RAMAIAH
Institute of Technology

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
(ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)
and
COMPUTER SCIENCE AND ENGINEERING
(CYBER SECURITY)

CIP67/CYP67
TERM: March-June 2024

MINI PROJECT
Pharmaceutical Products Supply Chain Management Using Blockchain

Submitted to
Dr. Mohana Kumar S and Mrs. Shankaramma

TEAM MEMBERS

Sl. No	USN	Name
1.	1MS21CY010	ANU S M
2.	1MS21CY028	M CHAITHRA
3.	1MS22CY402	MEGHANA K
4.	1MS22CI404	SANVI H R

M.S. RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)

RAMAIAH
Institute of Technology

Table of Contents

RAMAIAH Institute of Technology

1. PROJECT ORGANIZATION

1.1 Software Process Models

The Agile software development methodology is a fitting choice for the Supply-Chain-Dapp project, seamlessly aligning with its dynamic nature and evolving requirements. By adopting Agile principles, our team will embrace iterative development cycles, allowing for continual refinement and adaptation. This approach facilitates transparent collaboration among stakeholders, ensuring that feedback is integrated efficiently and effectively. Agile promotes flexibility, enabling us to respond adeptly to changing market demands and technological advancements throughout the project lifecycle. With a focus on delivering incremental value and fostering continuous improvement, the Agile methodology serves as a robust framework for the successful development and deployment of the Supply-Chain-Dapp solution.

1.2 Roles and Responsibilities

ROLES	RESPONSIBILITY
Project Lead	Plans and oversees the project's progress, ensuring it stays on schedule and meets quality standards.
Blockchain Developer	Writes, tests, and optimizes smart contracts using Solidity, ensuring secure and efficient blockchain transactions.
Frontend Developer	Designs and implements user interfaces for the DApp using HTML, CSS, and JavaScript frameworks, ensuring an intuitive and responsive user experience.
Backend Developer	Develops and integrates server-side logic and APIs for interaction with the blockchain, ensuring smooth and efficient communication between the frontend and the blockchain backend.

2. LITERATURE SURVEY

2.1 Introduction

The pharmaceutical supply chain plays a critical role in ensuring the safe and timely delivery of drugs to patients. However, this complex network is often plagued by challenges such as counterfeit drugs, lack of visibility, and inefficient tracking mechanisms. In recent years, there has been growing interest in leveraging emerging technologies like blockchain, Internet of Things (IoT), and RFID to address these issues and enhance the security and transparency of pharmaceutical supply chains.

This literature review examines several research papers that propose innovative solutions to improve pharmaceutical supply chain management using blockchain and other technologies. These papers aim to tackle the challenges of counterfeit drugs, lack of traceability, and trust issues within the supply chain. By analyzing the methodologies, limitations, and suggestions for improvement outlined in these papers, this review aims to provide insights into the current state of research and identify areas for future exploration and development.

2.2 Related Works with the citation of the References

Table 2.3 Summary of Literature review

Author(s)	Paper Title	Methodology Used (Existing Approach)	Gap Analysis (Limitations and suggestions to improve/novelty)
Agya Pathak, Sameer Shrivastava, Palempati Harsha Vardhini, Abhinay Meka, Divesh Swami, Zakir Hussain, Malaya Dutta Borah	Blockchain Technology in Pharmaceutical Supply Chain Management	The authors proposed a system that utilizes blockchain technology to secure the pharmaceutical supply chain. They designed smart contracts and deployed them on a local blockchain using Ganache, aiming to make the supply chain tamper-proof and ensure the safe and traceable supply of pharmaceuticals.	The paper identifies the current challenges in detecting tampering and unethical practices within the pharmaceutical supply chain. It suggests that blockchain technology can address these issues by providing a more secure environment. However, the paper does not detail specific limitations or suggestions for improvement within the proposed system itself
Mahsa Dashtizadeh, Fatemeh Meskaran, David Tan	A Secure Blockchain-based Pharmaceutical Supply Chain Management	The paper proposes a blockchain-based system to enhance the security of the pharmaceutical supply chain.	The paper identifies a lack of visibility, traceability, and security in the current pharmaceutical supply chain as key issues.

	System: Traceability and Detection of Counterfeit Covid-19 Vaccines	It suggests the use of a permissioned blockchain to store transactions, with only trusted parties having the permission to add data.	It suggests that blockchain technology can mitigate these issues by adding transparency and secure tracking of drug movement. year 2022
Deluwar Hussen Tanvir, Mohammad Shamsul Islam, Ruhul Amin, Ashraful Islam, Muhammed Mamunur Rashid	Blockchain Interoperability for a Reputation-Based Drug Supply Chain Managemen	The paper examines how blockchain technology can be used to create a reputation-based system for drug supply chain management. The system aims to enhance trust, transparency, and reliability in the supply chain by tracking drugs and assessing the reputation of supply chain participants.	Challenges include achieving interoperability between different blockchain networks and managing their complexity. Suggestions include developing standardized protocols for interoperability and fostering collaboration among regulatory authorities and industry players to overcome legal and regulatory barriers.
Laveesh Gupta, Manvendra Bansal, Muskan Gupta, Nishit Khaitan, Meeradevi	Blockchain Based Solution to Enhance Drug Supply Chain Management for Smart Pharmaceutical Industry	The paper presents a blockchain-based solution for enhancing drug supply chain management. The solution utilizes the Hyperledger Fabric framework, chosen for its modular design, high efficiency, quality code, and open-source nature. The approach aims to trace and track drugs during transit, provide transparency, and ensure legitimacy across the supply chain. It offers a reliable certification process and QR code generation/scanning for easy accessibility, security, and reliability.	The paper does not specify particular limitations, but potential challenges in blockchain adoption could include scalability and the integration of different systems. Suggestions for improvement might involve ongoing collaboration with stakeholders to ensure compatibility and continuous innovation to maintain efficiency and address emerging challenges. year 2022
Mohammad Zayd, Arpit Johari, M. Manimozhi	Supply Chain Management using Blockchain and IoT	Utilized blockchain and IoT technologies to monitor pharmaceutical	Limitations: High cost, integration challenges with current systems, trade-offs

	in Pharmaceutical Industries	products in real-time, ensuring data integrity and security. Smart contracts automated supply chain processes.	between security and performance, decentralization, and scalability. Suggestions to Improve/Novelty: Address cost concerns through optimization, focus on seamless integration, explore solutions balancing security and performance, enhance decentralization and scalability.
Kumareshan N, Prasanna T, Navin Venkatesh K, Prasanna K, Manoj K, Kamaleshwaran L	Implementation of an Anti-counterfeit Pharmaceutical Supply Chain System	Developed an IoT and RFID technology-based system for tracking and monitoring drug transportation from manufacturer to retailer. Real-time tracking of location and status aimed at preventing counterfeit drugs.	Limitations: May face challenges in implementation due to costs and infrastructure requirements. Suggestions to Improve/Novelty: Explore cost-effective solutions, consider scalability for different sizes of pharmaceutical companies, and ensure interoperability with existing systems.

2.3 Conclusion of Literature Survey

The literature review highlights the growing interest in utilizing blockchain and other emerging technologies to address the challenges in pharmaceutical supply chain management. These technologies offer promising solutions to enhance transparency, traceability, and security within the supply chain, ultimately ensuring the safe and efficient delivery of pharmaceutical products to end-users.

However, several limitations and challenges remain to be addressed. These include high implementation costs, interoperability issues between different blockchain networks, scalability concerns, and the need for seamless integration with existing systems. Future research should focus on overcoming these challenges by developing cost-effective solutions, standardized protocols for interoperability, and innovative approaches to enhance decentralization and scalability.

Overall, the findings of this survey underscore the importance of continued research and collaboration among industry stakeholders, regulatory authorities, and academia to realize the full potential of blockchain and other technologies in transforming pharmaceutical supply chain management.

3. SOFTWARE REQUIREMENT SPECIFICATIONS

3.1 Purpose

- Develop a decentralized application (Dapp) leveraging blockchain technology to enhance supply chain management efficiency in the pharmaceutical industry.
- Utilize smart contracts deployed on the Ethereum blockchain to facilitate transparent and secure transfer of pharmaceutical products from manufacturers to customers via online e-commerce platforms.
- Streamline supply chain operations by reducing administrative overhead and minimizing paperwork associated with traditional management processes.
- Establish a trusted and auditable record of product transactions, ensuring accountability and traceability across the supply chain ecosystem.
- Improve transparency, integrity, and trust among stakeholders involved in the pharmaceutical supply chain by revolutionizing traditional management practices.

3.2 Project Scope

The scope of the Supply Chain Management project encompasses the development of a decentralized application (Dapp) leveraging blockchain technology to optimize supply chain operations within the pharmaceutical industry. This includes the creation of smart contracts to model key roles and stages involved in the supply chain, along with the implementation of functionalities to store and manage information about pharmaceutical products. The project aims to enhance transparency, efficiency, and security throughout the supply chain process, from raw material sourcing to product distribution. Non-functional aspects such as security, performance, usability, and scalability will also be addressed to ensure the robustness and reliability of the application. It is important to note that while the project focuses on digital management and tracking of pharmaceutical products, it does not encompass physical logistics or regulatory compliance aspects, which may vary depending on jurisdiction.

3.3 Overall description

3.3.1 Product perspectives

- **Identification and Description**: Each pharmaceutical product within the supply chain will be identified by unique attributes such as product name, description, batch number, and serial number.

- **Lifecycle Management:** The smart contract will facilitate tracking of the product lifecycle, including stages such as production, distribution, and sale.

- **Status and Condition Monitoring**: Information about the current status and condition of pharmaceutical products, such as their location, temperature, and quality, will be recorded and monitored throughout the supply chain.

- **Regulatory Compliance:** Product perspectives will include adherence to regulatory requirements and standards specific to the pharmaceutical industry, ensuring compliance with safety, quality, and labeling regulations.

- **Authentication and Verification**: Mechanisms for product authentication and verification will be implemented to prevent counterfeit products and ensure the authenticity of pharmaceuticals at each stage of the supply chain.

3.3.2 Product features

- **Product Information Management:** Ability to store and manage detailed information about pharmaceutical products, including name, description, batch number, manufacturing date, expiry date, and serial number.

- **Supply Chain Tracking:** Tracking of product movement throughout the supply chain, from raw material sourcing to distribution and sale, providing real-time visibility into the product's location and status.

- **Stage Monitoring:** Monitoring and recording of the product's current stage in the supply chain, allowing stakeholders to track its progress and identify any bottlenecks or delays.

- **Quality Assurance:** Integration of quality control measures to ensure product integrity and compliance with industry standards and regulatory requirements.

- **Temperature Monitoring:** Implementation of temperature monitoring features to track and record temperature variations during storage and transportation, ensuring product quality and safety.

- **Authentication and Verification:** Implementation of mechanisms for product authentication and verification, such as QR codes or RFID tags, to prevent counterfeit products and ensure product authenticity.

- **Transaction History:** Recording of transaction history for each product, including details of all interactions and movements within the supply chain, providing a transparent and auditable record of product transactions.

- **Alerts and Notifications:** Provision of alerts and notifications to stakeholders in case of any deviations from predefined thresholds or critical events within the supply chain, enabling timely action and resolution

3.3.3 Operating environment

Software Environment:

- The system is built on blockchain technology using Ethereum blockchain.
- Development is done using tools like Visual Studio Code, Node.js, and Git.
- Frontend interface is developed using React.js for user interaction.
- Web3.js facilitates communication with the Ethereum blockchain network.

Hardware Environment:

- Local deployment and testing are done using Ganache.
- MetaMask browser extension wallet is used for secure transactions.

3.4 External Interface Requirements

3.4.1 User Interfaces

- Manufacturer Interface: Allows manufacturers to input product information, initiate product transfers, and track the status of products within the supply chain.

- Distributor Interface: Enables distributors to receive and process product orders, manage inventory, and coordinate product shipments to retailers.

- Retailer Interface: Provides retailers with tools to manage product listings, monitor sales, and update product availability for customers.

- Customer Interface (E-commerce Platform): Integrates with external e-commerce platforms to offer customers a seamless shopping experience, including product browsing, ordering, and tracking of product deliveries.

- Admin Interface: Offers administrators the ability to manage user accounts, configure system settings, and generate reports on supply chain activities.

3.4.2 Hardware Interfaces

None

3.4.3 Software Interfaces

- **Truffle Framework**: The system utilizes the Truffle framework for compiling, migrating, and deploying smart contracts onto the Ethereum blockchain network.

- **Ganache:** Ganache, a personal blockchain for Ethereum development, is used for local testing and simulation of blockchain network behavior during smart contract development.

- **MetaMask Wallet:** MetaMask, a browser extension wallet, serves as the interface between the frontend application and the Ethereum blockchain network, enabling secure transactions and interactions with smart contracts.

- **Web3.js**: Web3.js library is utilized to establish communication between the frontend interface and the Ethereum blockchain network, allowing seamless integration with smart contracts and blockchain transactions.

- **React.js:** The frontend user interface is developed using React.js, providing a responsive and interactive platform for users to interact with the Supply Chain Management system.

3.4.4 Communication Interfaces

- **Blockchain Network**: Communication between the frontend application and the Ethereum blockchain network is facilitated through Web3.js, allowing the system to interact with smart contracts and execute blockchain transactions securely.
- **MetaMask Integration**: MetaMask serves as the communication interface between the frontend application and the Ethereum blockchain network, providing a secure channel for sending and receiving transaction requests.

3.5 System Features

3.5.1 Functional requirements

- **User Authentication and Authorization**: Users must be able to authenticate securely and access the system based on their assigned roles (e.g., manufacturer, distributor, retailer) with appropriate permissions.
- **Product Information Management:** Ability to input, store, and manage detailed information about pharmaceutical products, including product name, description, batch number, manufacturing date, expiry date, and serial number.
- **Supply Chain Tracking and Monitoring:** Tracking of product movement throughout the supply chain, from raw material sourcing to distribution and sale, enabling stakeholders to monitor product status and location in real-time.
- **Role-based Access Control:** Role-based access control mechanisms to restrict access to sensitive information and functionalities based on user roles and permissions, ensuring data security and privacy.
- **Product Transfer and Verification:** Facilitation of secure transfer of products between supply chain participants (e.g., manufacturer to distributor, distributor to retailer) with verification mechanisms to ensure product authenticity and integrity.
- **Transaction History and Audit Trail:** Recording and maintenance of a comprehensive transaction history for each product, including details of all interactions and movements within the supply chain, to establish an audit trail and ensure accountability.
- **Notification and Alerting System:** Implementation of a notification and alerting system to notify stakeholders about critical events, deviations from predefined thresholds, or required actions within the supply chain, enabling timely responses and decision-making.

3.5.2 Nonfunctional requirements

- **Performance:** Ensure prompt response times, scalability to handle increasing loads, and high throughput for efficient data processing.
- **Security:** Implement robust data encryption mechanisms to protect sensitive information, enforce strict access control policies based on user roles and permissions, and conduct thorough security audits of smart contracts to prevent vulnerabilities.
- **Usability:** Design a user-friendly interface with intuitive navigation and clear layout, ensure accessibility compliance for users with disabilities, and provide informative error messages for effective issue resolution.
- **Reliability:** Maintain high system availability with minimal downtime, ensure data integrity to prevent corruption or loss, and implement robust backup and recovery mechanisms for disaster recovery.
- **Interoperability:** Support seamless integration with external platforms, such as e-commerce websites, through standardized communication protocols and APIs, facilitating data exchange and interoperability.

3.5.3 Use case description

- **User Authentication and Authorization**: Users authenticate themselves using their credentials and are granted access to the system based on their assigned roles and permissions. The system verifies user identities securely to ensure authorized access.
- **Product Information Management:** Authorized users input and manage detailed information about pharmaceutical products, including name, description, batch number, manufacturing date, and expiry date. They can update or retrieve product information as needed.
- **Supply Chain Tracking and Monitoring:** Stakeholders track the movement of products throughout the supply chain, from raw material

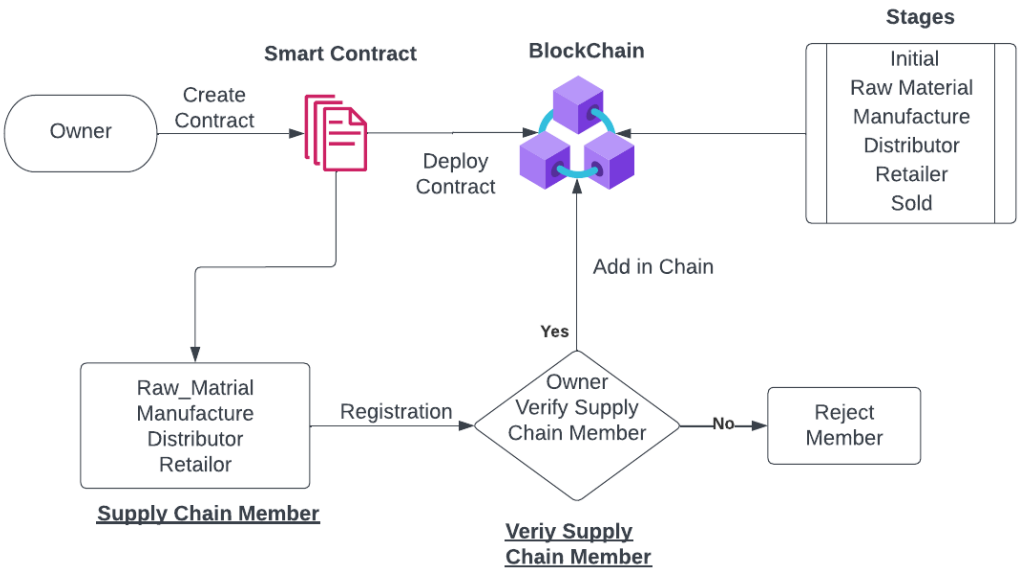
sourcing to distribution and sale. They monitor product status and location in real-time, ensuring transparency and accountability.

- **Role-based Access Control:** The system enforces role-based access control, allowing users to access only the functionalities and information relevant to their roles. Administrators have the authority to manage user roles and permissions.

- **Product Transfer and Verification:** Authorized users initiate and verify the secure transfer of products between supply chain participants. They ensure product authenticity and integrity throughout the transfer process, mitigating the risk of counterfeit products.

- **Transaction History and Audit Trail:** The system maintains a comprehensive transaction history for each product, recording all interactions and movements within the supply chain. Users can review transaction details and audit trails to trace product provenance and identify potential issues.

3.5.4 Use case diagram



Signature of the Guide