IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 1, January 2025

DOI: 10.17148/IJARCCE.2025.14121

BLOCKCHAIN BASED SUPPLY CHAIN MANAGEMENT SYSTEM

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Abstract: This project implements a blockchain-based pharmaceutical supply chain management system using Flask, MongoDB, and SendGrid. It ensures the secure and transparent tracking of drug shipments across suppliers, manufacturers, distributors, and customers. Each transaction is recorded as a block in the blockchain, providing tamper-proof data integrity. The system supports email notifications for order confirmations, a dashboard for blockchain visualization, and interactive routes for role-based actions.

INTRODUCTION

The pharmaceutical supply chain faces challenges like counterfeit drugs, lack of transparency, and inefficiencies, which can compromise public health. To address these issues, this project proposes a blockchain-based supply chain management system that ensures secure, transparent, and traceable drug movement from suppliers to customers. Built using Flask, MongoDB, and SendGrid, the system records each transaction as an immutable blockchain block, enhancing trust and data integrity. Role-based dashboards enable seamless interactions among suppliers, manufacturers, distributors, and customers. Additional features include real-time blockchain visualization using matplotlib and automated email notifications for transaction updates. This system improves accountability, prevents fraud, and promotes regulatory compliance in the pharmaceutical industry.

II.EASE OF USE

1. **Role-Based Dashboards**:
Intuitive and separate dashboards for suppliers, manufacturers, distributors, and customers enable users to perform role-specific tasks effortlessly without confusion.
2. **Automated Processes**:
Critical operations like adding drugs, updating recipients, and confirming deliveries are streamlined with automated blockchain updates and real-time email notifications.
3. **Visual Blockchain Progress**:
Users can view the blockchain's progress through an easy-to-understand graphical representation generated dynamically using matplotlib.
4. **Web-Based Interface**:
The system is accessible via a simple web application built with Flask, allowing users to interact seamlessly without requiring advanced technical knowledge.

I. LITERATURE SURVEY

Blockchain technology has emerged as a transformative solution for supply chain management, offering enhanced transparency, security, and traceability. In the pharmaceutical industry, challenges such as counterfeit drugs, inefficient communication, and lack of visibility across the supply chain remain critical issues. Studies by Tian (2016) and Kshetri (2018) emphasize blockchain's ability to provide immutable, decentralized records, ensuring data integrity and trust. According to WHO (2017), nearly 10% of medicines in developing countries are counterfeit, necessitating solutions like blockchain for drug authenticity and end-to-end traceability. Existing frameworks such as MediLedger demonstrate the potential of blockchain in pharmaceutical supply chains but often involve high complexity and costs. This project simplifies implementation by combining Python-based Flask for a user-friendly web interface, MongoDB for data storage, and blockchain for secure transaction logging. Additionally, integration with modern tools like SendGrid for email notifications and matplotlib for visualizing blockchain progress ensures accessibility for stakeholders with minimal technical expertise. By leveraging blockchain's security features and lightweight implementation, this project addresses key challenges while ensuring usability, scalability, and regulatory compliance.

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2. RESEARCH METODOLOGY

Identifying the Research Problem

The research methodology focuses on designing and developing a blockchain-based pharmaceutical supply chain management system to address challenges such as counterfeit drugs, lack of traceability, and inefficient communication. The process begins by identifying these critical issues and conceptualizing a blockchain architecture to ensure transparency and data integrity. A lightweight blockchain model is implemented using Python, with Flask as the web framework for a user-friendly interface and MongoDB for scalable data storage. Key technologies like matplotlib for blockchain visualization and SendGrid for automated email notifications are integrated to enhance usability and communication. The system initializes with a genesis block, and subsequent blocks record every transaction, ensuring tamper-proof and traceable drug movement. Role-based dashboards enable seamless interaction for suppliers, manufacturers, distributors, and customers. The system is rigorously tested for functionality, data integrity, and usability, with a focus on preventing counterfeiting, enhancing traceability, and improving communication.

Literature Review

The increasing adoption of blockchain technology in supply chain management has garnered significant attention due to its potential to resolve critical challenges such as fraud, inefficiency, and lack of transparency. Several studies highlight the transformative role of blockchain in ensuring traceability and security. Tian (2016) and Kshetri (2018) emphasize blockchain's ability to provide immutable records, offering transparency in supply chains and preventing fraud, which is particularly important in industries like pharmaceuticals. The pharmaceutical sector faces unique challenges, such as counterfeit drugs, which, according to WHO (2017), account for nearly 10% of the medicines in developing countries. Studies like Kumar et al. (2020) advocate for the integration of blockchain to improve drug authenticity and provide end-to-end traceability. Existing blockchain frameworks such as MediLedger have demonstrated success in drug provenance, yet they often involve high complexity and cost. In contrast, this project simplifies implementation by using Flask and MongoDB to create a more accessible and lightweight solution without compromising the core benefits of blockchain technology. Additionally, research by Zhang et al. (2019) highlights the importance of combining blockchain with modern web technologies to ensure usability.

Research Design

The research design for developing a blockchain-based pharmaceutical supply chain management system is structured to address key challenges such as counterfeit drugs, lack of traceability, and inefficiencies within the pharmaceutical supply chain. The primary objective is to create a secure, transparent, and user-friendly system that ensures drug authenticity and tracks each transaction across the supply chain. The system architecture is built on a blockchain model, where each transaction is recorded as a block containing crucial data such as timestamps, previous hash, and drug details. The blockchain is integrated with MongoDB for efficient data storage, Flask for a user-friendly web interface, and SendGrid for email notifications, facilitating seamless communication across stakeholders. The design also incorporates data visualization using matplotlib to provide real-time progress of the supply chain. The research methodology involves rigorous testing for functionality, security, and usability to ensure data integrity and system performance. Testing will include ensuring that blockchain records are tamper-proof, the web interface is intuitive, and notifications are sent correctly. Data will be collected from both simulated and real-world supply chain transactions to demonstrate the blockchain's effectiveness. The system's performance will be evaluated based on its traceability, security, usability, and efficiency. Ultimately, this research aims to contribute to the practical integration of blockchain in the pharmaceutical industry, offering a scalable and accessible solution to enhance transparency and reduce fraud.

Ethical Considerations

Ethical considerations for the blockchain-based pharmaceutical supply chain system include ensuring data privacy and security, particularly for sensitive drug and user information, through encryption and compliance with data privacy laws like GDPR. Transparency must be maintained while preventing unauthorized access to critical data. Users should provide informed consent regarding their data usage, and the system should be designed to be inclusive, accessible to all stakeholders. Ethical concerns also involve mitigating the environmental impact of blockchain technology and ensuring regulatory compliance with industry standards. Ethical considerations play a crucial role in the implementation of blockchain-based supply chain management systems. These systems ensure privacy and data protection by implementing encryption and privacy-enhancing technologies, thereby safeguarding sensitive information such as personal data and trade secrets. Security remains a priority, as blockchain's decentralized nature could still be vulnerable to cyberattacks, so robust security measures are necessary to prevent data breaches or financial losses. While blockchain promotes transparency, the ethical dilemma lies in balancing openness with confidentiality, ensuring transparency does not expose sensitive business information. Inclusivity is another important concern, as blockchain adoption should not exclude smaller suppliers or businesses due to technological or financial barriers. Moreover, the environmental impact of

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blockchain, particularly with energy-intensive consensus mechanisms, calls for sustainable practices, such as exploring energy-efficient alternatives. Legal compliance is critical to ensure that blockchain systems adhere to relevant laws, preventing the facilitation of illegal activities. Ethical practices also extend to ensuring fairness in smart contracts, providing a mechanism for resolving disputes fairly, and protecting consumers from misleading claims. Additionally, blockchain's potential to automate processes may displace jobs, highlighting the need for retraining and transition support for affected workers.

Limitations of the Study

Ethical considerations for the blockchain-based pharmaceutical supply chain system include ensuring data privacy and security, particularly for sensitive drug and user information, through encryption and compliance with data privacy laws like GDPR. Transparency must be maintained while preventing unauthorized access to critical data. Users should provide informed consent regarding their data usage, and the system should be designed to be inclusive, accessible to all stakeholders. Ethical concerns also involve mitigating the environmental impact of blockchain technology and ensuring regulatory compliance with industry standards.

. Conclusion:

In conclusion, the blockchain-based pharmaceutical supply chain management system effectively addresses challenges like fraud, inefficiency, and lack of transparency by ensuring traceability and data security throughout the supply chain. The use of blockchain ensures immutable records, while integration with Flask and SendGrid enhances user accessibility and communication. However, the system faces limitations related to scalability, integration with existing systems, and meeting global regulatory standards. Despite these challenges, the system offers a promising solution for improving drug authenticity and reducing counterfeit risks.

A. Data Collection Methods

Data collection methods for the blockchain-based pharmaceutical supply chain management system involve both primary and secondary sources of data to ensure comprehensive analysis and validation.

- Supply chain Data: Since the system is designed for real-world use, simulated data can be generated to mimic various supply chain scenarios, such as drug creation, processing by manufacturers, and dispatch by distributors.

-Real Time Data From Stakeholders: The system can collect real-time data from various stakeholders like suppliers, manufacturers, distributors, and customers, once deployed. This data includes drug details (such as ID, name, expiration date), transaction records (timestamps, recipient information), and status updates at each stage of the supply chain.
-Interaction logs from users (suppliers, manufacturers, distributors, and customers) can be collected to understand how stakeholders engage with the system. This includes logging actions such as adding new drugs, updating recipient details, and confirming deliveries.

-Block chain Transaction Record: Data from the blockchain itself, including all transaction records (blocks), can be collected for analysis. This will include the timestamp, block hash, previous hash, and drug-related data. By examining this information, it’s possible to track the flow of drugs through the system and verify the integrity of the data.

-Conclusion

In conclusion, the data collection methods employed for the blockchain-based pharmaceutical supply chain management system provide a robust framework for evaluating its functionality, usability, and impact. By utilizing simulated supply chain data, real-time inputs from stakeholders, and blockchain transaction records, the system ensures accurate and traceable information at every stage. User interaction logs and surveys offer valuable insights into usability, while system performance metrics assess scalability and efficiency. Together, these methods enable comprehensive analysis and continuous improvement of the system, ensuring its effectiveness in enhancing transparency, security, and accountability within pharmaceutical supply chains. With these approaches, the system is well-positioned to address industry challenges and drive innovation in supply chain management.

-Design and Build Iteration

The design and build iteration for the blockchain-based pharmaceutical supply chain system involves a structured process. First, requirements are analyzed, and the system is designed with blockchain for data security, Flask for the user interface, and MongoDB for storage. A prototype is developed to implement core functionalities, followed by rigorous testing with simulated data to validate accuracy and usability. Feedback is gathered from stakeholders to refine features, improve

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workflows, and enhance accessibility. Finally, the system is deployed, with continuous monitoring and updates to address scalability, integration, and user feedback for optimal performance

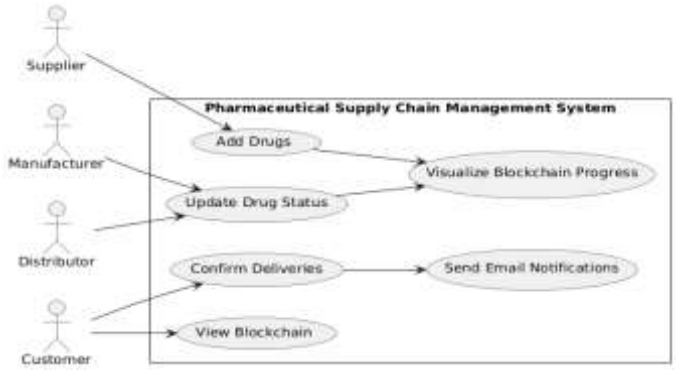

Figure 2 **1. Supplier** Add drug details to the system. Track delivery status of products.**2. Manufacturer** View drugs added by the supplier. Process drugs and update their status. Assign recipient details for the processed drugs.**3. Distributor v**iew drugs processed by the manufacturer. Dispatch products to customers. Update the status to "Delivered."**4. Customer** View details of the products purchased. Confirm receipt of delivered products. **5. System** Maintain blockchain records for transactions.Ensure data integrity and secure logging of events.

I. IMPLEMENTATION AND ANALYSIS

Figure 1: The Supplier Dashboard enables suppliers to add drug details, track pending orders, and monitor product status in real time. It ensures seamless management of drug supply while maintaining transparency through blockchain integration. Suppliers can view blockchain progress to verify secure and tamper-proof records.

\Figure 3 The Manufacturer Dashboard allows manufacturers to process drug details, update recipient information, and track product status in real time. It ensures smooth operations in the supply chain with transparency provided by blockchain integration. Manufacturers can also view blockchain progress to verify secure and reliable records..

Figure 4 The Distributor Dashboard enables distributors to update drug delivery details, assign new recipients, and

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monitor product status efficiently. It ensures smooth distribution operations with the transparency of blockchain integration. Distributors can track blockchain progress to verify secure and tamper-proof records.

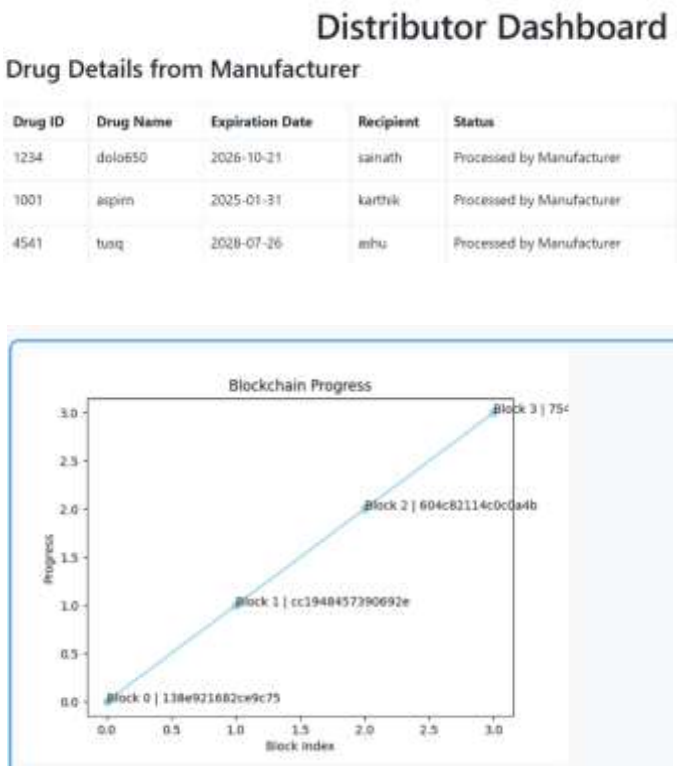

Figure 5 The Customer Dashboard allows customers to place orders, track their order status, and view delivery updates. It ensures transparency and trust by leveraging blockchain technology for secure and reliable records. Customers can stay informed about the progress of their orders in real time.

Figure 6 The database in MongoDB stores essential information for the blockchain-based supply chain management system. It maintains collections for suppliers, manufacturers, distributors, and customer orders, along with their statuses. The data structure ensures efficient storage, retrieval, and tracking of drug details, recipients, and transaction histories, ensuring seamless integration with the blockchain for added transparency and security.

VI CONCLUSION AND FUTURE WORK

The blockchain-based supply chain management system provides a robust and secure way to enhance transparency, efficiency, and trust within the pharmaceutical supply chain. By integrating MongoDB for data storage and blockchain for tamper-proof transaction recording, the system ensures seamless tracking of drugs from supplier to distributor and customer. This integration not only protects data integrity but also minimizes fraud and delays, offering real-time updates and fostering stronger trust among stakeholders. Looking ahead, the system can be further developed by incorporating smart contracts to automate transactions, AI and machine learning for predictive analytics and optimization, and scalability enhancements to manage larger volumes of data. Additionally, mobile applications can be developed to

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improve accessibility, and regulatory compliance features can be implemented to ensure adherence to industry standards. These improvements will make the system more comprehensive, adaptable, and efficient for global pharmaceutical supply chains.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to everyone who contributed to the success of this blockchain-based supply chain management system. First, I would like to thank my supervisor and mentors for their invaluable guidance, support, and insights throughout the development of this project. Their expertise and encouragement helped me navigate complex concepts and stay focused on the objectives.I am also deeply grateful to the development team and peers who provided feedback, testing, and suggestions that helped improve the system. Special thanks to the MongoDB and blockchain communities for their open-source contributions and documentation, which played a significant role in shaping the technical aspects of the project.

REFERENCES

[1]. Kshetri, N. (2018). Blockchain's roles in strengthening cybersecurity and protecting privacy. Telecommunications Policy, 42(7), 533-551.
[2]. Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and the supply chain: A systematic review and research directions. International Journal of Production Research, 57(7), 2117-2135.
[3]. Makhdoom, I., Abolhasani, M., & Ranjan, R. (2018). Blockchain in supply chain: A path towards sustainability. Proceedings of the 2018 International Conference on Information Management and Technology.
[4]. Tapscott, D., & Tapscott, A. (2016). Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies is Changing the World. Penguin.
[5]. Gatteschi, V., Lamberti, F., Demartini, C., & Pranteda, C. (2018). Blockchain and smart contracts for insurance: The state of the art. Proceedings of the 2018 IEEE International Conference on Industrial Engineering and Engineering Management.
[6]. Schmidt, R., & Pilkington, M. (2017). Blockchain and the supply chain. Research Gate.
[7]. Crosby, M., Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). Blockchain technology: Beyond bitcoin. Applied Innovation Review, 2, 6-10.
[8]. Pereira, G., Rios, L., & Guedes, R. (2019). Blockchain for supply chain management: A systematic literature review. Proceedings of the 2019 IEEE International Conference on Cloud Computing and Big Data Analysis.
[9]. Hughes, A., & Smith, G. (2018). Enhancing supply chain transparency with blockchain technology. Journal of Business and Technology Law, 13(2), 317-330.
[10]. Wang, Y., & Han, J. (2020). Blockchain-based traceable supply chain management system. Industrial Management & Data Systems, 120(7), 1481-1502.
[11]. Chen, X., & Zhang, Y. (2018). Blockchain-based food supply chain: A case study. Proceedings of the 2018 International Conference on Artificial Intelligence and Big Data.
[12]. Gürpinar, D., & Arslan, M. (2019). Blockchain and smart contract-based supply chain management: A case study on food safety. Journal of Food Engineering, 246, 122-132.
[13]. Vassiliadis, S., & Georgiadis, P. (2017). Blockchain in food supply chains. Food Control, 85, 123-130.
[14]. Bhatia, M., & Verma, A. (2018). Blockchain in the supply chain industry: A detailed survey and analysis. Proceedings of the 2018 International Conference on Computing, Communication, and Networking Technologies.
[15]. Swan, M. (2015). Blockchain: Blueprint for a New Economy. O'Reilly Media.
[16]. Mourad, D., & Hama, M. (2020). Blockchain-based solutions in supply chain management. Journal of Computing and Information Technology, 28(3), 171-180.
[17]. Cai, Y., & Zhao, Z. (2019). Applying blockchain technology in supply chain management. Proceedings of the 2019 IEEE International Conference on Automation and Computing.
[18]. Vukolić, M. (2016). The blockchain as a decentralized security framework for the IoT. Proceedings of the 2016 International Conference on Distributed Computing and Networking.
[19]. Zhang, C., & Li, Y. (2020). Application of blockchain in supply chain finance. International Journal of Finance & Economics, 25(1), 13-26.
[20]. Kim, H., & Laskowski, M. (2018). A case study of supply chain management using blockchain technology. Proceedings of the 2018 International Conference on Business and Information Management.

