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International Journal on Advanced Computer Theory and Engineering

ISSN: 2319-2526
Volume 14 Issue 01, 2025

Blockchain-Based Framework for Transparent, Immulate and Secure Vaccine Supply Chains

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Peer Review Information

Submission: 15 Feb 2025
Revision: 23 March 2025
Acceptance: 27 April 2025

Keywords

Blockchain
Pharmaceutical Supply Chain
Smart Contracts

Abstract

This project uses blockchain technology to make the pharmaceutical supply chain safer and more transparent. It helps stop counterfeit (fake) drugs by recording every step — from raw materials to the patient — in a secure, unchangeable way. Today's supply chains have many problems like lack of information sharing, complex processes, and too much central control, which makes it easier for fake drugs to enter the market. According to the World Health Organization, fake medicines cause many deaths, especially among children, and cost the industry a lot of money.
Our solution uses smart contracts to track and verify each step of the drug's journey. We designed a system with detailed architecture, diagrams, and algorithms to show how it works. Testing shows that our blockchain system is secure, easy to scale, and can be used in different pharmaceutical supply chains to ensure drug authenticity and safety

INTRODUCTION

This project introduces a blockchain system to improve how we track and verify medicines in the supply chain. It uses smart contracts and decentralized storage to make the drug journey clear and trustworthy, without depending on central authorities. This helps prevent fake medicines from reaching patients.
Today's pharmaceutical supply chain is complicated, involving many people like sup pliers, manufacturers, distributors, pharmacies, hospitals, and patients. Because of poor communication and too much central control, counterfeit drugs can easily get into the sys tem. In some poor countries, up to 30Our blockchain solution solves these issues by making every step in the supply chain recorded permanently and openly. It uses smart contracts and tracking algorithms to check the history of each drug. Testing shows that the system improves traceability, increases trust among participants, and can be used for different types of medicines worldwide

Key Features of the System:

- Blockchain-Enabled Traceability

- Data Integrity and Security
- Real-Time Tracking
- Smart Contracts for Automation
- Counterfeit Prevention
- Transparency for Stakeholders
- Decentralized Data Access

LITERATURE SURVEY

1. Blockchain Technology for Pharmaceutical Supply Chains
According to authors Kshetri and Voas (2018), blockchain offers an immutable ledger to track pharmaceutical products, preventing counterfeit drugs and improving transparency. Existing systems struggle with data sharing across stakeholders, but blockchain enhances trust and traceability. Future scope involves integrating IoT sensors for real-time condition monitoring and regulatory compliance. [1]

2. A Blockchain-Based Framework for Vaccine Supply Chain Transparency
Smith et al. (2021) propose a blockchain architecture to address vaccine traceability challenges during COVID-19 vaccine distribution. The study highlights data tampering risks in traditional systems and uses smart contracts to enforce cold chain conditions. Future work aims at improving scalability and integrating with national health databases. [2]

3. Enhancing Cold Chain Integrity Using Blockchain and IoT
Patel and Kumar (2020) focus on maintaining vaccine efficacy by tracking temperature conditions using IoT sensors connected to blockchain ledgers. The framework records immutable temperature logs accessible to regulators and manufacturers. Future improvements include AI-driven anomaly detection and predictive maintenance. [3]

4. Smart Contracts for Automated Compliance in Vaccine Distribution
Chen et al. (2022) examine how smart contracts can automate regulatory compliance checks in vaccine supply chains, reducing human error and fraud. The study showcases a prototype deployed on Ethereum and discusses challenges like transaction costs and network latency. Future research could optimize contract execution and interoperability. [4]

5. Blockchain for Counterfeit Detection in Pharmaceutical Supply Chains
Lee and Park (2019) address counterfeit drug problems by applying blockchain for product authentication at each supply chain step. Their approach uses QR codes linked to blockchain records, allowing end-users to verify authenticity. The future scope involves integrating AI to detect suspicious transactions. [5]

6. Distributed Ledger Technology for Healthcare Supply Chain Security
Garcia et al. (2020) discuss distributed ledger benefits for securing healthcare logistics beyond vaccines, including medical devices and diagnostics. The paper highlights privacy concerns and proposes encryption mechanisms to protect sensitive data. Future work includes scalable permissioned blockchains tailored for healthcare. [6]

7. Real-Time Vaccine Supply Chain Monitoring Using Blockchain and Edge Computing
Zhang and Wang (2023) combine blockchain with edge computing to enable faster, localized data processing for vaccine tracking. This reduces latency in verifying shipment conditions and enables immediate alerts. The future direction includes AI-enabled decision-making to optimize logistics. [7]

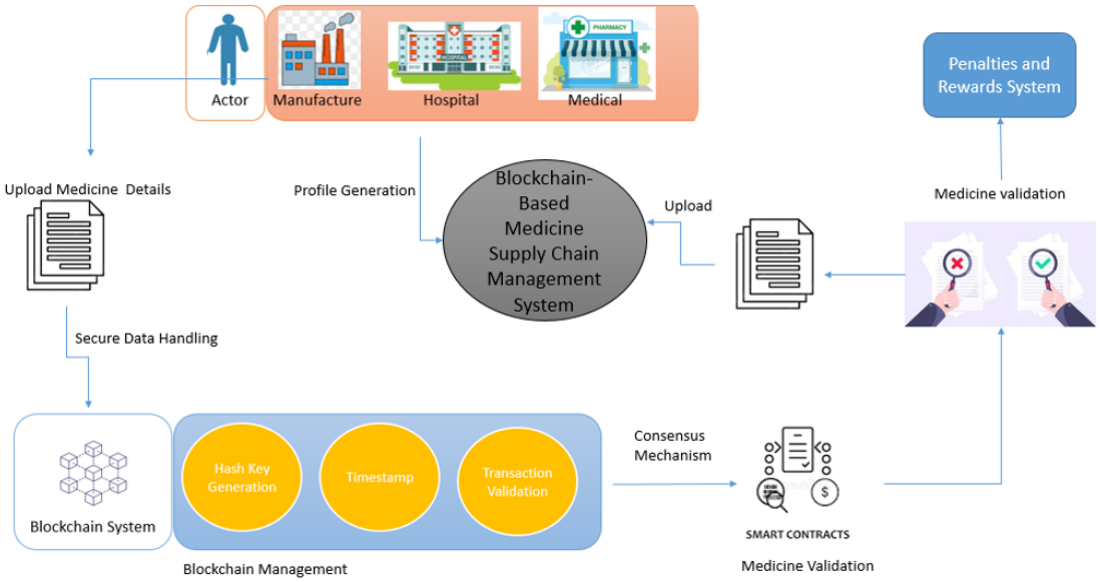
8. Privacy-Preserving Blockchain Frameworks for Medical Data Sharing
Nguyen et al. (2021) focus on balancing transparency and patient privacy in blockchain-based healthcare supply chains. They propose zero-knowledge proofs and selective disclosure techniques to secure sensitive information. Future research aims at enhancing usability and regulatory compliance. [8]

9. Blockchain-Enabled Traceability in Global Vaccine Supply Chains
Kumar et al. (2022) present a cross-border vaccine tracking system leveraging blockchain to overcome jurisdictional data silos. The platform improves cooperation between governments and manufacturers. Future improvements involve policy standardization and integration with international logistics networks. [9]

10. AI and Blockchain Integration for Fraud Detection in Pharmaceutical Logistics
Singh and Sharma (2024) explore combining blockchain's immutability with AI models to detect anomalous patterns indicating fraud or supply chain disruptions. The system improves proactive response capabilities. Future scope includes expanding datasets and refining AI algorithms for better accuracy. [10]

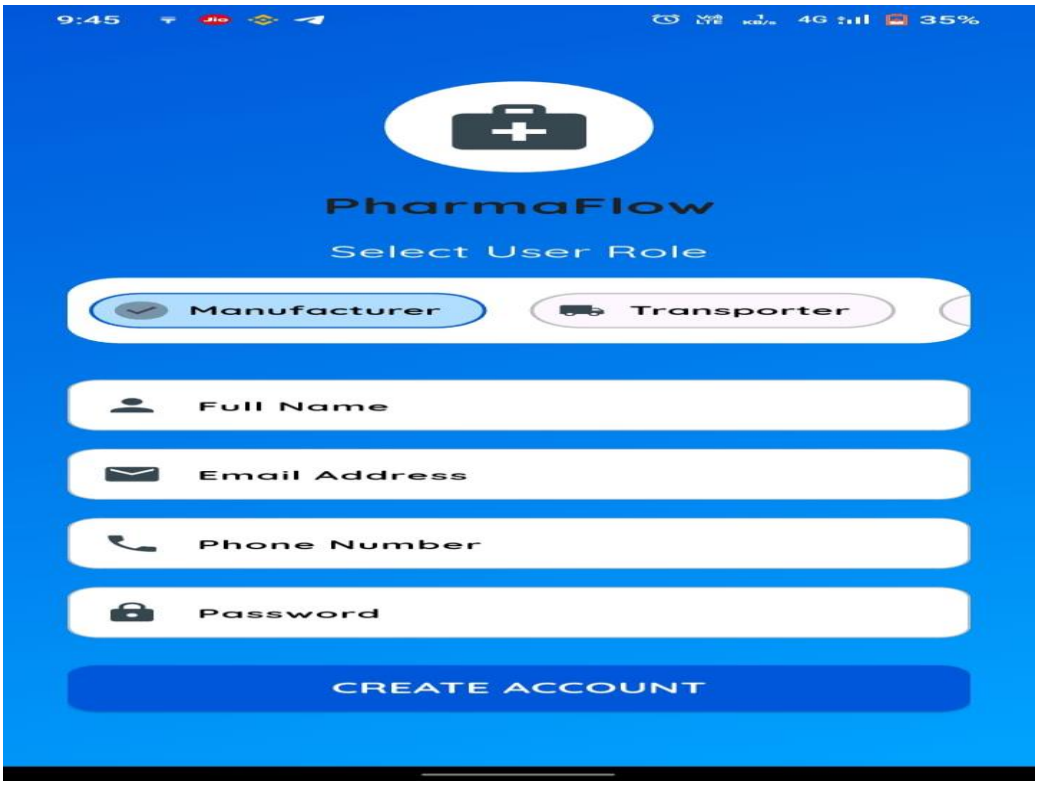
Limitations of existing system:
- High Setup Cost: Building and starting a blockchain system can be expensive.
- Technical Knowledge Needed: Users and companies must understand how to use blockchain, which can be hard for some.
- Slow Transactions: Sometimes blockchain networks can be slow, especially when many people use them at once.
- Data Privacy Concerns: Everyone on the network can see the data, so protecting private information can be tricky.

SYSTEM ARCHITECTURE



The proposed blockchain-based system improves the security and transparency of the phar maceutical supply chain by tracking each stage of a drug's journey—from raw material suppliers to patients. Using smart contracts and decentralized storage, the system records every transaction on an immutable ledger, ensuring that data cannot be tampered with. This removes the need for middlemen and allows all stakeholders to access the same trusted information. As products move through the supply chain, their details are automatically verified and recorded, helping prevent counterfeit drugs and ensuring compliance with safety standards. The system is scalable and can be applied to various pharmaceutical products, making the supply chain more efficient, secure, and trustworthy.

RESULTS/OUTPUT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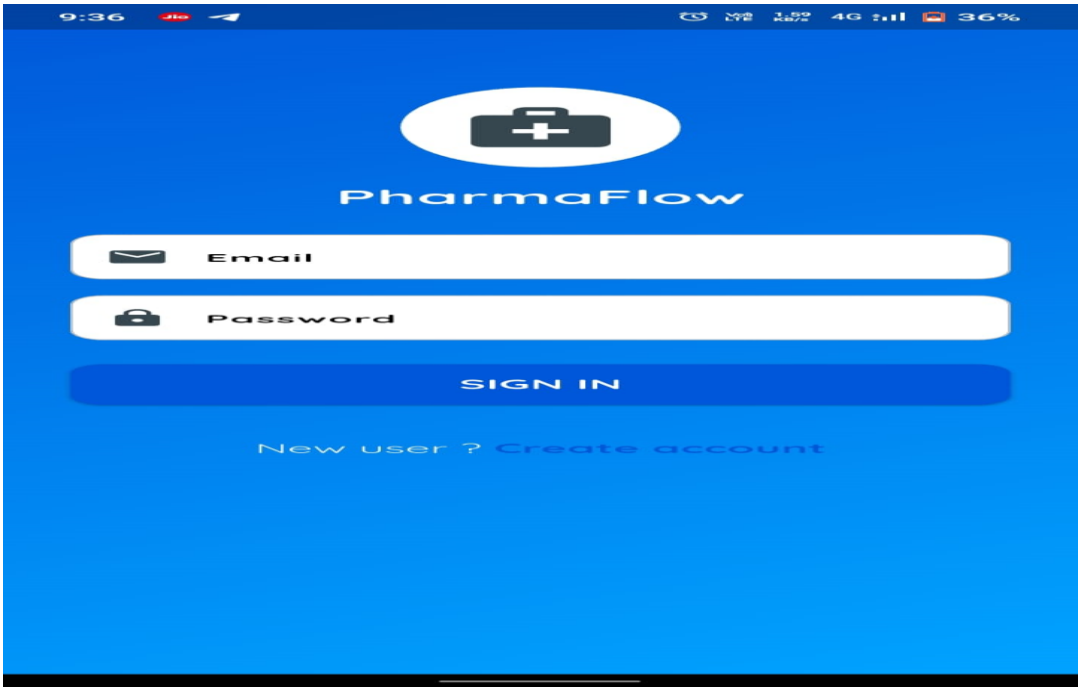
PharmaFlow
Select User Role
Manufacturer
Transporter
Full Name
Email Address
Phone Number
Password
CREATE ACCOUNT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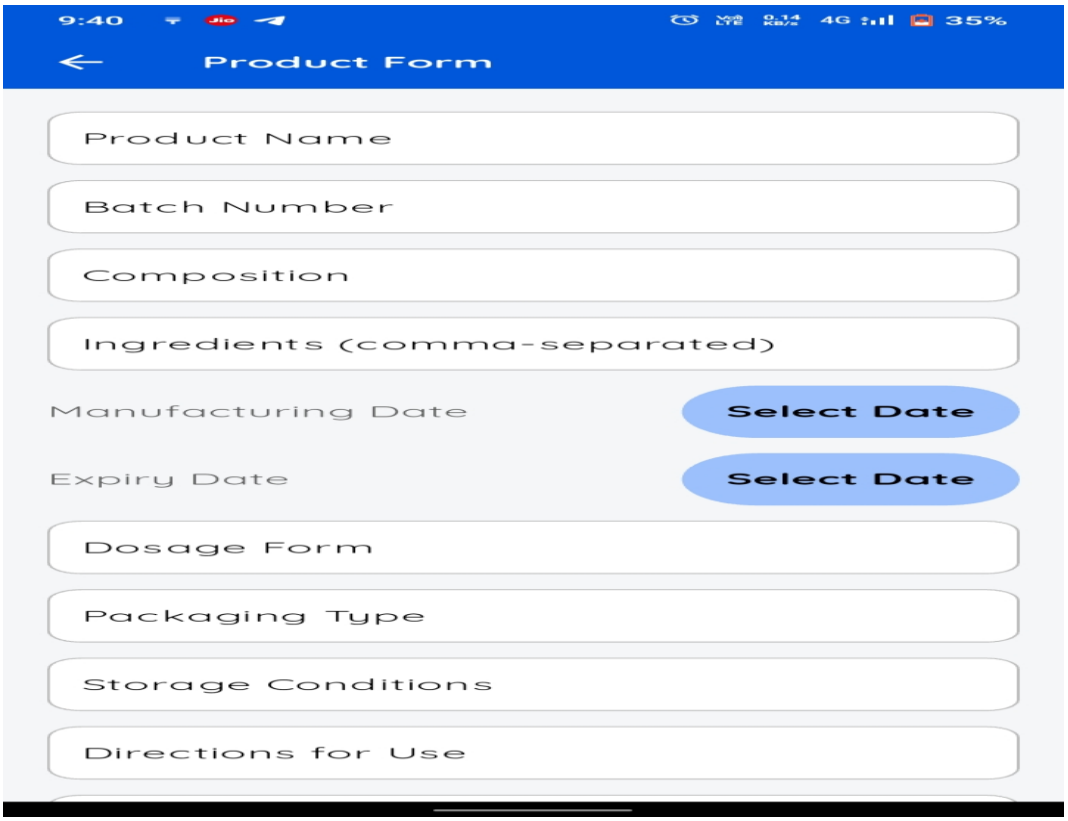
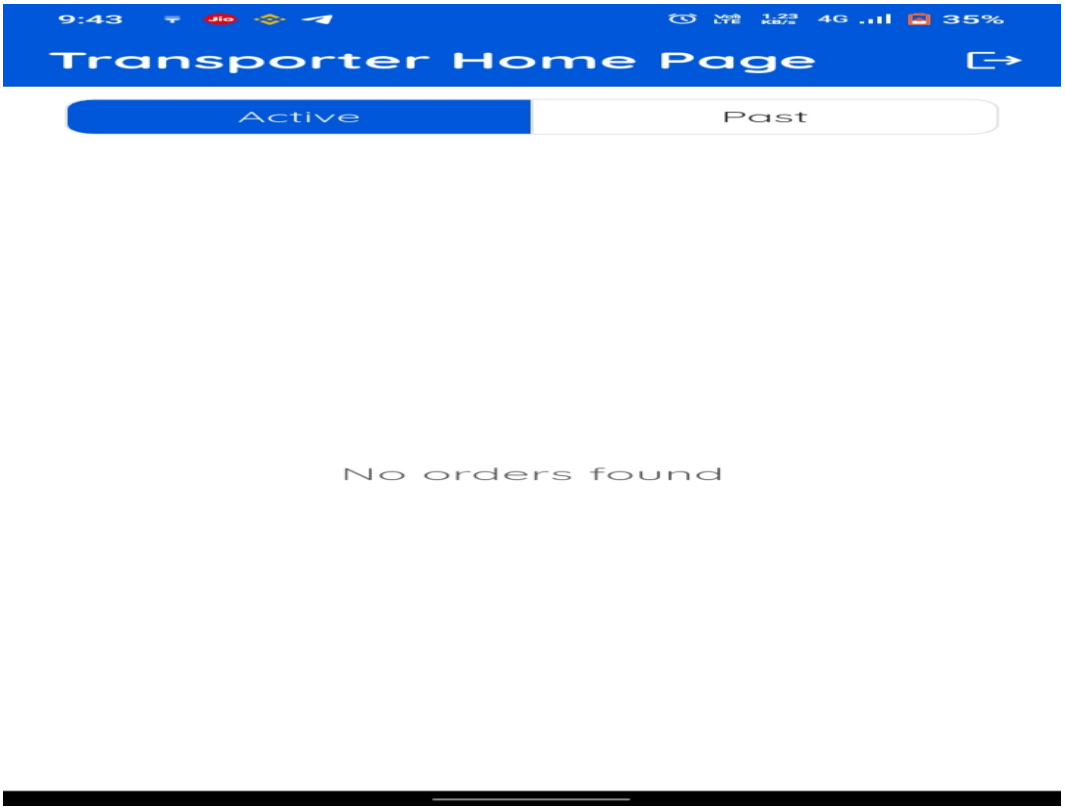
PharmaFlow
Email
Password
SIGN IN
New user ? Create account





CONCLUSION

The proposed blockchain-based system improves the security and transparency of the phar maceutical supply chain by tracking each stage of a drug's journey—from raw material suppliers to patients. Using smart contracts and decentralized storage, the system records every transaction on an immutable ledger, ensuring that data cannot be tampered with. This removes the need for middlemen and allows all stakeholders to access the same trusted information. As

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