is marked as a counterfeit product. The diagram visually represents the process flow between manufacturers, the blockchain system, and customers, demonstrating the role of Hyperledger in preventing fraud.

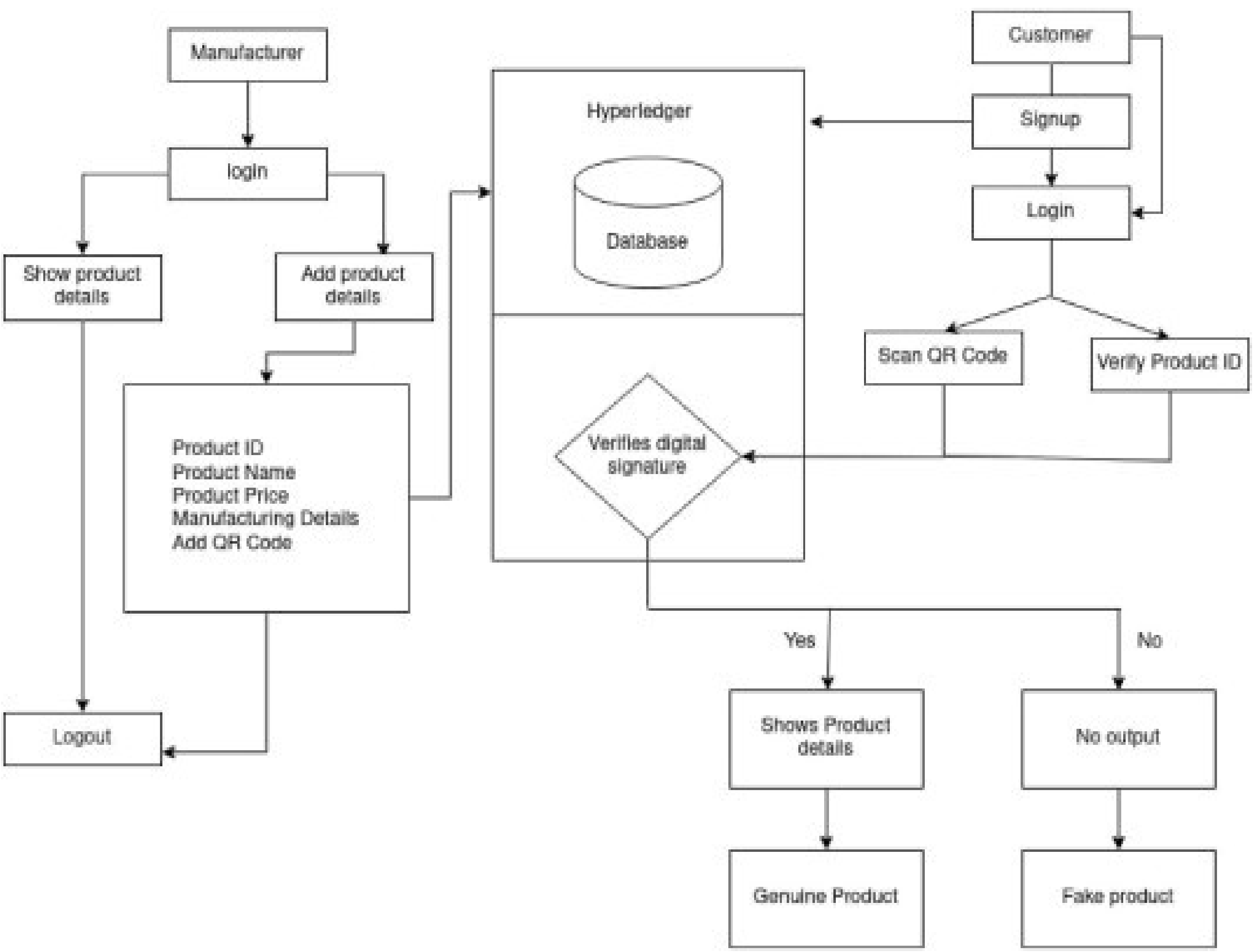

Fig. 4.1: Flow Chart Identifying Fake Products Through A Barcode-Based Blockchain System

4.5 Security and Privacy

Security and privacy are critical aspects of the decentralized product authentication system. The system incorporates the following measures:

a) Smart Contract Security

- **Require Statements**: Enforces input validation to prevent invalid transactions.
- **Ownership Verification**: Ensures only manufacturers can register products.
- **Reentrancy Protection**: Prevents multiple function calls in a single transaction.

b) Data Security

- No personally identifiable information (PII) is stored on the blockchain.
- Only essential product authentication data is recorded.

c) Blockchain Immutability

- All records are permanent and tamper-proof.
- Eliminates fraudulent modifications to product details.

d) Fraud Prevention

- Digital signatures verify the legitimacy of registered products.
- Ensures that counterfeit products cannot pass authentication.

4.6 Benefits

The blockchain-based barcode authentication system enhances product verification and prevents counterfeit goods. The key benefits include:

a) **Enhanced Transparency:** All product details and verification records are stored immutably on the blockchain, ensuring a tamper-proof history accessible to manufacturers, retailers, and consumers.

b) **Improved Security:** Blockchain eliminates the risks associated with centralized databases, preventing unauthorized modifications, hacking, or fraudulent data alterations.

c) **Reliable Product Authentication:** Each product is assigned a unique barcode linked to blockchain records, allowing real-time verification and ensuring that fake products are easily identified.

d) **Automation & Accuracy:** Smart contracts automate product verification, reducing human errors and manual interventions in counterfeit detection.

e) **Fraud Prevention:** Since blockchain records cannot be altered or deleted, counterfeit products fail verification checks, protecting brands and consumers from fraud.

f) **Consumer Trust & Brand Protection:** Buyers can verify product authenticity instantly by scanning a barcode linked to blockchain data, increasing trust in genuine products and protecting brands from counterfeiting losses.

g) **Cost Efficiency:** Reduces the need for third-party authentication services, cutting costs while ensuring fast and reliable product verification.

5. IMPLEMENTATION

5.1 Barcode Authentication Workflow

The blockchain-based barcode authentication system ensures product authenticity using the following steps:

Step 1: Manufacturer Registers the Product

- The manufacturer logs into the system and accesses the dashboard.
- They add product details, including:
  - Product ID
  - Product Name
  - Manufacturer Details
  - QR Code or Barcode
- The product data is stored on the Hyperledger blockchain.

  Step 2: Digital Signature Verification
- The system digitally signs the product details and stores them immutably in the blockchain.

  Step 3: Customer Verification Process
- The customer signs up and logs into the system.
- They scan the QR code/barcode using a mobile/web application.
- The system retrieves the product ID and matches it with the blockchain records.

  Step 4: Authenticity Check
- The system verifies the digital signature to confirm whether the product is genuine or fake.
- If verification is successful, the system displays product details, confirming it as a genuine product.
- If verification fails (no matching product ID), the system flags the item as fake.

5.2 Choose the Blockchain Type

- Private Blockchain (Hyperledger, Quorum) – Best for controlled product authentication, ensuring low transaction fees and security.
- Public Blockchain (Ethereum, Polygon, Binance Smart Chain) – Not recommended due to high gas fees for frequent verification requests.

5.3 Design Smart Contracts for Barcode Authentication

The smart contract must include:

- Product Struct – Stores details like ID, name, manufacturer, barcode, and authenticity status.
- RegisterProduct Function – Allows manufacturers to add new products securely.

- VerifyProduct Function – Enables customers to scan a barcode and verify authenticity.
- Events – Notifies when a product is registered or verified.
- Access Control – Ensures only authorized manufacturers can register products.

5.4 Develop & Deploy Smart Contracts

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract ProductAuth {
    uint public productCount = 0;
    mapping(uint => Product) public products;

    struct Product {
        uint id;
        string name;
        address manufacturer;
        string barcode;
        bool verified;
    }

    event ProductRegistered(uint id, string name, string barcode, address manufacturer);
    event ProductVerified(uint id, bool verified);

    function registerProduct(string memory _name, string memory _barcode) public {
        productCount++;
        products[productCount] = Product(productCount, _name, msg.sender, _barcode, false);
        emit ProductRegistered(productCount, _name, _barcode, msg.sender);
    }

    function verifyProduct(uint _id, string memory _barcode) public view returns (bool) {
        Product memory product = products[_id];
        require(keccak256(abi.encodePacked(product.barcode)) == keccak256(abi.encodePacked(_barcode)),
"Invalid barcode");
        return true;    }}
```

5.5 Frontend & Web3 Integration

- Tech Stack: React.js + Web3.js/Ethers.js
- Steps:
    1. Load smart contract
    2. Connect wallet
    3. Scan barcode
    4. Verify product authenticity

5.6 Test the Smart Contracts

- Tools: Hardhat, Truffle
- Key Tests:
    - Security vulnerabilities
    - Gas efficiency

5.7 Deploy on Blockchain

- Testnet: Goerli, Mumbai for testing
- Mainnet: Ethereum, Polygon for live use

5.8 Monitor & Maintain

- Track activity with: Tenderly, Alchemy
- Optimize UI & gas fees
- Upgrade contracts if needed

6. ADVANTAGES

Using blockchain for barcode authentication provides several significant benefits:

6.1 Enhanced Transparency

- **Real-time tracking**: Blockchain enables stakeholders to track products instantly.
- **Immutable records**: Transactions are permanently stored, preventing tampering.

6.2 Improved Traceability

- **End-to-end tracking**: Ensures authenticity from production to purchase.
- **Auditability**: Provides a verifiable transaction history to detect fraud.

6.3 Enhanced Security

- **Cryptographic protection**: Secures transactions with encryption.
- **Decentralized ledger**: Reduces risks of hacking and data breaches.

6.4 Reduced Fraud and Counterfeiting

- **Immutable verification**: Prevents unauthorized product alterations.
- **Product authenticity**: Ensures buyers receive genuine products.

6.5 Better Collaboration

- **Shared visibility**: Enables all supply chain participants to access real-time data.
- **Smart contracts**: Automate verification and transactions, reducing errors.

6.6 Increased Efficiency

- **Streamlined processes**: Eliminates intermediaries and automates verification.
- **Faster transactions**: Enhances processing speed and reduces paperwork.

6.7 Improved Compliance and Regulatory Reporting

- **Data accuracy**: Ensures compliance with safety and ethical regulations.
- **Simplified auditing**: Blockchain's transparency makes compliance easier.

6.8 Consumer Trust and Loyalty

- **Transparency of sourcing**: Verifies ethical and sustainable sourcing.
- **Product verification**: Allows customers to confirm product authenticity.

6.9 Cost Savings

- **Reduced paperwork & intermediaries**: Lowers administrative costs.
- **Minimized fraud losses**: Prevents counterfeit-related financial losses.

6.10 Sustainability

- **Environmental impact tracking**: Monitors carbon footprint.
- **Waste reduction**: Enhances inventory management and prevents overproduction.

6.11 Scalability & Future-Proofing

- **Layer 2 solutions**: Improves speed and reduces gas fees.
- **Interoperability**: Integrates with AI, IoT, and other technologies.

  Adaptability: Supports business growth without performance issues.

7. CHALLENGES

While blockchain offers many benefits, certain challenges must be addressed:

7.1 High Transaction Costs

- **Gas fees**: Ethereum and other networks can have high fees, increasing costs.
- **Scalability issues**: More transactions may drive costs up, reducing efficiency.

7.2 Scalability Limitations

- **Network congestion**: Public blockchains can experience delays.
- **Limited throughput**: Traditional blockchains process fewer transactions than centralized systems.

7.3 Regulatory Uncertainty

- **Lack of clear policies**: Regulations vary across regions.
- **Compliance challenges**: Adhering to evolving legal frameworks adds complexity.

7.4 Security Risks

- **Smart contract vulnerabilities**: Exploits in contracts can cause losses.
- **Phishing & hacking**: Users may fall prey to scams and cyber threats.

7.5 Complexity in User Adoption

- **Technical knowledge required**: Users must understand blockchain basics.
- **Difficult onboarding**: Wallet setup and key management can be overwhelming.

7.6 Lack of Consumer Trust

- **Market volatility**: Cryptocurrency price fluctuations may impact adoption.
- **Fear of scams**: Fraudulent projects affect blockchain credibility.

7.7 Energy Consumption

- **High power usage**: Proof-of-Work blockchains consume significant energy.
- **Sustainability concerns**: Proof-of-Stake alternatives are more eco-friendly.

7.8 Limited Interoperability

- **Cross-chain issues**: Blockchains often operate in isolation.
- **Integration challenges**: Connecting blockchain with existing systems is complex.

7.9 Legal and Dispute Resolution Challenges

- **Smart contract limitations**: Automated transactions lack built-in dispute resolution.
- **Jurisdiction conflicts:** Decentralized transactions complicate legal enforcement.

7.10 Resistance from Traditional Industries

- **Lack of support**: Established businesses may resist decentralized models.
- **Fear of disruption**: Intermediary-based industries may oppose blockchain adoption.

8. CONCLUSION

The integration of blockchain, smart contracts, and IoT in a barcode-based blockchain system for identifying fake products offers numerous advantages, including enhanced transparency, security, efficiency, and cost savings [1]. By eliminating intermediaries and leveraging automated processes, blockchain-based authentication systems create a more reliable and trust-driven ecosystem for manufacturers, retailers, and consumers [8]. These technologies enable seamless product verification, reducing reliance on centralized authorities while increasing operational efficiency and trust in supply chains.

Blockchain ensures transparency by maintaining an immutable ledger of product information, which enhances accountability and trust in the authentication process. Smart contracts automate verification, reducing the potential for fraud and human error while ensuring that only genuine products are validated. IoT-enabled barcode scanning further enhances the system by providing real-time product tracking and authentication, allowing consumers and businesses to verify product authenticity instantly [6]. The combination of these technologies fosters a decentralized framework that benefits industries such as pharmaceuticals, luxury goods, and consumer electronics.

However, several challenges must be addressed to facilitate widespread adoption. Scalability limitations pose a significant barrier, as blockchain networks often experience congestion and high transaction costs, which can hinder real-time verification processes [3]. Additionally, regulatory uncertainty creates ambiguity regarding compliance and legal requirements, making it difficult for businesses to navigate the evolving landscape [9]. Security risks, including vulnerabilities in smart contracts and potential cyberattacks, must also be mitigated to maintain user confidence and data integrity. The integration of IoT devices raises concerns about data privacy and the need for secure communication channels to prevent unauthorized access.

Overcoming these obstacles will require continuous technological advancements, including the development of more scalable blockchain solutions, such as layer-2 protocols and consensus mechanisms that improve transaction speeds while maintaining decentralization. Improved regulatory frameworks will provide clarity and establish guidelines that support innovation while ensuring compliance with legal and ethical standards. Additionally, the development of user-friendly applications and intuitive interfaces will drive adoption by making barcode-based blockchain authentication systems accessible to a broader audience.

Despite these challenges, barcode-based blockchain systems hold immense potential to revolutionize product authentication by enabling real-time tracking, secure verification, and global accessibility [6]. As blockchain technology continues to evolve, businesses and consumers alike can look forward to a more transparent and efficient approach to counterfeit prevention [4]. By addressing scalability, regulatory, and security concerns, blockchain can serve as the foundation for a future where trust and authenticity are embedded in supply chains, fostering a new era of product integrity and consumer confidence.

9. SDG's ADDRESSED

A barcode-based blockchain system for identifying fake products contributes significantly to multiple United Nations Sustainable Development Goals (SDGs) by ensuring product authenticity, protecting consumers, and enhancing supply chain transparency. Below are the key SDGs addressed:

SDG 1: No Poverty

- **Protects Small Businesses** – Helps small manufacturers and retailers avoid financial losses due to counterfeit goods.
- **Increases Consumer Trust** – Ensures buyers get authentic products, boosting sales for genuine businesses.

SDG 8: Decent Work and Economic Growth

- **Strengthens Market Integrity** – Reduces revenue losses due to counterfeiting, supporting fair competition.
- **Encourages Ethical Trade** – Promotes transparent supply chains, discouraging exploitative labor practices.
- **Boosts Innovation** – Encourages brands to adopt blockchain for secure product verification.

SDG 9: Industry, Innovation, and Infrastructure

- **Enhances Product Authentication** – Uses blockchain and barcodes for tamper-proof verification.
- **Prevents Fraud and Fake Goods** – Ensures every product has a verifiable history, reducing counterfeit risks.
- **Improves Supply Chain Transparency** – Tracks product movement from manufacturer to consumer in real-time.

SDG 12: Responsible Consumption and Production

- **Encourages Ethical Sourcing** – Ensures products are made with legitimate and sustainable materials.
- **Reduces Wastage** – Prevents consumers from buying fake, low-quality products that get discarded quickly.
- **Supports Circular Economy** – Helps track recycled and reused products to validate sustainability claims.

10. RFERENCES

1. Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.
2. Wood, G. (2014). Ethereum: A Secure Decentralized Generalized Transaction Ledger.
3. Kshetri, N. (2018). Blockchain's roles in strengthening cybersecurity and protecting privacy. Telecommunications Policy.
4. Tian, F. (2016). An agri-food supply chain traceability system for China based on RFID & blockchain technology.
5. Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification, and open issues.
6. Treiblmaier, H. (2019). The impact of blockchain on supply chain management: A theoretical framework and future research agenda.
7. Wüst, K., & Gervais, A. (2018). Do you need a blockchain? IEEE Security & Privacy.
8. Christidis, K., & Devetsikiotis, M. (2016). Blockchains and smart contracts for the Internet of Things. IEEE Access.
9. Xu, X., Pautasso, C., Zhu, L., Grammel, L., & Garlan, D. (2016). The blockchain as a software connector.
10. Toyoda, K., Mathiopoulos, P. T., Sasase, I., & Ohtsuki, T. (2017). A blockchain-based product ownership management system (POMS) for anti-counterfeits in the post-supply chain. IEEE Access.

11. APPENDIX A