SECURE DRUG TRACKING IN HEALTHCARE USING BLOCKCHAIN

[1] T. Abdul Raheem, [2] PALAKOMMU JOHN, [3] SHAIK SALEEM BASHA, [4] DUPATI SHRIHARI, [5] MADRI UDAY KUMAR

[1] *Assistant Professor,* [2345] *Students*

Department of Computer Science and Engineering

St. John's College of Engineering & Technology, Yerrakota, Yemmiganur, Kurnool, A.P.

abdul.13459@gmail.com, johnpalakommu1520@gmail.com, shaiksaleem2360@gmail.com, dupatishrihari@gmail.com, madriudaykumarmuday@gmail.com

ABSTRACT

The increasing complexity of pharmaceutical supply chains has made it difficult to ensure transparency, authenticity, and traceability of drugs as they move from manufacturers to patients. One of the major challenges in healthcare supply chains is the presence of counterfeit medicines, which pose serious risks to patient safety and cause significant financial losses to the pharmaceutical industry. Traditional drug tracking systems rely on centralized databases and identification technologies such as barcodes and RFID tags, which often lack transparency, security, and trust among supply chain stakeholders. To address these limitations, this study proposes a secure drug tracking system in healthcare using blockchain technology. The proposed framework utilizes a decentralized blockchain network combined with smart contracts to record and verify drug transactions across the entire supply chain. Each stakeholder, including suppliers, manufacturers, distributors, pharmacies, and patients, can access a secure and immutable record of drug movement and ownership. The blockchain ledger ensures data integrity, prevents unauthorized modifications, and enhances transparency among all participants. Additionally, the system improves traceability by providing a complete history of each drug from production to distribution. The implementation of blockchain-based drug tracking significantly reduces the risk of counterfeit medicines, strengthens trust in the healthcare supply chain, and enhances the overall safety and reliability of pharmaceutical products.

Keywords: Blockchain Technology, Drug Traceability, Healthcare Supply Chain, Smart Contracts, Counterfeit Drug Prevention, Secure Drug Tracking.

I. INTRODUCTION

The healthcare industry relies heavily on a complex pharmaceutical supply chain to ensure that safe and effective medicines reach patients on time. This supply chain involves multiple stakeholders, including raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients. Each stage of the supply chain is responsible for handling, storing, and transferring pharmaceutical products. Due to the involvement of numerous participants and the movement of drugs across different geographical locations, maintaining transparency and accurate tracking of medicines becomes a challenging task.

One of the major problems affecting pharmaceutical supply chains is the increasing presence of counterfeit drugs. Counterfeit medicines are products that are deliberately manufactured or mislabeled to appear as genuine pharmaceutical products. These drugs may contain incorrect ingredients, insufficient active pharmaceutical components, harmful substances, or may even be completely ineffective. The distribution of counterfeit drugs not only threatens patient safety but also leads to severe economic losses for pharmaceutical companies and healthcare systems. In many developing countries, counterfeit medicines represent a significant percentage of the drugs available in the market, making this issue a critical global health concern.

Traditional drug tracking systems use technologies such as barcodes, RFID tags, and centralized databases to monitor the movement of pharmaceutical products across the supply chain. Although these methods help track product information, they still suffer from several limitations. Centralized systems are vulnerable to data manipulation, lack transparency among stakeholders, and often require intermediaries to verify transactions. In addition, data stored in centralized systems can be altered or lost due to cyberattacks, system failures, or unauthorized access. These limitations make it difficult to ensure complete traceability and authenticity of drugs throughout their lifecycle.

Blockchain technology has emerged as a promising solution for addressing these challenges in healthcare

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supply chains. Blockchain is a distributed ledger technology that records transactions in a decentralized and immutable manner. Each transaction is verified through cryptographic techniques and stored in blocks that are linked together in a secure chain. Once recorded, the information cannot be modified without the consensus of the network participants, ensuring high levels of transparency, security, and data integrity.

By integrating blockchain technology into pharmaceutical supply chains, it becomes possible to create a secure drug tracking system that records every stage of a drug's journey from production to final delivery. Smart contracts can automate transactions between stakeholders and provide real-time updates about product ownership and location. This approach improves traceability, prevents counterfeit drugs from entering the supply chain, and enhances trust among all participants involved in drug distribution.

Therefore, implementing a secure drug tracking system using blockchain technology can significantly improve the transparency, security, and efficiency of healthcare supply chains. Such systems help ensure that patients receive authentic medicines while enabling regulatory authorities and healthcare providers to monitor drug distribution more effectively.

II. LITERATURE SURVEY

The growing problem of counterfeit medicines and lack of transparency in pharmaceutical supply chains has attracted significant research attention. Various studies have explored methods for improving drug traceability, supply chain monitoring, and secure data management using advanced technologies such as blockchain, smart contracts, and digital identification systems.

Chambliss et al. discussed the role of pharmacists in preventing the distribution of counterfeit medications. Their study emphasized that pharmacists play a critical role in verifying the authenticity of pharmaceutical products before dispensing them to patients. The research highlighted several preventive strategies such as purchasing drugs from reliable suppliers, monitoring counterfeit alerts, and using scanning technologies to verify product authenticity. The study concluded that strengthening the verification process in pharmacies can significantly reduce the circulation of counterfeit medicines.

The World Health Organization has reported that counterfeit and substandard medicines represent a major global health issue. According to global health studies, a significant percentage of medical products circulating in developing countries are either falsified or substandard. These medicines may fail to treat diseases properly or may even cause serious health complications. The reports emphasize the urgent need for better monitoring systems and stronger regulatory frameworks to improve drug safety and quality control.

Research by various healthcare analysts has also highlighted that the complex structure of pharmaceutical supply chains contributes to the difficulty of tracking medicines. Because multiple stakeholders are involved in manufacturing, packaging, distribution, and retailing, maintaining accurate records of product movement becomes challenging. In many cases, insufficient visibility across the supply chain allows counterfeit products to enter the distribution network without detection.

Several researchers have proposed digital tracking systems that use technologies such as barcodes, RFID tags, and electronic product codes to monitor pharmaceutical products. These technologies allow stakeholders to identify and track products throughout different stages of the supply chain. Although these systems improve tracking capabilities, they often depend on centralized databases that can be vulnerable to manipulation, unauthorized access, or system failures.

Recent studies have explored the use of blockchain technology as a potential solution for improving supply chain transparency and security. Blockchain provides a decentralized and tamper-resistant ledger that records transactions across multiple nodes in a network. Each transaction is verified using cryptographic techniques, ensuring that the recorded data cannot be altered without consensus from the network participants. Researchers have suggested that blockchain can enhance trust among stakeholders and improve the traceability of pharmaceutical products.

Some studies have also proposed blockchain-based frameworks for managing healthcare supply chains by integrating smart contracts and decentralized storage systems. Smart contracts automate the verification of transactions and ensure that all participants follow predefined rules when transferring ownership of

pharmaceutical products. This approach reduces the need for intermediaries and improves the reliability of drug tracking systems.

Despite these advancements, many existing systems still lack a comprehensive framework that integrates blockchain technology with the entire pharmaceutical supply chain. Therefore, there is a strong need for a secure and transparent drug tracking system that can monitor pharmaceutical products from raw material suppliers to final delivery to patients. Implementing blockchain-based solutions can significantly improve drug traceability, reduce the risk of counterfeit medicines, and strengthen the overall security of healthcare supply chains.

III. SYSTEM ANALYSIS

EXISTING SYSTEM

Traditional drug tracking systems in healthcare supply chains mainly rely on centralized databases and identification technologies such as barcodes, RFID tags, and electronic product codes to track pharmaceutical products. In these systems, each stakeholder records product information when drugs move from one stage of the supply chain to another. Hospitals, pharmacies, and warehouses scan the product identifiers to verify the drug details stored in a centralized repository.

Although these systems help monitor the movement of drugs, they often lack transparency and security across the entire supply chain. Since the data is stored in centralized systems, it is vulnerable to manipulation, unauthorized access, and system failures. Moreover, the lack of trust among supply chain participants makes it difficult to ensure the authenticity of drug records. As a result, counterfeit medicines may enter the supply chain without proper detection, creating serious risks for patients and healthcare providers.

Disadvantages of Existing System

1. **Lack of Transparency and Trust**
   Centralized systems do not provide full visibility of transactions to all stakeholders, making it difficult to verify the authenticity of drug records.

2. **Vulnerability to Data Manipulation**
   Information stored in centralized databases can be modified, deleted, or tampered with by unauthorized users, compromising the integrity of the supply chain data.

3. **Ineffective Detection of Counterfeit Drugs**
   Traditional tracking technologies alone cannot fully prevent counterfeit medicines from entering the supply chain due to limited verification mechanisms.

PROPOSED SYSTEM

The proposed system introduces a **Secure Drug Tracking System in Healthcare using Blockchain technology**. In this approach, all drug-related transactions are recorded on a decentralized blockchain network where each stakeholder, including suppliers, manufacturers, distributors, pharmacies, and regulators, participates in maintaining the ledger. Every time a drug changes ownership or location, the transaction is recorded as a new block in the blockchain.

Smart contracts are used to automate the validation of transactions and enforce predefined rules within the supply chain. Each drug lot is assigned a unique digital identity that allows it to be tracked from production to final delivery to patients. The blockchain ledger provides a secure, immutable, and transparent record of all transactions, ensuring that drug information cannot be altered once recorded.

Advantages of Proposed System

1. **Enhanced Security and Data Integrity**
   Blockchain ensures that all drug transaction records are tamper-resistant and securely stored across a distributed network.

2. **Improved Traceability and Transparency**
   Every stakeholder can view and verify the history of drug movement across the supply chain, ensuring complete product traceability.

3. **Prevention of Counterfeit Drugs**
   The immutable blockchain ledger and automated verification through smart contracts help detect and prevent counterfeit medicines from entering the supply chain.
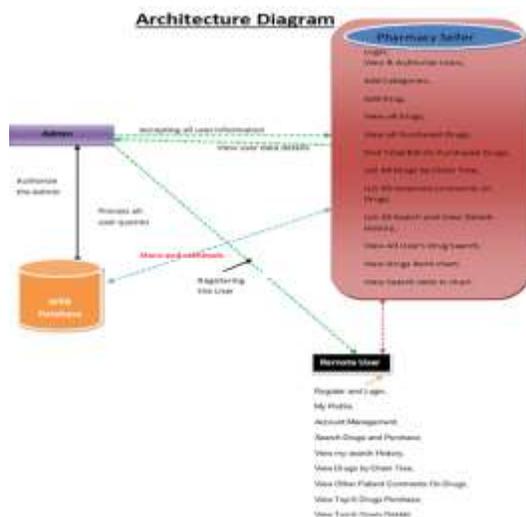
Fig 1: System Architecture

IV.   RESULTS AND DISCUSSION

Experimental Setup

The proposed Secure Drug Tracking System using Blockchain technology was implemented and evaluated to analyze its effectiveness in improving transparency, traceability, and security within the pharmaceutical supply chain. The system was tested by simulating drug transactions among different stakeholders such as suppliers, manufacturers, distributors, pharmacies, and patients. The evaluation focused on verifying the system's ability to record drug movements securely, prevent counterfeit drug entry, and provide complete traceability of pharmaceutical products.

Drug Traceability Evaluation

The blockchain-based system successfully recorded every transaction related to drug movement across the supply chain. Each drug lot was assigned a unique identifier, and all ownership transfers were stored as blockchain transactions. The immutable nature of the blockchain ensured that once data was recorded, it could not be modified or deleted. As a result, stakeholders were able to track the complete history of a drug from its manufacturing stage to its final delivery to the patient. This significantly improved the traceability of pharmaceutical products compared to traditional centralized tracking systems.

Security Analysis

Security analysis showed that the blockchain network effectively prevented unauthorized data modifications. Because the system uses cryptographic hashing and distributed ledger technology, any attempt to alter transaction records would require consensus from multiple network nodes, making unauthorized changes extremely difficult. This mechanism strengthened trust among supply chain participants and ensured the integrity of drug tracking data.

Smart Contract Performance

Smart contracts were implemented to automate the validation and recording of drug transactions. These smart contracts automatically verified participant roles and ensured that only authorized stakeholders could update supply chain records. The automated execution of transactions reduced human intervention and minimized the possibility of manual errors or delays. The smart contracts also generated event notifications whenever ownership of a drug lot changed, allowing stakeholders to monitor the supply chain in real time.

Cost and Efficiency Evaluation

The proposed system demonstrated improved operational efficiency by eliminating the need for intermediaries in the verification process. Blockchain technology enabled direct interaction between supply chain participants, reducing transaction delays and administrative overhead. Although the implementation required initial setup costs for blockchain infrastructure, the long-term benefits of improved transparency, reduced counterfeit risks, and enhanced supply chain management outweighed these costs.

Discussion

The results confirm that blockchain technology can significantly enhance the reliability and transparency of pharmaceutical supply chains. The decentralized ledger ensures secure data storage, while smart contracts automate transaction validation and improve operational efficiency. Compared to traditional drug tracking systems, the proposed solution provides stronger protection against counterfeit medicines and enables real-time monitoring of pharmaceutical products. These improvements contribute to safer healthcare systems and strengthen trust among all stakeholders involved in drug distribution.

V.   CONCLUSION

The pharmaceutical supply chain plays a critical role in ensuring that safe and effective medicines reach patients. However, the increasing presence of counterfeit drugs and the lack of transparency in traditional supply chain systems pose serious risks to public health and the pharmaceutical industry. Conventional drug tracking

systems rely on centralized databases and identification technologies that often fail to provide complete security, traceability, and trust among stakeholders. These limitations make it difficult to detect counterfeit medicines and maintain accurate records of drug distribution.

The proposed Secure Drug Tracking System using Blockchain technology provides an effective solution to these challenges by introducing a decentralized and tamper-resistant framework for monitoring pharmaceutical products. By recording every transaction on a blockchain ledger, the system ensures that drug information is securely stored and cannot be altered without network consensus. The use of smart contracts further enhances the system by automating the validation of transactions and enabling real-time tracking of drug ownership across the supply chain.

The implementation of this blockchain-based system improves transparency, data integrity, and traceability in healthcare supply chains. It enables all stakeholders—including suppliers, manufacturers, distributors, pharmacies, and patients—to verify the authenticity and movement of pharmaceutical products at every stage. This approach significantly reduces the risk of counterfeit drugs entering the market while improving trust and collaboration among supply chain participants.

Overall, the proposed system demonstrates the potential of blockchain technology to transform pharmaceutical supply chain management by providing secure, transparent, and efficient drug tracking mechanisms. Such systems can play an important role in enhancing patient safety, strengthening regulatory compliance, and improving the reliability of healthcare supply networks.

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