https://doi.org/ 10.33472/AFJBS.6.Si2.2024.1354-1361

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Pharmaceutical Supply Chain Management Using Blockchain Technology

K.Kavitha[1], S.Keerthana[2], S.Gayathri Shruti[3], M.Y.Shahanas[4]

[1] *Assistant Professor, Department of CSE- (IoT and Cybersecurity including Blockchain Technology), Manakula Vinayagar Institute of Technology, Pondicherry, India.*

[2,3,4]*B. Tech, Department of CSE- (IoT and Cybersecurity including Blockchain Technology), Manakula Vinayagar Institute of Technology, Pondicherry, India.*

[1] kavithaiot@mvit.edu.in,[2]lakshmikeerthana1892@gmail.com, [3] gayathrishruti53@gmail.com, [4] yacobshanas@gmail.com

Article History
Volume 6,Issue Si2, 2024
Received:27 Mar 2024
Accepted : 30 Apr 2024
doi: 10.33472/AFJBS.6.Si2.2024.1354-1361

Abstract**—***In the field of medicine, maintaining data security and privacy is of utmost importance when providing medical services. Patients often have concerns about the secure storage of their medical records and data. To establish a healthcare system that is both effective and profitable, a digital platform is necessary to facilitate secure and seamless communication. Over the past few years, blockchain technology has evolved, offering benefits such as distributed ledgers, immutability, decentralization, and transparency that have attracted many developers. The use of blockchain technology is expected to have a significant impact on healthcare systems as it provides a secure method for storing private medical data. This article presents a healthcare system that securely manages personal health data while also facilitating communication between patients, physicians, insurance companies, pharmacies, and medical shops.*

Keywords-Data security, Privacy,Medical records,Healthcare system,Digital platform,Blockchain technology,Immutability,Decentralization,Transparency

I. INTRODUCTION

The global healthcare business relies significantly on efficient and safe pharmaceutical supply chains to provide life-saving medications to patients all over the world. These intricate networks are vital for guaranteeing timely access to essential pharmaceuticals and promoting beneficial health outcomes. Despite their importance, traditional pharmaceutical supply chains have several constraints that reduce their efficacy and endanger patient safety.

One of the most significant issues is a lack of openness in these systems. Traditional paper-based record-keeping and segregated data management might make it difficult to trace medication movement across the supply chain. This opacity fosters counterfeiting, placing patients at risk of obtaining inefficient or even dangerous prescriptions. The World Health Organization believes that up to one in every ten medications in underdeveloped nations is counterfeit, underscoring the gravity of the situation. Furthermore, traditional methods are prone to human error and fraud, which can impede the supply of critical drugs and result in shortages. Furthermore, complicated regulatory requirements and bureaucratic processes can exacerbate supply chain operations, resulting in delays and inefficiencies.

To solve these restrictions and ensure pharmaceutical distribution that is secure and transparent, creative solutions are urgently required. Blockchain technology, with its key concepts of immutability, traceability, and decentralization, offers a viable way to transform pharmaceutical supply chain management. Blockchain functions as a secure and

distributed ledger system, allowing for the tamper-proof recording and tracking of drug movement along the supply chain. This enables all authorized parties to access a common view of the data, promoting openness and accountability.

The immutability of blockchain assures that once data is stored, it cannot be changed or erased, resulting in a permanent and verifiable audit trail. This traceability enables stakeholders to follow a medication's route from origin to consumption, successfully preventing counterfeiting and maintaining supply chain integrity.

By embracing blockchain technology's disruptive potential, we can build a more secure, transparent, and efficient pharmaceutical supply chain ecosystem. This will eventually lead to increased access to safe and effective medications for people globally.

II. Literature Survey

A. Blockchain distributed ledger technologies for biomedical and healthcare applications

This paper[1] examines the possible applications of blockchain technology in the biomedical and healthcare fields. Thanks to blockchain's distributed ledger features, which ensure secure and efficient data sharing, the healthcare sector may see a dramatic change. The authors address the need for better data security and privacy in the healthcare sector, highlighting how blockchain's cryptographic characteristics help secure sensitive patient data. They demonstrate how blockchain may improve data integrity, interoperability, and trust in healthcare systems—such as the administration of patient records, clinical trials, and medication supply chains—with several real-world use scenarios. The study emphasizes how important rules, regulations, and multidisciplinary collaboration are to maximize the benefits of blockchain technology.

B. Next-generation healthcare system: using blockchain for secure, trusted sharing of medical data

This study[2] looks at the potential applications of blockchain technology to build a trustworthy and secure network for exchanging medical data for the future generation of healthcare systems. The authors highlight the inherent challenges in maintaining patient data confidentiality and privacy and propose blockchain as a possible solution. They discuss how the decentralized, immutable ledger of blockchain technology may ensure data integrity and confidentiality, and they present a method for limiting who has access to medical records. The study looks at how blockchain technology may enhance patient-centered healthcare delivery, but it also emphasizes the need for more research and development to advance blockchain's use in the medical industry.

C. A new framework for identity and data sharing in healthcare

In this work[3], a unique blockchain-based identification and data sharing architecture for the healthcare sector called Trust:: Data is presented. The authors emphasize the critical need for trust and security while managing sensitive healthcare data. They proposed a strategy to use blockchain technology's decentralization and cryptography features to establish trust and control over personal health data. Potential Applications of Trust: The article covers data in healthcare use cases, including patientconsentmanagement, telemedicine, and electronic health records. By enabling more secure access to, management of, and sharing of health information, the framework eventually hopes to improve patient care and data integrity. By enhancing data security and openness, it does this.

D. Healthcare data gateways: Found healthcare intelligence on the blockchain with novel privacy risk control

This paper[4] proposes the concept of healthcare data gateways, which leverage blockchain technology, to create a secure and efficient healthcare intelligence system. It addresses the urgent need for improved risk management of privacy in the interchange of health information. The authors claim that the distributed ledger, blockchain's encryption, and its consensus processes are essential for creating a secure and private ecosystem for healthcare data. When discussing the architecture of healthcare data gateways, they go into great length about the roles played by various stakeholders, including patients, healthcare providers, and regulatory bodies. The increased control and openness in healthcare data management provided by this approach benefits both individuals and the healthcare industry as a whole.The report provides a workable plan for transforming the exchange of healthcare data while ensuring the integrity and confidentiality of private medical information.

E. MedRec: Using blockchain for medical data access and permission management

The MedRec system, which leverages blockchain technology to improve medical data access control and permission management, is implemented as described in this paper [5]. In the healthcare context, it is critical to ensure effective and safe access to patient data while protecting patient privacy. The authors offer MedRec as a solution to these problems. They discuss how MedRec leverages blockchain technology to provide people access control over their medical records and permission to share them with healthcare providers. By decentralizing patient data and utilizing cryptographic concepts, MedRec enhances data security and integrity. The study demonstrates how

blockchain technology may improve the management of medical records and allow patients greater control, leading to more patient-centered healthcare systems.

F. A blockchain-based approach to health information exchange networks

A blockchain-based technique for building networks for the sharing of health data is presented in this paper [6]. It emphasizes how important it is for medical professionals to transmit data securely and legally. The authors describe how blockchain technology may be used to safely and uniformly share health data across various stakeholders, such as payers, patients, and healthcare providers. They go into detail on how to use access control and data provenance in the sharing of health information using blockchain technology. The study discusses the potential for improving data accessibility and integrity, which would ultimately lead to more efficient and patient-centered healthcare systems. It also goes over challenges and considerations that should be made when integrating blockchain technology into networks that share health data.

III. EXISTING SYSTEM

The field of medication supply chain management includes a variety of strategies, each having pros and cons of its own. Conventional, centralized systems mostly rely on internal record-keeping and paper-based trails within businesses.However,In recent years, novel methods have arisen to overcome the limits of centralized systems. One method makes use of the InterPlanetary File System (IPFS) and blockchain technologies. Important data on the manufacture, distribution, and use of medications may be safely stored on decentralized networks thanks to this integration. Blockchain ensures the integrity and immutability of the records referencing this data, while IPFS effectively distributes data among several nodes.

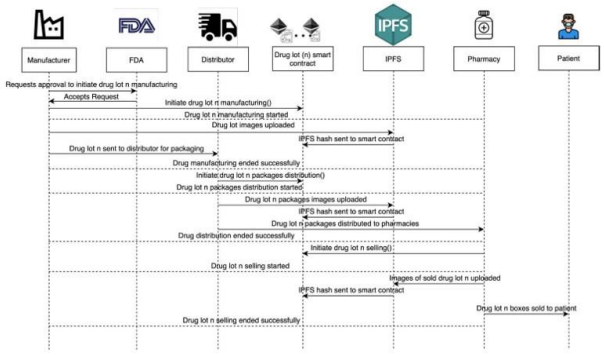

Fig1:Existing system architecture

A. Drawbacks of the Existing System

- Limited Traceability and Visibility Tracking the transportation of medications and identifying counterfeits or delays is challenging with traditional paper-based systems and compartmented data storage.
- Data Security Vulnerabilities: Manual procedures and centralized databases are vulnerable to human mistakes, cyberattacks, and data breaches, which jeopardize patient safety and data integrity.
- Scalability and Integration: Current systems are unable to handle the ever-increasing amounts of data and are not adaptable enough to include new technologies or users.
- Regulatory Compliance Issues: Complying with intricate data security and privacy laws can be difficult and reduce the effectiveness of the supply chain.
- Potential Scalability Limitations: As data volume grows, IPFS-based systems may encounter scalability limitations, depending on the platform selected.
- Integration Complexity: Although merging IPFS and blockchain has benefits, it can also make the system more complicated as a whole.

IV. PROPOSED SYSTEM

Our solution employs a hybrid blockchain architecture that expertly merges the unmatched security and immutability of blockchain with the scalability and cost-effectiveness of Swarm storage. This creates an unshakable foundation for safeguarding vital information about pharmaceuticals, such as ownership history, manufacturing particulars, and appropriate temperature conditions, all of which are tamper-proof and come with a verifiable audit trail.

In addition, our system seamlessly integrates with the Swarm decentralized storage network, making it incredibly easy and secure to store vast amounts of pharmaceutical-related data. This includes batch reports, logistical documentation, and even rich media material, all of which can be accessed safely and efficiently on our platform.

V. SYSTEM OVERVIEW

A. Participant Roles

The system includes multiple stakeholders involved in the pharmaceutical supply chain ecosystem.

- Manufacturers register medications on the blockchain platform with unique identifiers, such as batch numbers, expiry dates, and manufacturing information.

- Distributors track the movement of medications between themselves and other authorized participants in the network.

- Wholesalers securely store and manage pharmaceuticals within the blockchain-based system, ensuring proper storage conditions and maintaining accurate records.

- Retailers, such as pharmacies and other dispensing points, verify the authenticity and origin of medications before dispensing them to patients. Real-time access to the blockchain allows them to confirm the legitimacy of drugs.

- Regulatory bodies can monitor the supply chain for discrepancies or potential counterfeitingactivities using the transparent and unchangeable data stored on the blockchain.

B. Data Management Strategy

The system employs a layered data management technique, utilizing the characteristics of both blockchain and Swarm storage:

- Blockchain Storage: Critical data required for immutability and traceability, including ownership records, batch numbers, and expiration dates, will be maintained on the blockchain.
- Swarm Storage: The Swarm network can securely store larger data files linked with pharmaceuticals, such as batch reports, logistical paperwork, and potentially rich media material (for example, temperature sensor readings). Hashes (unique identifiers) for this data on Swarm will be maintained on the blockchain to provide traceability and retrievability.

C. Data Tracking and Traceability

The blockchain systemrecords crucial data for every medication, creating a comprehensive and verifiable audit trail. Some of the data includes:

- Drug Name and Identification Number: Unique identifiers ensure accurate tracking of each medication throughout the supply chain.
- Batch Number and Expiry Date: This information allows for efficient stock management and facilitates timely recalls i necessary.
- Manufacturing Location and Date: Transparency regarding origin helps to identify potential counterfeiting attempts.
- Ownership History: The blockchain records every transfer of ownership throughout the supply chain, providing a clear picture of a medication's journey.
- Temperature and Storage Conditions:For temperature-sensitive medications, the system can track and record storage conditions to ensure drug efficacy

D. Smart Contract for Automation

The Blockchain system includes Smart contracts which areself-executing programs that run on the blockchain and automate particular system operations, increasing security andoverall efficiency of the system.

- Automated warnings: Smart contracts can send out warnings if specified storage or transit criteria (such as temperature swings) are not met, enabling prompt intervention.

- Simplified Ownership Records: By automating the transfer of ownership records amongst supply chain partners, they may cut down on mistakes and streamline procedures.

- Secure Payments: Using smart contracts, authorized parties inside the network may make secure, transparent payments.

E. Security Considerations

The inclusion of Swarm storage creates extra security considerations that must be addressed:

- Data Access Control: Mechanisms will be created to guarantee that only authorized participants have access to certain data kept on Swarm, according to their responsibilities in the supply chain.

- Data Integrity: Techniques like cryptographic hashing can be used to assure the integrity and non-tampering of data stored on Swarm.

F. Benefits

- Enhanced Traceability and Transparency: By storing related documents securely on Swarm and placing crucial data on the blockchain, the combination of blockchain and Swarm storage

offers a thorough understanding of pharmaceutical data.

- Better Scalability and Cost-Effectiveness: By using Swarm instead of keeping everything on the blockchain, scalability issues are resolved and storage expenses may be lowered.
- Prevention and Detection of Counterfeit: Data integrity is ensured by the immutability of blockchain, which makes it challenging to counterfeit pharmaceuticals.
- Enhanced Efficiency:Smart contracts and streamlined data interchange lead to more efficient supply chains.
- Enhanced Patient Safety: A safer pharmaceutical supply chain is facilitated by improved traceability and counterfeit detection.
- Improved Regulatory Oversight:blockchain technology may be used by regulatory organizations to better monitor and enforce compliance in the pharmaceutical sector.

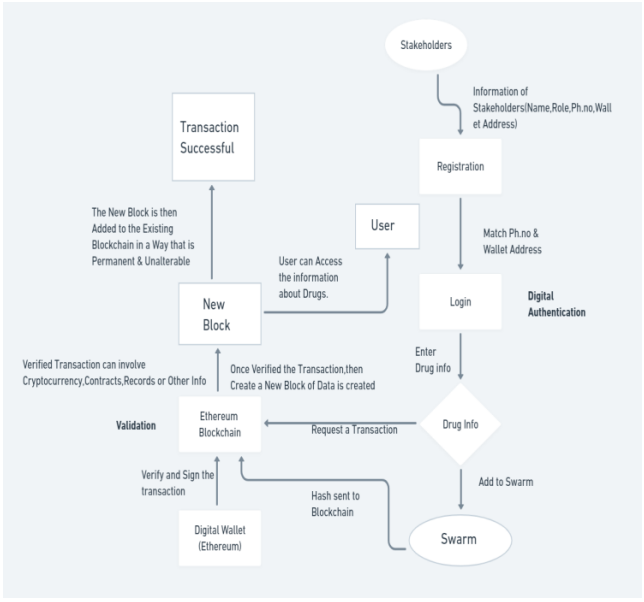

Fig2:System Architecture

VI.PERFORMANCE ANALYSIS

Quantifying the performance of the proposed algorithm involves considering various factors. While specific metrics may vary based on the nature of thealgorithm and goal of the system, a general representation can be provided. Let's denote the overall performance, P, as a function of key performance indicators: P=f(Efficiency,Data Handling,Transactional Delays,Transparency,Scalability,Data Integrity)

1.Efficiency(E):

The algorithm's efficiency can be represented as the ratio of successful and automated processes to the total processes executed.

$$E = \frac{\text{Successful Automated Processes}}{\text{Total processes executed}}$$

2.Data handling:

Data handling performance may be measured by assessing the time efficiency in managing large-scale datasets.

$$D = \frac{\text{Swift access to criticale information}}{\text{Time taken for data handling}}$$

3.Transactional delays:

Transactionaldelays can be quantified by evaluating thetime reduction achieved through smart contract automation.

$$TD = \frac{\text{Reduced transactional time with smart contract}}{\text{Total transactional time}}$$

4.Transparency:

Transparency can be measured as the percentage of transactions with clear traceability.

$$T = \frac{\text{Transparent and traceable transactions}}{\text{Total transactions}}$$

5. Scalability (S):

Scalability can be assessed by considering the growth in the system's capability with increasing datasets or transactions:

$$S = \frac{\text{System capability with increased data transactions}}{\text{Initial system capacity}}$$

6. Data Integrity (DI):

Data integrity can be expressed as the ratio of successfully maintained tamper-proof information to the total information stored:

$$DI = \frac{\text{Tamper proof data successfully maintained}}{\text{Total data stored}}$$

Fig3:Comparison between existing and proposed system.

VII. EXPERIMENTAL RESULT

In this project, we trace the flow of medicine from the manufacturer to the customer. It includes data confidentiality, integrity,time stamp, and hashed key. When the manufacturer signs up with the app, the details will be mined and hashed,then it will be added to the blockchain network as blocks. The same goes for the retailer and other authorized users connected to the Ethereum network. After the sign-up process, They can log in using their ID and password to add the details of the medicine to the blockchain network. Once the stakeholders enter the details of the medicine,it will be mined and the transaction will become successful,resulting in the production of a hashed key,adding the block to the Ethereum network. When a customer who wants to see the details of the medicine can go to the webpage and insert the product ID. The mentioned product ID's details will be retrieved from the swarm file system. The stakeholders can't change or modify the data that has been time-stamped and stored in the blockchain network, ensuring data security and integrity.

A. OUTPUT

Fig4: Home Page

The homepage of a pharmaceutical supply chain management website with blockchain technology is displayed after opening the webpage.The Suppliers,Manufacturers and Retailers use this webpage to enter the details of a specific order, including product name, quantity, order date, and current status (pending).

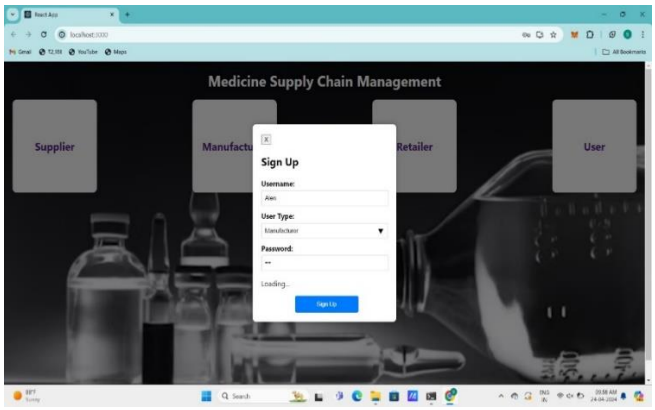

Fig5: Sign Up Form

The image shows a user starting the signup process for a blockchain-based pharmaceutical supply chain management platform. The user selects their role and enters essential credentials.

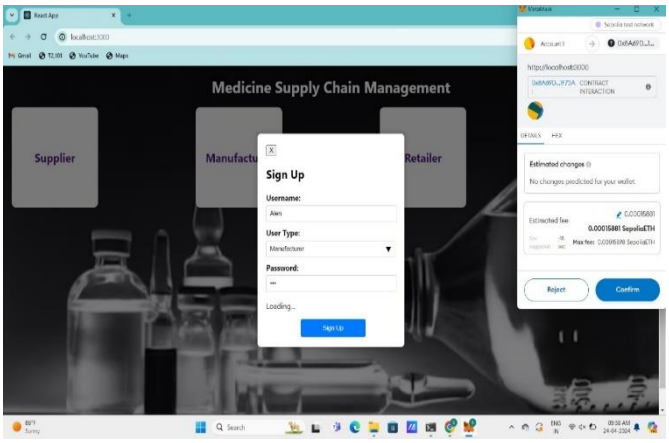

Fig6:Sign Up Process Using Metamask Account

The image portrays the sign-up process. Upon clicking sign-in, MetaMask wallet is launched, containing the required ether balance. After the user confirms the transaction, the mining process starts.

Fig 7: Transaction Successful Conformation

The confirmation message is displayed once the transaction has been successfully completed.

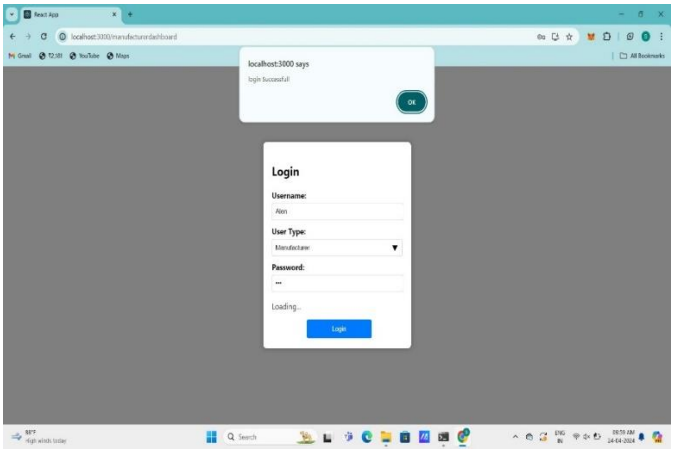

Fig .8 Login Page

Users will be able to select their account and log on to the dashboard after signing up.Login will be successful only if they are authorized users.

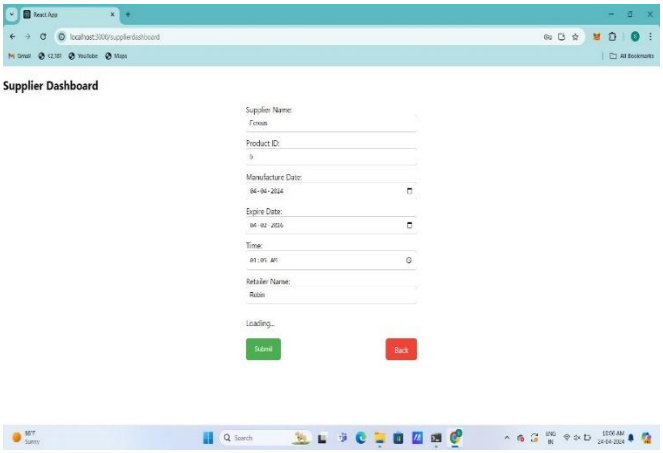

Fig 9: Supplier Dashboard

This image displays the supplier's dashboard where the Supplier can enter the medicine data such as Supplier name,product ID,Manufacturing date,Expiry date,time, and Retailer name.

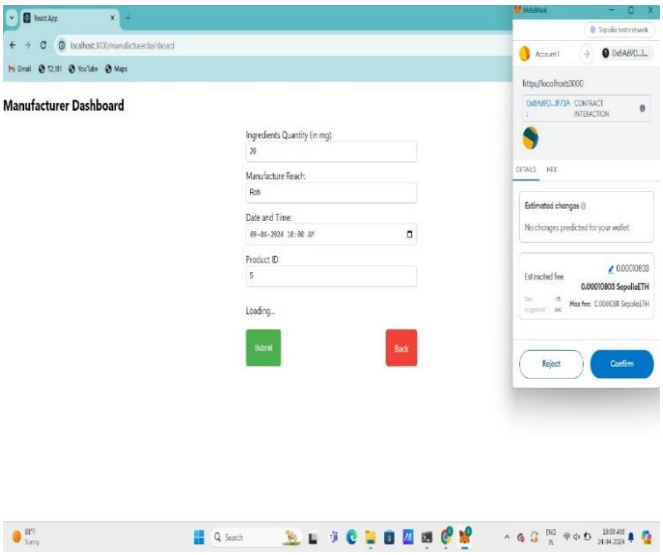

Fig 10: Manufacturer Dashboard

This image displays the Manufacturer's dashboard where the manufacturer can enter the medicine data such as ingredients quantity,Manufacturer name,date and time, and product ID.

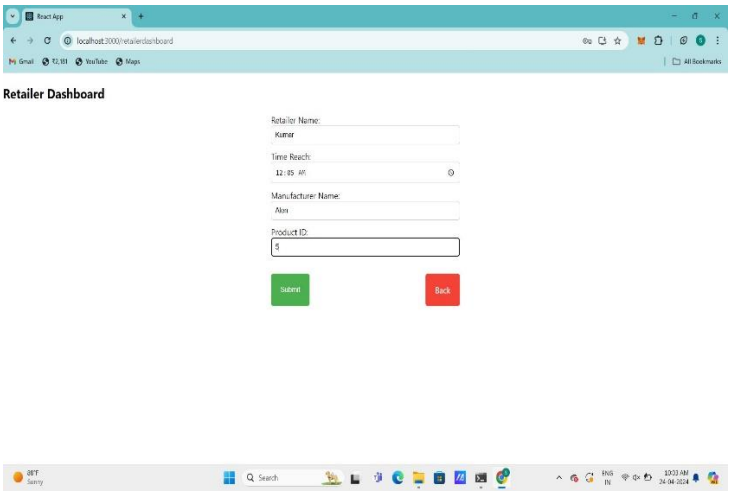

Fig 11: Retailer Dashboard

This image displays the Retailer's dashboard where the Retailer can enter data such as Retailer name,Time reached,Manufacturer name, and product ID.

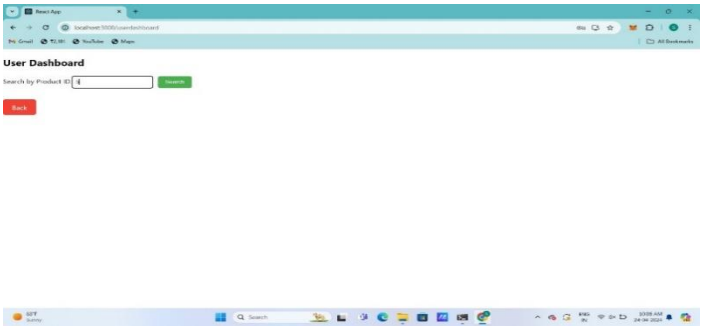

Fig 12: User Dashboard

In this user's dashboard user can enter the product ID which is the primary key to retrieve and add the data related to a particular medicine.Each medicine hasa unique product ID.

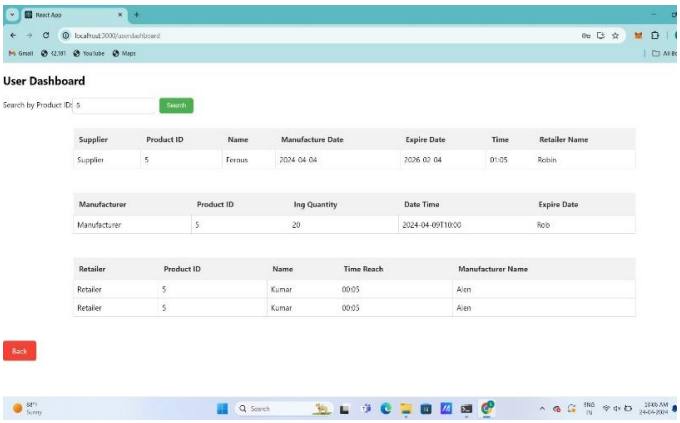

Fig 13: Output Page

After entering the product ID,the user can view all the data related to medicine entered by authorized Suppliers, manufacturers, and retailers.

VIII. CONCLUSION

The existing pharmaceutical supply chain has major hurdles in ensuring medicine validity, data integrity, and effective traceability. Existing solutions, whether centralized or employing blockchain-IPFS integration, have transparency, security, and scalability challenges. This article investigated the possibilities of a unique strategy that addresses these issues by combining blockchain technology and Swarm storage integration.

This proposed system is a revolutionary approach to pharmaceutical supply chain management. By exploiting blockchain's immutability, the system allows for thorough medicine monitoring throughout their trip. Stakeholders have real-time visibility into the transit of drugs, allowing them to quickly identify possible concerns such as counterfeiting or delays. Furthermore, the use of cryptographic hashing and smart contracts on the blockchain assures tamper-proof data storage and reduces the danger of cyberattacks or human mistakes. This improves data integrity and creates a safer environment for handling sensitive pharmacological information. Finally, Swarm storage provides a more scalable option than IPFS, allowing the system to efficiently manage the ever-increasing volume of data related to drugs. As the sector advances and data volumes grow, the suggested solution would seamlessly adapt and handle these changes.

This blockchain-based solution, which includes Swarm storage integration, represents a substantial advancement in the security and simplification of pharmaceutical supply chains.While this work has concentrated on the system's main features, more research might reveal even greater possibilities.By constantly exploring, improving, and enhancing this method, we may build a future in which the pharmaceutical supply chain is not just efficient, but also demonstrably secure and trustworthy. This will eventually lead to increased patient safety, higher medicine quality, and a stronger pharmaceutical sector.

REFERENCES

[1] Makhdoom, I., Abolhasani, M., & Javadi, B. (2019). Blockchain for Gastroenterology: A novel approach for management and sharing of patients' clinical data. Journal of Gastrointestinal and Liver Diseases, 28(3), 289-292.

[2] Li, H., Zhu, L., Shen, M., Gai, K., & Yang, Y. (2018). Blockchain-based data preservation system for medical data.Journal of Medical Systems, 42(8), 141..

[3] Xia, Q., Sifah, E. B., Asamoah, K. O., Gao, J., Du, X., & Guizani, M. (2017). MeDShare: trust-less medical data sharing among cloud service providers via blockchain. IEEE Access, 5, 14757-14767.K. Elissa, "Title of paper if known," unpublished.

[4] Yue, X., Zhang, Y., Jin, D., & Zhang, J. (2018). Trust but verify: A blockchain-based approach to improving transparency in supply chain social auditing. IEEE Transactions on Industrial Informatics, 14(8), 3690-3697.

[5] Mettler, M. (2016). Blockchain technology in healthcare: The revolution starts here. In Proceedings of the IEEE 18th International Conference on e-Health Networking, Applications and Services (Healthcom) (pp. 1-3). IEEE.M.

[6] Halamka, J. (2017). Beyond the EHR: Blockchain for healthcare and social determinants of health. Health Affairs Blog,10.

[7] Cheng, S., & Roan, J. (2018). Blockchain-based sharing services for medical records in EHR systems. IEEE Access, 6,3857-3865.

[8] Huh, S., Cho, S., Kim, S., & Kang, B. (2017). Secure data sharing scheme for electronic health records in cloud computing. Healthcare informatics research, 23(3), 201-207.