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Review on Blockchain Technology for Enhancing Drug Traceability within the Healthcare Supply Chain

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ABSTRACT: Healthcare supply chains are sophisticated networks that traverse organizational and regional borders, serving as the backbone of important services for daily living.Due to their intrinsic complexity, these systems are susceptible to impurities such as incomplete, opaque, and erroneous data sources. One result of these restrictions in the current supply chains is counterfeit medication, which not only poses a major risk to public health but also results in significant financial losses for the healthcare sector. For this reason, previous research has underlined the necessity of a strong, end-to-end track and trace system for pharmaceutical supply chains.
Ensuring product safety and eradicating counterfeits in the pharmaceutical supply chain requires an end-to-end product tracking system. The majority of track and trace systems now in use are centralized, which causes problems with data privacy, authenticity, and openness in healthcare supply chains.

In this paper, we give an Ethereum blockchain-based method for effective product tracing in the healthcare supply chain that makes use of smart contracts and decentralized off-chain storage. The smart contract gives all parties access to a safe, unchangeable history of transactions, ensures the provenance of data, and does away with the need for middlemen. We outline the system architecture and specific algorithms that underpin our suggested solution's operation. We do testing and validation, as well as provide a cost and security analysis of the system to assess how well it works to improve traceability in supply chains for pharmaceuticals.

KEYWORDS: Drug Trace, Blockchain, Counterfeiting, Healthcare, Supply Chain

I. INTRODUCTION

Drug traceability is crucial for individual health and safety, business integrity, and regulatory compliance. Regulations like the U.S. Drug Supply Chain Security Act (DSCSA) highlight the global emphasis on reliable drug tracking systems. However, ensuring the effectiveness of these systems presents challenges that demand innovative solutions. Effective drug traceability requires seamless tracking of medication transactions across the supply chain, providing stakeholders with transparent information on drug provenance and flow. Existing systems often struggle with data integrity, privacy, and efficiency issues, compounded by the complexity of the healthcare supply chain, which increases the risk of counterfeit drugs.

This study proposes a novel approach leveraging blockchain technology to enhance drug traceability. Blockchain's inherent features—transparency, immutability, and decentralization—address the limitations of traditional systems. Our blockchain-based solution aims to advance secure and efficient drug traceability mechanisms, ultimately enhancing patient safety and regulatory compliance in the pharmaceutical industry.

II. LITERATURE REVIEW

1. The literature review provides a comprehensive overview of existing research on blockchain-based solutions for various applications, including IoT data monetization, e-voting security, document version control, pharmaceutical drug traceability, food traceability, and general traceability solutions. These studies highlight the potential of blockchain technology to enhance transparency, security, and efficiency across diverse domains.

2. In the realm of drug traceability, Huang et al. proposed "Drug ledger," a practical blockchain system designed to rebuild service architectures and ensure the authenticity and privacy of traceable data. Similarly, Jamil et al. introduced-a novel blockchain model for managing drug supply chain integrity, demonstrating improved system performance through experiments.

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3. However, challenges persist in achieving scalability and performance in blockchain-based solutions. Khan et al. conducted an in-depth examination of scalability criteria, revealing trade-offs between factors such as block production rate and transaction processing rate.

4. This study aims to contribute to the existing body of research by proposing a blockchain-based solution for drug traceability within the pharmaceutical supply chain. Leveraging Ethereum smart contracts and decentralized storage, our objective is to enhance security, traceability, and accessibility. Additionally, we aim to address scalability challenges and evaluate the performance of our proposed solution through experimentation.

III. OBJECTIVES

1. Propose a blockchain-based solution for the pharmaceutical supply chain that ensures security, traceability, immutability, and accessibility of drug data provenance.
2. Create a smart contract to oversee different transactions between stakeholders in the pharmaceutical supply chain.3. Present, implement, and test the smart contract to demonstrate the working principles of the proposed solution.
4. Analyze costs and security to assess how well the blockchain-based solution works.

IV. METHODOLOGY

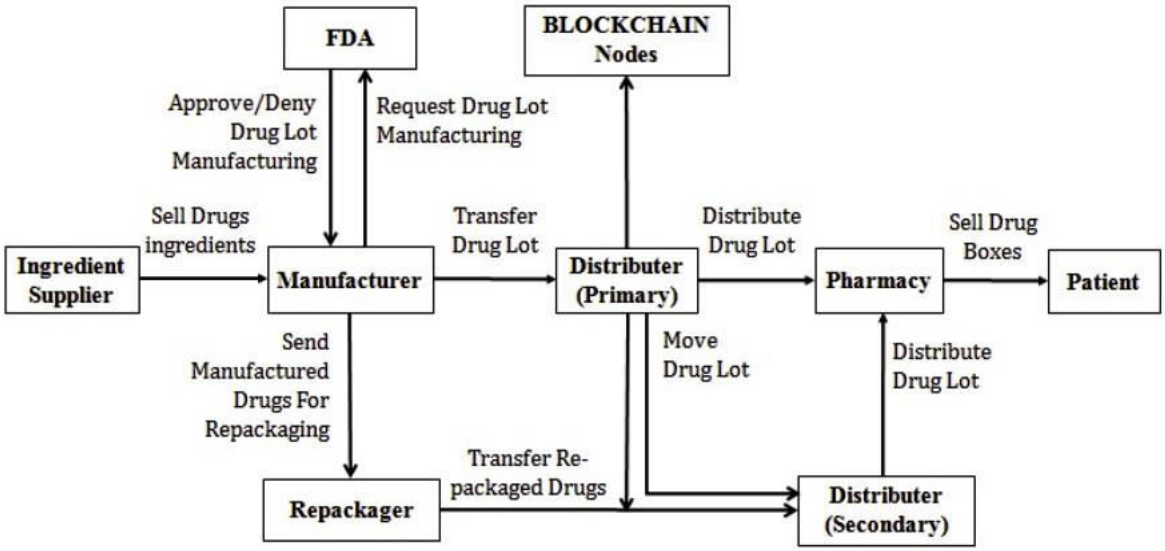

Figure 1: Stakeholders in the Drug Supply Chain and Their Interactions

The ingredient supplier supplies every necessary component needed to make the particular medication. The manufacturer must obtain an authenticated certificate from the FDA (Food and Drug Association) before to beginning production. The manufacturer begins producing the medications following approval. Manufacturer sends drug lot to packager and primary distributor. Repackaged medications are sent to the secondary distributor by the packager, who creates fresh packeging. Hospitals and pharmacies directly get medicine lots from both primary and secondary distributors. Both hospital patients and patrons of pharmacies can be found in the patient block.

FUNCTIONALITY:

This study describes a drug traceability system that uses blockchain and smart contract technology to track pharmaceuticals across the pharmaceutical supply chain. The system's immutability precludes unauthorized manipulation of drug-related data.

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The system functions through four key phases:

1. Deployment of Smart Contracts: To facilitate drug traceability, a self-executing program called a smart contract is introduced onto the blockchain network. The terms and conditions of this contract outline how the system will function, including the creation of distinctive drug codes, the blockchain's storing of drug information, and the verification of the legitimacy of drugs.

2. Registration of Drug by Manufacturer: A drug manufacturer enters the drug's information into the system whenever they produce a new batch of medications. This contains the name of the medication, its batch number, its production date, its expiration date, its price, and any other pertinent data. The batch is then given a unique medication code that is created using chain links or a hashing technique. This code is safely kept on the blockchain and acts as a unique identifier for the batch.

3. Supplier Authentication of the Drug: Using the distinct drug code, a supplier authenticates the drug and confirms its details after receiving the drug consignment from the manufacturer. This guarantees that the drug's legitimacy can be checked at each stage of the distribution network.

4. End User Access to Drug Details: By going to the appropriate portal and entering the unique drug code, an end user can quickly and simply obtain the details of a drug they want to confirm. They can access and examine the drug's information that has been stored on the blockchain by entering the code. Every drug unit has a unique drug code printed on it so that customers can verify the authenticity of the product they have bought.

5. The application of smart contract and blockchain technology provides a creative answer to the problem of medication traceability, guaranteeing that every stage of the pharmaceutical supply chain may be tracked and validated. Additionally, the system offers improved transparency and security, which is advantageous to both manufacturers and customers.

V. CONCLUSION

Our conclusion into the issue of drug traceability in pharmaceutical supply chains indicated that, blockchain technology has the potential to address challenges in healthcare and related businesses. The availability, decentralised nature, security, integrity, and authentication principles provided by the global ledger are the most extensively studied applications of blockchain technology. Blockchain technology has significant potential in healthcare due to its key qualities. When tested, the application improved transparency in identifying the distributor, supplier, or manufacturer of a drug. Blockchain technology enables traceability, leading to this improvement.

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