International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | Jun 2023 www.irjet.net p-ISSN: 2395-0072

Product Serialization using Blockchain

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Abstract - *Our project has successfully implemented a blockchain-based solution for pharmaceutical product serialization, replacing traditional databases with a secure and transparent blockchain network. By leveraging the decentralized and immutable nature of blockchain, our platform enables real-time tracking and tracing of products, reducing the risk of counterfeit goods, and enhancing supply chain integrity. The utilization of blockchain technology also enhances data security through encryption and distribution of information across the network. Our project showcases the potential of blockchain in improving supply chain management and contributing to a safer pharmaceutical supply chain ecosystem.*

Key Words: Blockchain-based Solution, Pharmaceutical Product Serialization, Decentralized, Blockchain Network, Immutable, Supply Chain Management, Distributed ledger technology

1. INTRODUCTION

Product serialization is an essential technique enforced by agencies and companies worldwide to assign unique numbers to individual items. This technique allows organizations to track and trace their products' location in a supply chain involving multiple parties, promoting transparency and traceability. It is particularly crucial for products exchanged among multiple hands during their life cycle, ensuring authenticity and safety, especially in the pharmaceutical sector where counterfeit drugs can pose significant threats to public health. Counterfeit goods amounted to as much as $509 billion in 2016, representing 3.3% of world trade[1]. Counterfeiting leads to the loss of 5.4 million jobs globally, and up to 1 million people die from fake medicine every year[0], emphasizing the need for continuous improvement in product serialization.

2. PROBLEM STATEMENT

Our project aims to tackle the limitations of existing product serialization systems, which are susceptible to security breaches and counterfeiting. These systems rely on centralized and vulnerable traditional databases, making it difficult to ensure product authenticity in a complex global supply chain.

We propose to develop a more robust solution by leveraging blockchain technology, which offers enhanced security and transparency as a decentralized and immutable ledger. By replacing traditional databases with a blockchain network, we can create a tamper-proof system where product serialization data is encrypted and distributed. This significantly reduces the risks of security breaches and counterfeiting, and enables real-time tracking and tracing of products, thereby enhancing the integrity of the supply chain.

3. LITERATURE REVIEW

Multiple papers were selected for full review in the context of this project. Based on the research papers reviewed, several key insights can be gathered for developing a blockchain application to manage pharmaceutical supply chains.

First, blockchain can improve supply chain traceability and transparency in the pharmaceutical industry [2] [4] [6] [8] [9] [10]. Blockchain technology can provide an immutable and transparent record of all transactions and activities in the supply chain, allowing for enhanced visibility and accountability. This can help prevent counterfeit drugs, track and verify the authenticity of pharmaceutical products, and ensure compliance with regulatory requirements.

Second, scalability and security are important considerations when implementing a blockchain-based solution for supply chain management [3] [7]. Blockchain solutions need to be able to handle large volumes of data and transactions in real-time to be effective in managing pharmaceutical supply chains. Additionally, ensuring the security and privacy of data stored on the blockchain is crucial to protect sensitive information and prevent unauthorized access.

Third, interoperability and collaboration among multiple parties in the supply chain are critical for successful implementation of a blockchain-based supply chain solution [3] [5] [7] [8]. Pharmaceutical supply chains involve multiple stakeholders, including manufacturers, distributors, retailers, and regulatory agencies, and it is important to establish interoperability standards and collaboration protocols to enable seamless data exchange and coordination among these parties.

Fourth, a systematic review of existing literature can provide valuable insights and guidelines for developing a blockchain-based supply chain solution for the pharmaceutical industry [6] [9] [10]. Reviewing existing research can help identify best practices, potential challenges, and opportunities for innovation in implementing blockchain technology in pharmaceutical supply chains.

In conclusion, developing a blockchain application for pharmaceutical supply chain management requires careful consideration of scalability, security, interoperability, and collaboration among multiple stakeholders. Blockchain has the potential to improve traceability and transparency in the pharmaceutical industry, and a thorough review of existing research can provide valuable insights for successful implementation.

4. EXISTING SYSTEMS

Product serialization is essential in the pharmaceutical supply chain management system to ensure the safety and quality of pharmaceutical products. Currently, several solutions are in use for product serialization, such as EDI, RFID, and track-and-trace technologies. EDI facilitates the electronic exchange of data between trading partners, but it may lack transparency, manual data entry can introduce errors, and it may not provide granular visibility into the movement of individual items or pallets. RFID technology can track individual items or pallets but is limited in coverage, requires manual scanning, and can be expensive. Track-and-trace technologies rely on different formats, which may lack standardization and provide limited visibility into the movement of products. Blockchain-based solutions can address these limitations by providing a decentralized, transparent, and immutable ledger, enhancing the security and efficiency of the supply chain management process.

5. WORKFLOW

The `Fakeproduct` contract is a smart contract written in Solidity that contains several structs to store information about users, files, and QR codes. The contract also includes mappings to map addresses to the corresponding structs, as well as arrays to store all the instances of the structs.

The contract defines three main structs:

1. `filedetails`: Contains details about a file, including the file owner's address, filename, product ID, product name, product category, product price, username, and password.

2. `userinfo`: Stores user information, such as the user's address, name, date of birth, mobile number, email address, password, and type of user.

3. `qrinformation`: Holds information related to a QR code, such as the QR owner's address, product ID, product name, product category, product price, and QR name.

The contract includes mappings to associate user addresses with their respective `filedetails`, `userinfo`, and `qrinformation` structs. Additionally, there are arrays to store all instances of the structs, namely `allfiledetailss`, `allusers`, and `allQrInformation`.

The contract provides a set of functionalities for user registration, login, adding file details, viewing uploaded products, and validating products. The userRegister function facilitates user registration by storing their information in the userinfo struct and adding it to the allusers array. To enable user login, the Login function is employed, which verifies the entered name, password, and user type against the stored user information. The addFiledetails function allows users to add file details, which are saved in the filedetails struct and then appended to the allfiledetailss array. The viewUploadedproducts function enables users to view all the uploaded products by fetching information from the allfiledetailss array. The validateProduct function validates a product by cross-checking the provided name, password, and user type against the stored user information in the allusers array. Lastly, the addQrCode function permits users to add QR codes and saves the related information in the qrinformation struct and allQrInformation array.

It's important to note that the contract uses the `pragma experimental ABIEncoderV2;` statement, which indicates that it's using the experimental ABIEncoderV2 feature in Solidity. This feature allows for encoding and decoding of complex data types, such as structs, in function arguments and return values. However, it is worth noting that experimental features may not be fully tested or stable, and their usage should be approached with caution in production contracts.

6. FLOWCHART

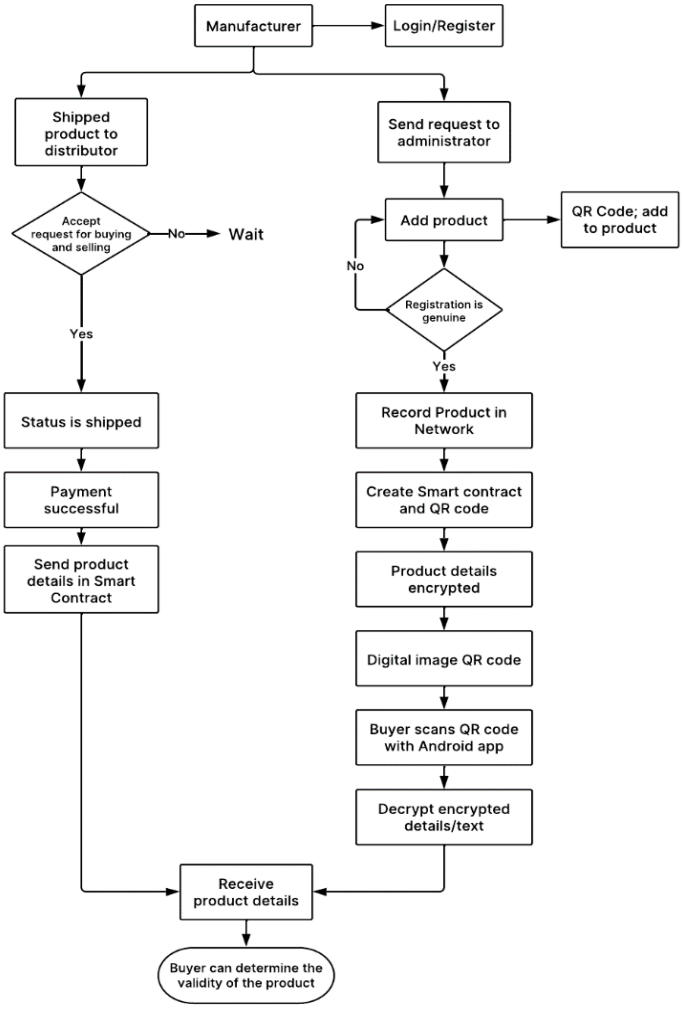

Figure 1: Flowchart of the system

7. USE CASE DIAGRAM

The use case diagram is an essential tool for requirement analysis as it helps to identify the requirements of the system from the user's perspective. It helps to define the scope of the system and ensures that the system meets the user's needs. Additionally, it provides a high-level overview of the system's functionality and can be used as a starting point for further design and development.

The Use Case diagram is a powerful tool for visualizing the system's requirements and its interactions with the external entities. It helps to ensure that the system meets the needs of the users and provides a clear understanding of the system's functionality.

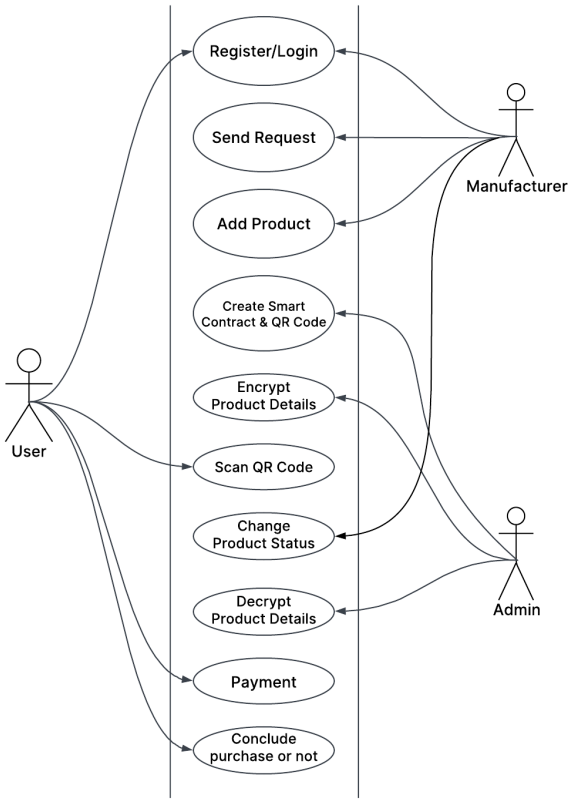

Figure 2: Use Case Diagram

8. TEST CASES

The testing phase involves evaluating the software using various test cases to ensure that it is functioning correctly.

Some of the test cases that can be used in supply chain management software include login, homepage, search property, booked property, and logout. Each of these test cases is designed to test a specific functionality of the software and ensure that it is working as intended.

During the testing phase of our supply chain management project, we have performed these test cases and found that the software is giving completely expected output results. This indicates that the flow of program actions is being performed correctly and the software is functioning as expected.

Precondition	Test	Expected Result	Result
Collect a huge product database.	To add a product on the network.	QR code will get assigned to that product.	PASS
Product is recorded.	Encrypt details of product.	Create a smart contract and a unique QR code	PASS

Manufacturer will ship the product	Product shipped.	Status is set as shipped	PASS
Payment is successful.	Check status	Status changed	PASS
User gets product	Scan QR code	Get decrypted details of the product	PASS

Figure 3: Testing Cases

9. RESULTS

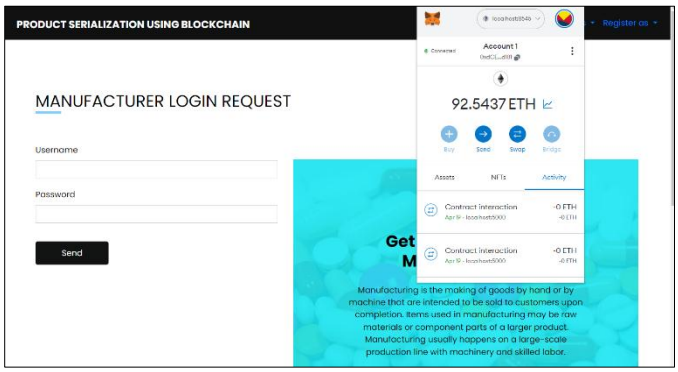

Figure 4: Manufacturer Login

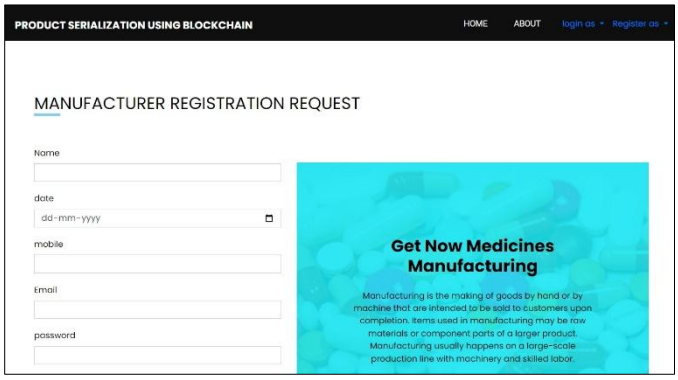

Figure 5: Manufacturer Registration

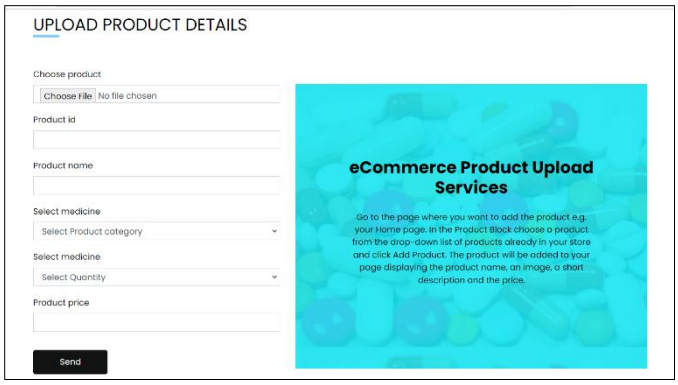

Figure 6: Manufacturer Portal – Upload Product Details

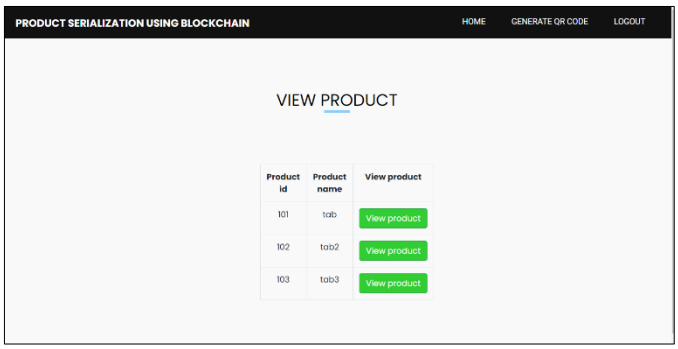

Figure 7: Admin Portal – QR Code Generation for Viewing Product

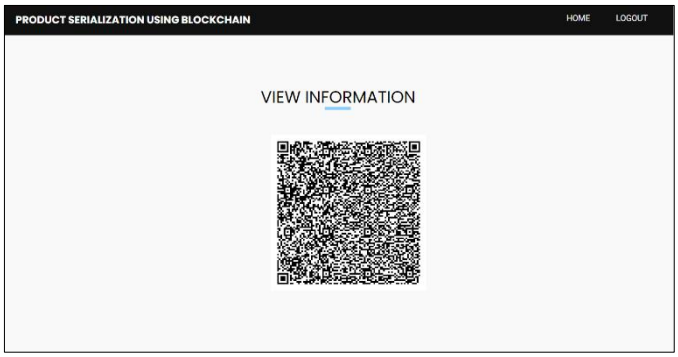

Figure 8: Admin Portal – QR Code Generated

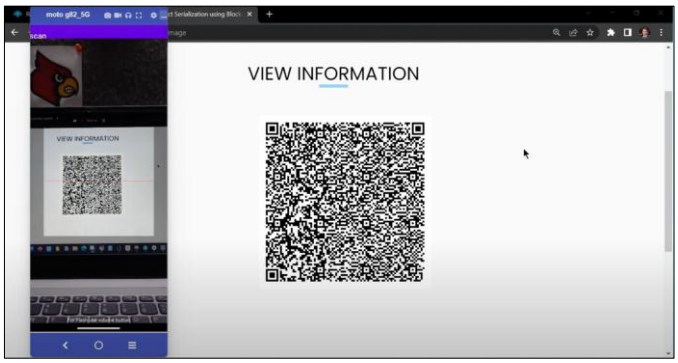

Figure 9: Scanning the generated QR to fetch the details of the product

10. PERFORMANCE METRICS

To evaluate the performance of our blockchain-based pharmaceutical product serialization application, we have considered the following metrics:

- Security: Assessed the level of security provided by the blockchain solution, including resistance to tampering, data breaches, and unauthorized access. Measured the number of attempted security breaches or attacks and the success rate of these attempts is extremely low.

- Transparency: Evaluated the transparency achieved by the blockchain network in terms of visibility into product movements, transactions, and supply chain events. Measured the high accuracy and timeliness of data recorded on the blockchain and compared it with traditional systems.

- Traceability: Measured the effectiveness of the real-time tracking and tracing functionality in the application. Assessed the ability to identify and track products throughout the supply chain, from manufacturing to distribution and end-consumers. Evaluated the time taken to trace a product and the accuracy of the information retrieved.

- Counterfeit Reduction: Measured the impact of the blockchain solution on reducing counterfeit products in the pharmaceutical supply chain. Compared the number of reported counterfeit incidents before and after the implementation of the blockchain-based serialization system.

- Efficiency: Evaluated the efficiency of the blockchain-based system compared to traditional databases in terms of data storage, retrieval, and processing. Measured the time taken to add product details, validate products, and generate QR codes.

- Scalability: Assessed the ability of the application to handle increasing volumes of product data and transactions as the supply chain expands. Measured the system's performance under high loads and evaluated its ability to maintain transaction speeds and response times.

- Cost Savings: Evaluated the cost savings achieved by implementing the blockchain solution compared to traditional product serialization systems. Considered factors such as reduced counterfeiting costs, improved supply chain efficiency, and potential savings in auditing and compliance processes.

These performance metrics will help assess the effectiveness and impact of our blockchain-based pharmaceutical product serialization application in enhancing supply chain integrity, reducing counterfeiting risks, and improving overall efficiency and transparency.

10. CONCLUSIONS AND FUTURE WORK

The completion of the supply chain management project using the reverse waterfall model has been a significant achievement. The project went through a comprehensive process, adhering to industry best practices and project management principles. The team demonstrated exceptional expertise in understanding and translating business needs into a robust software solution. Rigorous testing and validation processes ensured the software's functionality, performance, and security. The project's success can be attributed to the collaborative efforts and dedication of the entire team and stakeholder engagement. The organization has gained a valuable software product that contributes to overall organizational success. Lessons learned from this project will serve as valuable insights for future projects, ensuring continuous improvement in project management practices.

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BIOGRAPHIES

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