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Privacy Preserving Pharmaceutical Drug Tracking for Consumers using Blockchain

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Abstract: Ensuring the authenticity and safety of pharmaceutical drugs is a critical challenge in today's healthcare system, where counterfeit medicines and lack of transparency can pose serious risks to consumers. This project presents a privacy-preserving pharmaceutical drug tracking system using blockchain technology, designed to enhance trust, security, and traceability across the supply chain. The system integrates blockchain with modern technologies such as IoT and cloud computing to monitor drug movement from manufacturers to end users in a secure and tamper-proof manner. Each transaction is recorded as an immutable block, ensuring that data cannot be altered or manipulated, thereby preventing the circulation of counterfeit drugs. The proposed system tracks key information such as drug origin, manufacturing details, storage conditions, and distribution history, while maintaining user privacy through secure cryptographic mechanisms. Smart contracts are used to automate verification processes and ensure that only authorized participants can access or update the data. Additionally, the system enables real-time monitoring and efficient inventory management, allowing stakeholders to make informed decisions and respond quickly to potential issues. A key advantage of this approach is its ability to provide consumers with transparent and verifiable information about the medicines they purchase, improving confidence and safety. By combining decentralization, security, and automation, the system minimizes fraud, enhances accountability, and streamlines operations within the pharmaceutical supply chain. Overall, this project demonstrates how blockchain technology can be effectively utilized to create a reliable, secure, and consumer-centric drug tracking solution, ultimately contributing to improved public health outcomes and trust in the healthcare ecosystem.

Keywords: Blockchain Technology, Pharmaceutical Supply Chain, Drug Traceability, Privacy Preservation, Smart Contracts, Counterfeit Drug Detection, Decentralized System, IoT Integration, Secure Data Sharing, Transparency, Data Integrity, Real-Time Tracking, Consumer Safety, Cryptographic Security, Healthcare Technology.

I. INTRODUCTION

The pharmaceutical industry plays a crucial role in public health but faces major challenges such as counterfeit drugs, lack of transparency, and inefficient tracking systems. Fake or substandard medicines in the supply chain can cause serious health risks and reduce consumer trust. Traditional tracking systems are often centralized, making them vulnerable to data tampering and delays. Therefore, a secure and transparent solution is required.

This project proposes a Privacy Preserving Pharmaceutical Drug Tracking System using Blockchain to improve drug safety and reliability. Blockchain provides a decentralized and tamper-proof platform where all transactions are securely recorded, ensuring complete traceability of drugs from manufacturers to consumers.

The system integrates IoT and cloud technologies for real-time monitoring of drug movement and storage. Smart contracts automate validation and restrict access to authorized users, while privacy techniques protect sensitive data.

The web-based frontend, built with HTML and JavaScript, allows users to verify drug authenticity and track product details efficiently.

II. LITERATURE SURVEY

The pharmaceutical supply chain has been extensively studied due to increasing concerns about counterfeit drugs and lack of transparency. Traditional drug tracking systems rely on centralized databases and manual record-keeping, which are often vulnerable to data manipulation, inefficiencies, and limited accessibility for consumers. These challenges highlight the need for more secure and reliable tracking mechanisms. In recent years, researchers have explored the use of blockchain technology to improve drug traceability and supply chain transparency. Blockchain provides a decentralized and immutable ledger that ensures secure recording of transactions.

Several studies have focused on integrating blockchain with Internet of Things (IoT) devices to enable real-time monitoring of drug storage conditions such as temperature and humidity. This helps maintain drug quality during transportation.

Some research works have implemented smart contracts to automate verification processes and ensure that only authorized participants can update supply chain data. Other studies have emphasized privacy-preserving techniques, such as encryption and permissioned blockchain networks, to protect sensitive information. While these approaches show promising results, many systems still face challenges in scalability, cost, and seamless integration with existing infrastructure.

III. PROPOSED METHODOLOGY

A. System Architecture

The system architecture is divided into three main layers: Presentation Layer, Application Layer, and Data Layer.

The Presentation Layer consists of a web-based frontend developed using HTML and JavaScript. It allows users such as manufacturers, distributors, and consumers to register, log in, and interact with the system. Users can add drug details, track product movement, and verify the authenticity of medicines through a simple and user-friendly interface.

The Application Layer is handled by blockchain integration and supporting backend logic. It manages communication between the frontend and the blockchain network using Web3 libraries. This layer is responsible for executing smart contracts, processing transactions, validating user actions, and ensuring secure interaction with the decentralized system. It also integrates IoT data for monitoring storage conditions during transportation.

The Data Layer consists of the blockchain network and off-chain storage systems. The blockchain securely stores transaction records in an immutable format, while additional data such as logs or reports can be stored in cloud databases. Encryption and access control mechanisms are applied to ensure privacy and data security.

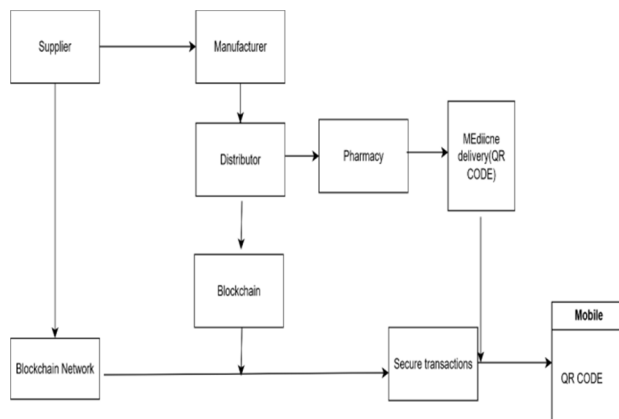


Figure 1: System Architecture

B. Proposed system

The proposed system is a web-based Privacy Preserving Pharmaceutical Drug Tracking platform developed to ensure safe and transparent monitoring of medicines across the supply chain. It uses blockchain technology to securely record and verify each transaction, preventing the circulation of counterfeit drugs. The system focuses on tracking key details such as drug origin, manufacturing information, distribution stages, and storage conditions to ensure product authenticity and quality.

The process begins with user registration for stakeholders such as manufacturers, distributors, and consumers. Manufacturers add drug details to the system, which are then recorded on the blockchain. As the product moves through the supply chain, each participant updates its status, creating a complete and traceable history. Consumers can scan or enter product details to verify authenticity and view the journey of the medicine.

A detailed record of each transaction is maintained in a tamper-proof format, ensuring transparency and trust. Privacy-preserving techniques are applied to protect sensitive data. The system acts as a reliable tool to improve drug safety and does not replace regulatory authorities.

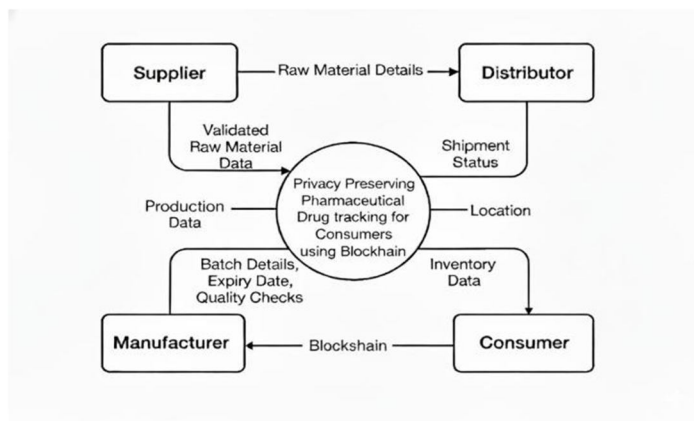


Figure 2: Proposed System

IV. RESULTS AND DISCUSSION

The proposed system was developed to track pharmaceutical drugs and ensure their authenticity using a blockchain-based approach. The system was implemented and tested across different stages of the supply chain. The results showed that the decentralized approach improved transparency and security compared to traditional centralized systems. The system successfully recorded and verified each transaction related to drug movement, demonstrating its effectiveness in preventing counterfeit drugs and ensuring reliable tracking for consumers.

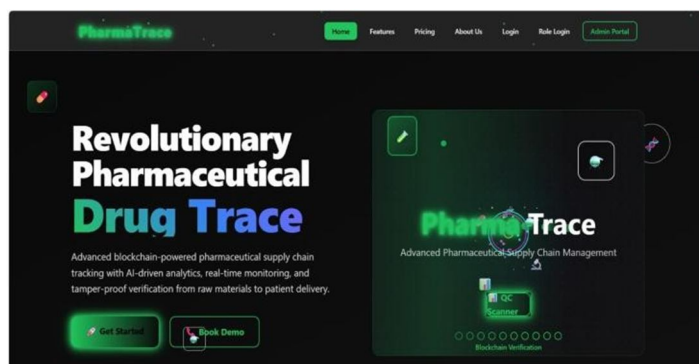


Figure 3.1: Home Page

The above Home page image represents a section of a web-based interface that appears to combine product browsing with a blockchain-enabled application. The upper portion shows a commercial product page with options like viewing features and watching a product video, along with promotional banners and category rankings. Below, the interface transitions into a blockchain-related system featuring options such as “Get Started” and “Book Demo.” A visual scanner element labelled blockchain verification is also present, indicating a feature used to verify product authenticity. The design highlights integration between e-commerce and blockchain technology for secure product validation and enhanced user interaction experience.

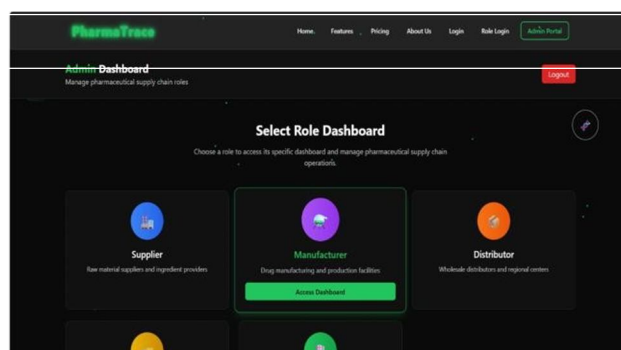


Figure 3.2: Admin portal

The Admin portal image represents a visual section of a digital interface with abstract and layered graphical elements. It appears to show overlapping shapes and textures in dark tones combined with lighter shades, possibly indicating a stylized background or a dynamically rendered UI component. The irregular patterns and pixel-like edges suggest either a design effect or a rendering distortion while loading content. Such visuals are often used in modern web applications to enhance user experience or indicate transitions and processing states. In the context of a system interface, this could represent a background animation, data visualization layer, or a temporary display while information is being fetched or processed from the system backend. Additionally, it may reflect real-time updates or system activity, giving users a sense of responsiveness and interaction within the application environment.

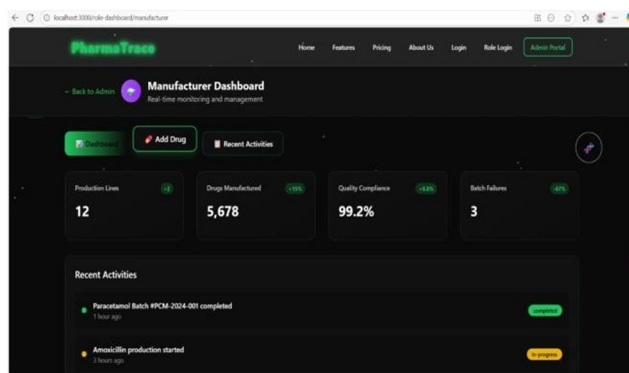


Figure 3.3: Manufacturer Dashboard

The Manufacturer dashboard image represents the Manufacturer Dashboard of the Pharma Trace system, designed for real-time monitoring and management of pharmaceutical production activities. It provides an overview of key metrics such as the number of production lines, total drugs manufactured, quality compliance percentage, and batch failures. The dashboard includes navigation options like Dashboard, Add Drug, and Recent Activities, allowing users to efficiently manage operations. A section displaying recent activities shows updates such as completed batches and ongoing production processes with status indicators. The interface is visually organized with a dark theme and clear layout, enabling manufacturers to track performance, maintain quality standards, and ensure efficient workflow within the pharmaceutical supply chain system.

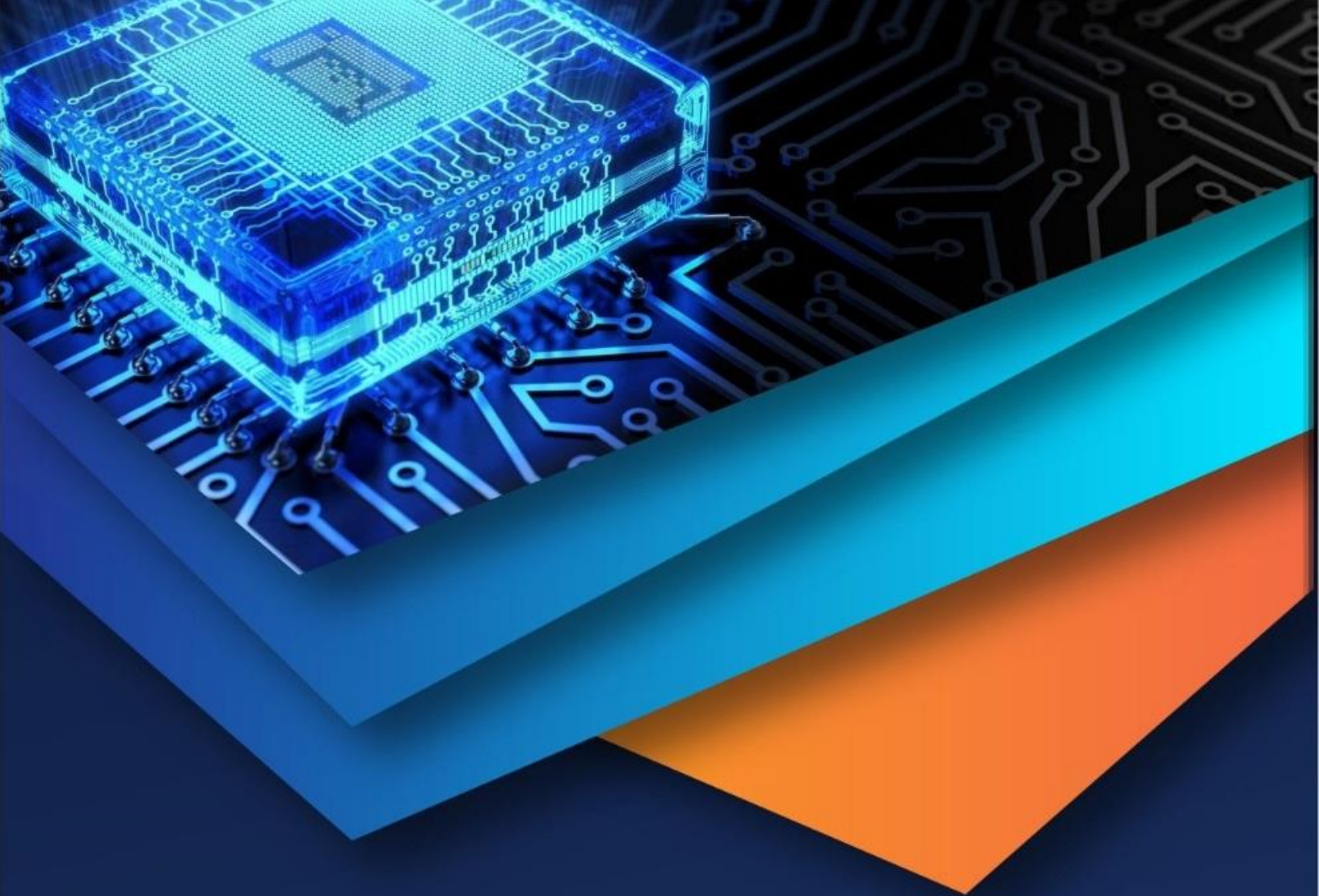
V. CONCLUSION

This project presents a practical and user-friendly system for privacy preserving pharmaceutical drug tracking using blockchain technology. The system ensures secure and transparent monitoring of drugs across the supply chain by recording every transaction in an immutable and decentralized manner. By enabling stakeholders to update and verify product details in real time, the platform simplifies the process of drug tracking and enhances trust among all participants.

In addition to tracking, the system provides verification features that allow consumers to check the authenticity and origin of medicines, helping prevent the use of counterfeit drugs. The integration of blockchain, smart contracts, and web-based interfaces makes the system efficient and easy to use. Although it does not replace regulatory authorities, it acts as a supportive tool that improves accountability and transparency. Overall, the project demonstrates how blockchain technology can be effectively applied to strengthen pharmaceutical supply chains and ensure consumer safety.

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