Blockchain for Pharmaceutical Supply Chain Integrity: A Decentralized Approach to Combat Counterfeit Drugs

Abstract: Ensuring the safety, legitimacy, and integrity of drugs throughout the pharmaceutical supply chain is a critical challenge. Issues such as counterfeit drugs, mishandling, and a lack of transparency pose severe health risks to consumers. Traditional supply chain systems, reliant on paper-based documentation and fragmented digital solutions, struggle to provide real-time tracking and regulatory compliance. This inefficiency increases the chances of counterfeit drugs entering the market, creating obstacles for regulators and healthcare providers in maintaining drug safety and authenticity.

This project introduces a blockchain-powered solution that establishes a secure, decentralized, and transparent ledger for pharmaceutical supply chain management. By leveraging blockchain technology, the system records every transaction in an immutable and tamper-proof manner, ensuring drug traceability from raw material sourcing to final retail distribution. Smart contracts automate verification at each stage, minimizing human errors and preventing fraudulent activities. Integrating tools like Ganache for blockchain simulation and MetaMask for account management, the system enables seamless interactions between manufacturers, distributors, retailers, and regulators. Additionally, an ID-based authentication mechanism ensures only authorized users can access the platform, enhancing security and data integrity.

The proposed methodology involves designing a blockchain-based drug tracking system that securely records and verifies each transaction in the supply chain. The system consists of multiple components, including a user-friendly interface for seamless navigation, an authentication module for access control, and a blockchain database for storing drug movement records. Key stakeholders—such as raw material suppliers, manufacturers, distributors, and retailers—interact with the system to register and verify drug authenticity at every stage. By implementing Ethereum smart contracts and exploring the Hyperledger Fabric framework for permissioned networks, this approach ensures real-time monitoring, regulatory compliance, and operational efficiency. This blockchain-driven solution significantly enhances transparency, prevents counterfeit drugs, and fosters trust in the pharmaceutical industry.