BHealth: Blockchain-aided Secure Healthcare System

A Project

Submitted in partial fulfilment of the requirements for

the award of the Degree of

BACHELOR OF COMPUTER APPLICATION

By

ANSHUMAN MAITY

ROLL NO-*12021004006092* AND REGISTRATION NO-*213661001210098*

SUPRATIM GHOSH

ROLL NO-*12021004006123* AND REGISTRATION NO-*213661001210069*

SAYAN SINGHA ROY

ROLL NO-*12021004006087* AND REGISTRATION NO-*213661001210104*

PRIYA MANDAL

ROLL NO-*12021004006088* AND REGISTRATION NO-*213661001210103*

BIPASHA JOARDAR

ROLL NO- *12021004006111* AND REGISTRATION NO- *213661001210080*

DEPARTMENT OF COMPUTER APPLICATION

INSTITUTE OF ENGINEERING & MANAGEMENT

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DECLARATION CERTIFICATE

This is to certify that the work presented in the thesis entitled **"BHealth: Blockchain-aided Secure Healthcare System"** in partial fulfilment of the requirement for the award of degree of **Bachelor of Computer Application** of Institute of Engineering & Management is an authentic work carried out under my supervision and guidance.

To the best of my knowledge the content of this thesis does not form a basis for the award of any previous Degree to anyone else.

Date: 12/04/2024

Faculty Name- Prof. Samik Datta

Dept. of Computer Application and Science

Institute of Engineering & Management, Kolkata

Prof. Dr. Rupam Bhattacharya
Assistant Head of the Department
Dept. of Computer Application
Institute of Engineering & Management

Prof. Nayantara Mitra
Assistant Head of the Department
Dept. of Computer Application
Institute of Engineering & Management

CERTIFICATE OF APPROVAL

The foregoing thesis entitled **"BHealth: Blockchain-aided Secure Healthcare System"** is hereby approved as a creditable study of research topic and has been presented in satisfactory manner to warrant its acceptance as prerequisite to the degree for which it has been submitted.

It is understood that by this approval, the undersigned do not necessarily endorse any conclusion drawn or opinion expressed therein, but approve the thesis for the purpose for which it is submitted.

(Internal Examiner) **(External Examiner)**

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Name of Student: Anshuman Maity

Roll Num: *12021004006092*

Name of Student: Supratim Ghosh

Roll Num: *12021004006123*

Name of Student: Sayan Singha Roy

Roll Num: *12021004006087*

Name of Student: Priya Mandal

Roll Num: *12021004006088*

Name of Student: Bipasha Joardar

Roll Num: *12021004006111*

Contents

Abstract:

This project aims to revolutionize the healthcare system by leveraging blockchain technology to enhance the security, transparency, and interoperability of health records. Traditional healthcare systems often face challenges related to data integrity, accessibility, and trust. Our solution, named **BHealth: Blockchain-aided Secure Healthcare System** to create a decentralized and tamper-resistant ledger for building a secure future for Healthcare data.

Blockchain is an emerging technology being applied for creating innovative solutions in various sectors, including healthcare. A Blockchain network is used in the healthcare system to preserve and exchange patient data through hospitals, diagnostic laboratories, pharmacy firms, and physicians. Blockchain applications can accurately identify severe mistakes and even dangerous ones in the medical field. Thus, it can improve the performance, security, and transparency of sharing medical data in the health care system. Blockchain plays a decisive part in handling deception in clinical trials; here, the potential of this technology offer is to improve data efficiency for healthcare. It provides versatility, interconnection, accountability, and authentication for data access. For different purposes, health records must be kept safe and confidential. In this work, we studied Blockchain technology and its significant benefits in healthcare.

Chapter 1

1.1 Introduction:

Medical and smart healthcare innovation has always been top priorities to be improved in every manner with the ongoing technology advancements. Improving the process, protocol, trust, and effectiveness of medical services and patient support feeding and caring for with expertise is the only thing that matters. The modern world has been witnessing people being less inclined to seek personal medical attention until a serious Hardship appears. Also, in recent years, the healthcare sector has faced challenges related to data security, privacy, and interoperability. Patient records are often scattered across various centralized systems, leading to inefficiencies, data breaches, and compromised patient care. To mitigate this, several researchers suggested the use of Blockchain technology, which is renowned for its decentralized and tamper-resistant nature, as a potential solution to address these issues.

With the emergence of Blockchain, recently, the technology has taken over all aspects of access, transaction, and storage management. Blockchain has also demonstrated a strong hold and potential in a variety of industries, including supply chain, retail, finance, healthcare, management, and so forth. For example, in healthcare, the first concern that consistently surfaced is the security and privacy of the data because many stakeholders frequently use it to take appropriate action.

For instance, insurance companies are one of the parties involved in offering the patient a specific service for which insurance is frequently required. The patient's data must be obtained by the provider to clearly assess it and outline the services, but it can frequently be observed that the companies manipulate the data and also leak it. In order to prevent data from being misused, as well as In order to preserve a clear sense of trust among the various parties involved, there is a real solution in this system.

Decentralization is a key feature of blockchain technology. There is no central authority to control the content added to the blockchain, but rather the entry that enters the blockchain agrees to the peer-to-peer network and uses the

various consensus minimization protocols here. Security of data is the main key focus of blockchain transaction. As data are transferred through blockchain without the involvement of any third parties, there is practically no risk of data theft or alteration. Persistence is another key feature of the blockchain. Entries can no longer be deleted once they have been recognized in the blockchain because of a shared ledger stored across many nodes. In addition, an interesting feature of the pseudonymity blockchain is that it is used in many blockchains.

The Blockchain data structure consists of the following components:

• The Blockchain network has secured list of blocks which contains the useful information.

• A peer-to-peer network which contains identical examples of the Blockchain data structure.

• A consensus mechanism which secures the harmonized growth of Blockchain.

• A security mechanism that ensures that the data stored in the Blockchain network is immutable.

Currently, there are a huge amount of separate health information systems, which hold the data of the individual patients in huge silos of health information. These information systems are organized by different ways. The ways of organizing data depends on the goals of the health care provider's business. It is totally different in case of a diagnostic centre or in case of a general practitioner. Anyway, in both cases ultimately (name, value) pairs describe the results of an encounter and different structuring procedures integrate the data into EHR records. The (name, value) pairs are implicitly always extended by several essentials attributes, where the time of the event represents a crucial role. In order to integrate these isolated data silos a series of interfaces are built and maintained continuously. To resolve the problem of interfacing the different health data recording systems a wide range of protocols have emerged.

Chapter 2

2.1 Background Studies

Healthcare Challenges:

- **Data Privacy Concerns:** Investigate the challenges related to protecting sensitive patient information and maintaining privacy in traditional healthcare systems.

- **Security Breaches:** Analyse instances of security breaches in healthcare and their impact on patient trust and data integrity.

- **Interoperability Issues:** Explore the difficulties arising from the lack of standardized data formats and protocols for sharing information among healthcare entities.

Blockchain Technology in Healthcare:

- **Decentralization in Healthcare:** Examine how the decentralized nature of blockchain can mitigate the risks associated with central points of failure in healthcare systems.

- **Smart Contracts:** Explore the potential of smart contracts to automate and enforce agreements, such as consent management and insurance claims.

- **Use Cases:** Investigate successful implementations of blockchain in healthcare, such as supply chain management, patient records, and pharmaceutical traceability.

2.2 Literature Survey

Blockchain in Healthcare: A Comprehensive Review:

This study explores the current state of blockchain applications in healthcare, highlighting various implementations for securing and managing patient data. It provides insights into the benefits and challenges of integrating blockchain into existing healthcare systems.

Decentralized Identity Management in Healthcare Using Blockchain:

Focusing on identity management in healthcare, this research discusses the potential of blockchain to create a decentralized patient identity system. It reviews existing solutions and proposes a novel approach to enhance patient control and privacy in managing their health data.

Smart Contracts in Healthcare: Opportunities and Challenges:

This literature review delves into the use of smart contracts in healthcare scenarios. It discusses how programmable contracts on the blockchain can automate and optimize processes such as billing, insurance claims, and consent management, offering a comprehensive understanding of the technology's potential impact.

Security and Privacy Considerations in Healthcare Blockchain Networks:

Examining the critical aspect of security and privacy, this paper assesses the vulnerabilities and risks associated with implementing blockchain in healthcare. It provides a comparative analysis of different blockchain platforms and protocols, focusing on their ability to safeguard sensitive health information.

Interoperability Challenges in Blockchain-Based Healthcare Systems:

Addressing the need for interoperability, this survey identifies challenges and opportunities in creating a blockchain-based healthcare ecosystem that seamlessly integrates with existing infrastructures. It reviews standards,

protocols, and interoperability frameworks to achieve a unified and interconnected healthcare network.

Patient-Centric Healthcare Systems: A Blockchain Perspective:

This research explores the concept of patient-centric healthcare and examines how blockchain technology can empower patients to have more control over their health data. It reviews case studies and existing implementations that prioritize patient autonomy and consent.

Case Studies of Blockchain Implementation in Healthcare Institutions:

A collection of case studies detailing the real-world implementation of blockchain in healthcare organizations. These case studies provide insights into the challenges faced, lessons learned, and outcomes achieved, offering practical knowledge for the design and execution of our project.

Legal and Ethical Implications of Blockchain in Healthcare:

Investigating the legal and ethical considerations, this literature survey explores the regulatory landscape surrounding the use of blockchain in healthcare. It addresses issues related to data ownership, consent management, and compliance with healthcare regulations.

By conducting a comprehensive literature survey covering these key areas, our project aims to build on existing knowledge and contribute to the advancement of blockchain technology in the healthcare sector.

Chapter 3

3.1 Proposed Methodology

The massive volume of healthcare data produced by the patients' needs to be processed and managed while adhering to a secure protocol. The Patient usually maintains the personal healthcare data and this data can be accessed by the doctor for proper medication. To make it secure, this data needs to store in external cloud database through the blockchain system. Fig. 1 depicts the schematic diagram of the proposed system.

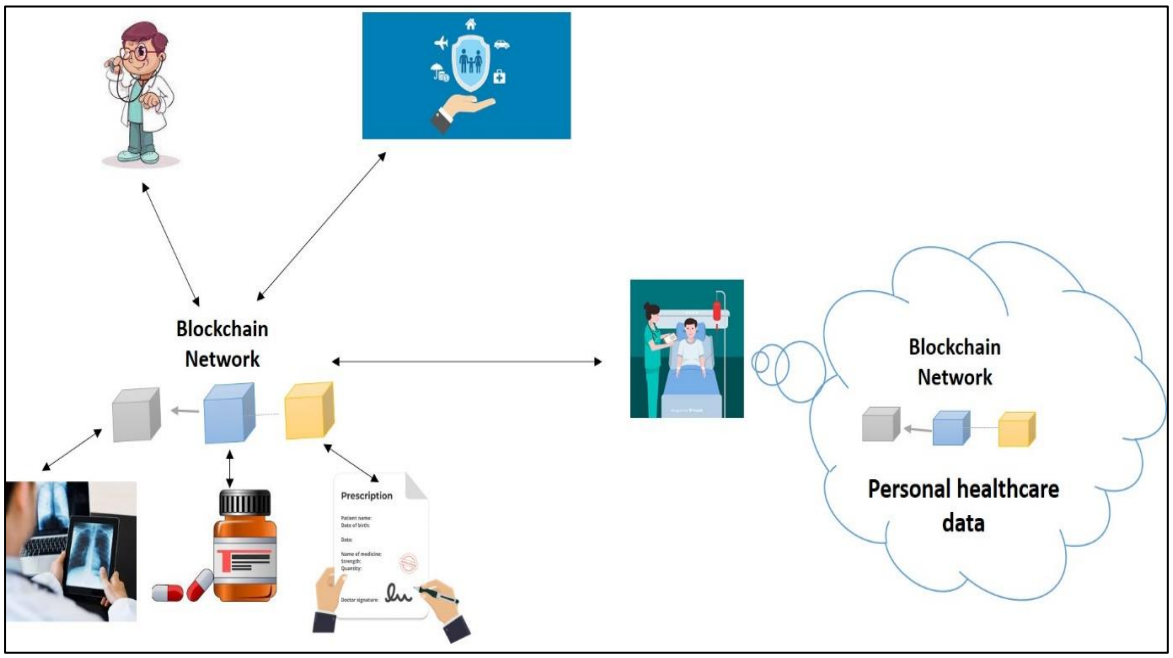

Fig. 1: Schematic Diagram for BHealth

This system is utilized for the purpose of securely managing the data that is being generated when a patient goes to the doctor. It usually stores the data generated by the healthcare centres, pharmacy bills, medical test reports, prescriptions and image data in the blockchain platform securely. The data is being appended to the chain based upon the consensus of all the stakeholders of the blockchain on the "Proof of Stake" algorithm. Fig. 2 and 3 shows architecture of secure data management system and information system of BHealth.

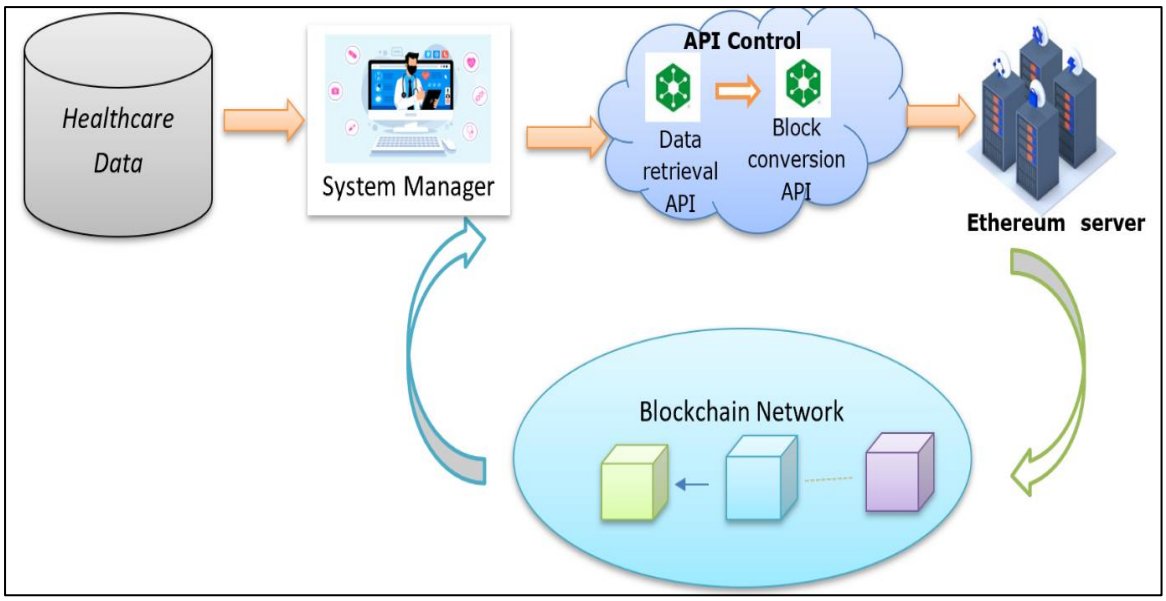

Fig. 2: Secure Data Management of BHealth

This diagram illustrates the process of how BHealth utilizes blockchain technology to ensure the secure management of health data. Here's a detailed breakdown of the components and processes depicted in the diagram:

Data Entry: Healthcare data, such as patient records, medical history, test results, and treatment plans, are entered into the BHealth system. This could be done by healthcare providers, laboratories, or directly by patients through authorized channels.

Encryption: Before being stored on the blockchain, the data is encrypted using robust encryption algorithms. This ensures that sensitive information remains secure and confidential throughout the process.

Blockchain Network: The encrypted data is then transmitted to the blockchain network, which consists of a decentralized network of nodes (computers) that validate and record transactions. Each transaction represents a data entry or update within the BHealth system.

Consensus Mechanism: The blockchain network relies on a consensus mechanism, such as Proof of Work (PoW) or Proof of Stake (PoS), to validate and agree on the validity of transactions. This ensures that only legitimate and authorized transactions are accepted onto the blockchain.

Immutable Ledger: Once validated, the encrypted data is added to the blockchain as a new block, forming an immutable and tamper-proof ledger. This means that once data is recorded on the blockchain, it cannot be altered or deleted without the consensus of the majority of the network.

Decentralization: The decentralized nature of the blockchain ensures that there is no single point of failure or control. This enhances the security and reliability of the BHealth system, as there is no central authority that can be compromised or manipulated.

Access Control: Access to the health data stored on the blockchain is controlled through cryptographic keys. Only authorized parties, such as healthcare providers and patients, have the necessary keys to access and view specific portions of the data, ensuring privacy and confidentiality.

Audit Trail: The blockchain maintains a transparent and immutable audit trail of all transactions and changes made to the health data. This enables traceability and accountability, as any unauthorized access or modifications can be easily detected and investigated.

Overall, the secure data management of BHealth leverages blockchain technology to create a transparent, secure, and privacy-preserving system for storing and managing health data.

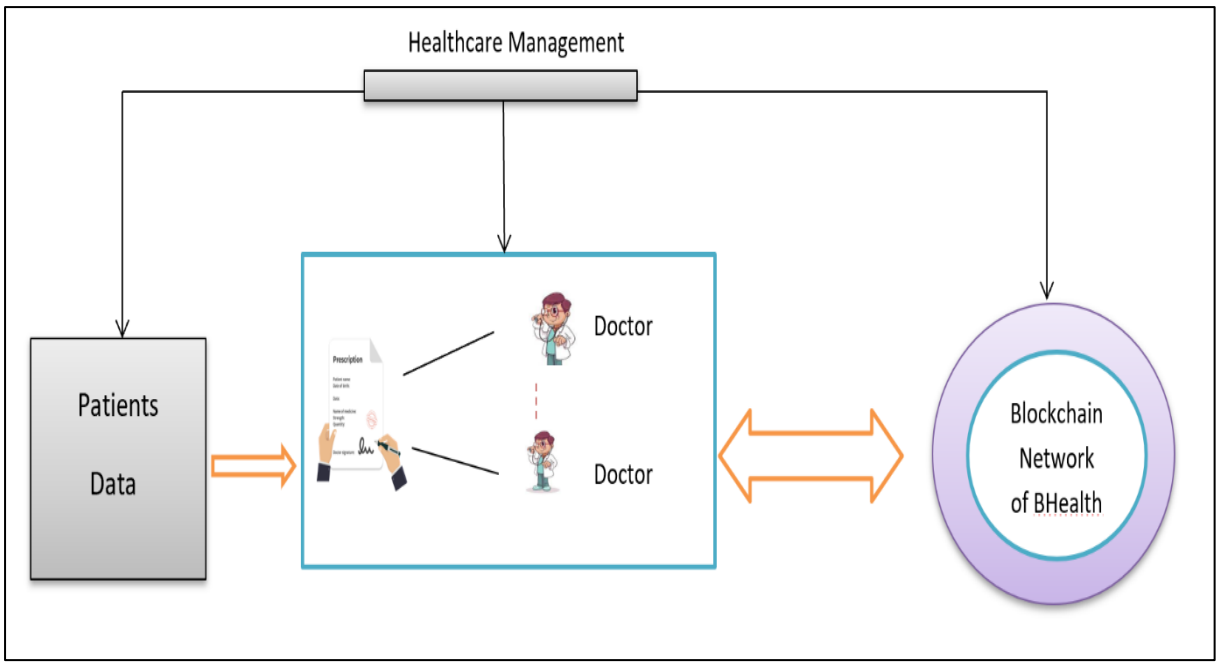

Fig. 3: BHealth Information System

This diagram provides an overview of the BHealth Information System, highlighting the key components and interactions within the system. Here's a detailed explanation of the elements depicted in the diagram:

User Interface (UI): The BHealth Information System features a user-friendly interface that allows healthcare providers, patients, and other authorized users to interact with the system. The UI provides access to various functionalities, such as viewing patient records, updating medical information, and accessing health services.

Blockchain Integration: The BHealth system is integrated with a blockchain network, which serves as the underlying infrastructure for storing and managing health data. Through blockchain technology, the system ensures data security, integrity, and privacy, while also enabling transparent and auditable transactions.

Data Storage: Patient health records, medical documents, diagnostic reports, and other relevant information are securely stored on the blockchain. Each

piece of data is encrypted and recorded as a transaction on the blockchain, ensuring that it cannot be tampered with or accessed by unauthorized parties.

Smart Contracts: Smart contracts are self-executing contracts with the terms of the agreement directly written into code. In the context of BHealth, smart contracts are used to automate and enforce various healthcare processes and agreements, such as insurance claims, treatment plans, and consent management. This helps streamline operations, reduce errors, and ensure compliance with predefined rules and regulations.

Integration with External Systems: The BHealth Information System may be integrated with external systems and databases, such as electronic health record (EHR) systems, laboratory information systems (LIS), and health insurance databases. These integrations allow for seamless exchange of data and interoperability between different healthcare entities, improving the overall efficiency and effectiveness of the system.

Security Measures: The BHealth system incorporates robust security measures to protect sensitive health data from unauthorized access, breaches, and cyber-attacks. This includes encryption techniques, access control mechanisms, multi-factor authentication, and regular security audits and updates.

Data Analytics and Reporting: The system may also feature built-in analytics tools and reporting functionalities, allowing healthcare providers and administrators to analyse trends, monitor patient outcomes, and generate insights from the data stored in the system. This supports evidence-based decision-making and continuous improvement of healthcare services.

Overall, the BHealth information system provides comprehensive and secure platform managing health information, facilitating communication and collaboration among healthcare stakeholders, and improving the quality and efficiency of healthcare delivery.

Chapter 4

4.1 Experimental Dataset

- **Platform Used:** Ethereum: Ethereum is one of the most widely used blockchain platforms for developing decentralized applications (DApps) and smart contracts. Ethereum was chosen for its robust smart contract capabilities, established community support, and widespread adoption in healthcare-related blockchain projects.

- **IDE Used:** IDE: Remix IDE: is an open-source web-based integrated development environment (IDE) primarily designed for Solidity smart contract development. It offers a user-friendly interface for writing, testing, and debugging smart contracts. Remix IDE provides features such as syntax highlighting, auto-completion, and built-in debugging tools, making it suitable for blockchain development projects.

- **Designing Tools Used:**

  - **Lucid chart:** Utilized for creating system architecture diagrams and illustrating the flow of patient data within the blockchain network.
  - **Draw.io:** Employed for creating visual representations of smart contract logic and interactions.

- **Web3.js:** serves as a crucial tool for developers building decentralized applications on the Ethereum blockchain, providing the necessary functionality to connect, interact, and integrate blockchain capabilities into web applications.

Chapter 5

5.1 Result and Discussions

- **Performance Metrics:** Define metrics for evaluating the performance of the blockchain-based healthcare system, such as transaction speed, scalability, and resource utilization.

- **Security Assessment:** Present the results of security assessments, including any attempts at unauthorized access and the system's resilience to such attempts.

- **Comparison with Traditional Systems:** Compare the proposed blockchain-based system with traditional centralized healthcare systems, highlighting advantages such as increased security and interoperability.

- **Performance Evaluation:** In this section, a thorough simulation is used to access the proposed system's performance. We use solidity to write smart contracts and Ethereum as the blockchain platform to implement our proposed system.

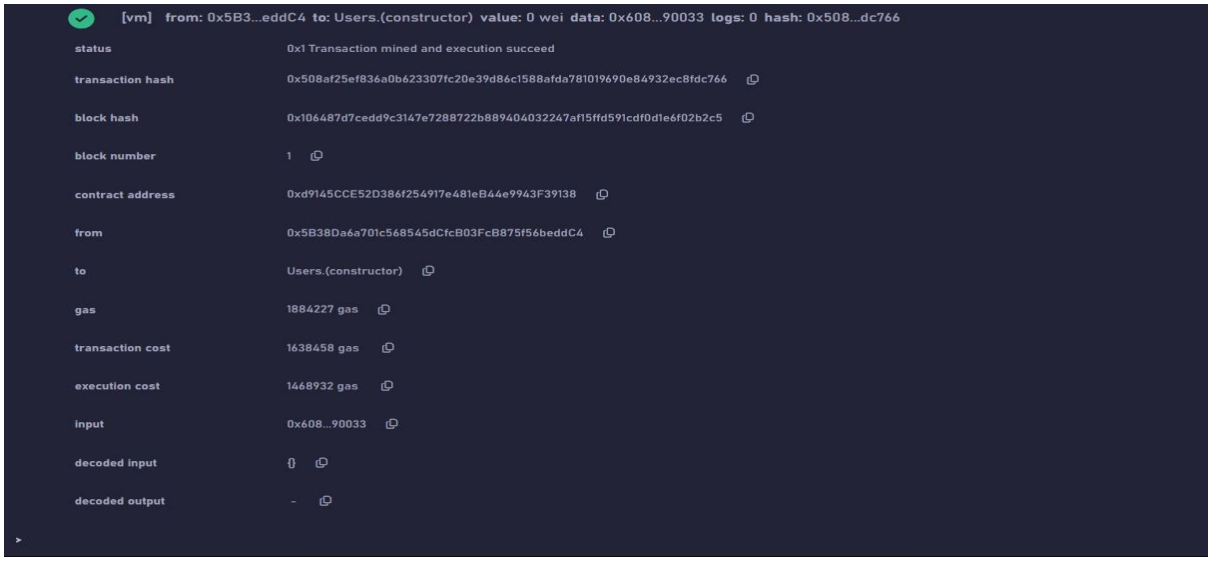

Fig 4: Logs for successful deployment of register contracts and validation.

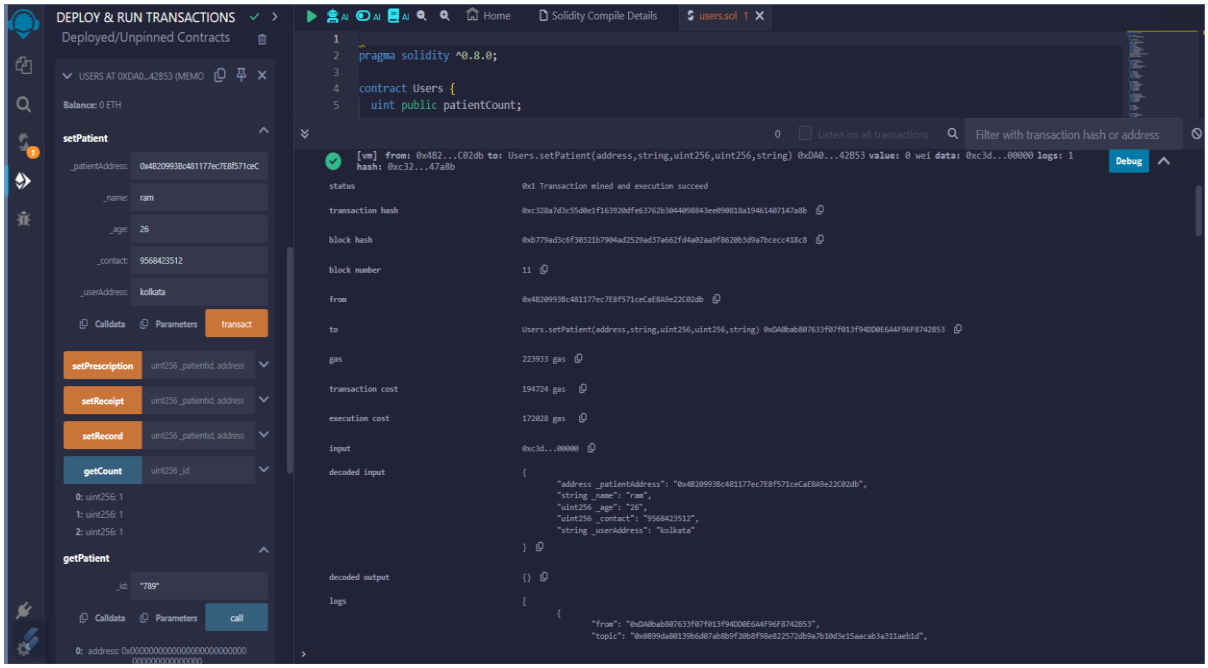

Fig 5: The function “set Patient” likely pertains to a software or system function designed to set or update patient information within a healthcare or medical application.

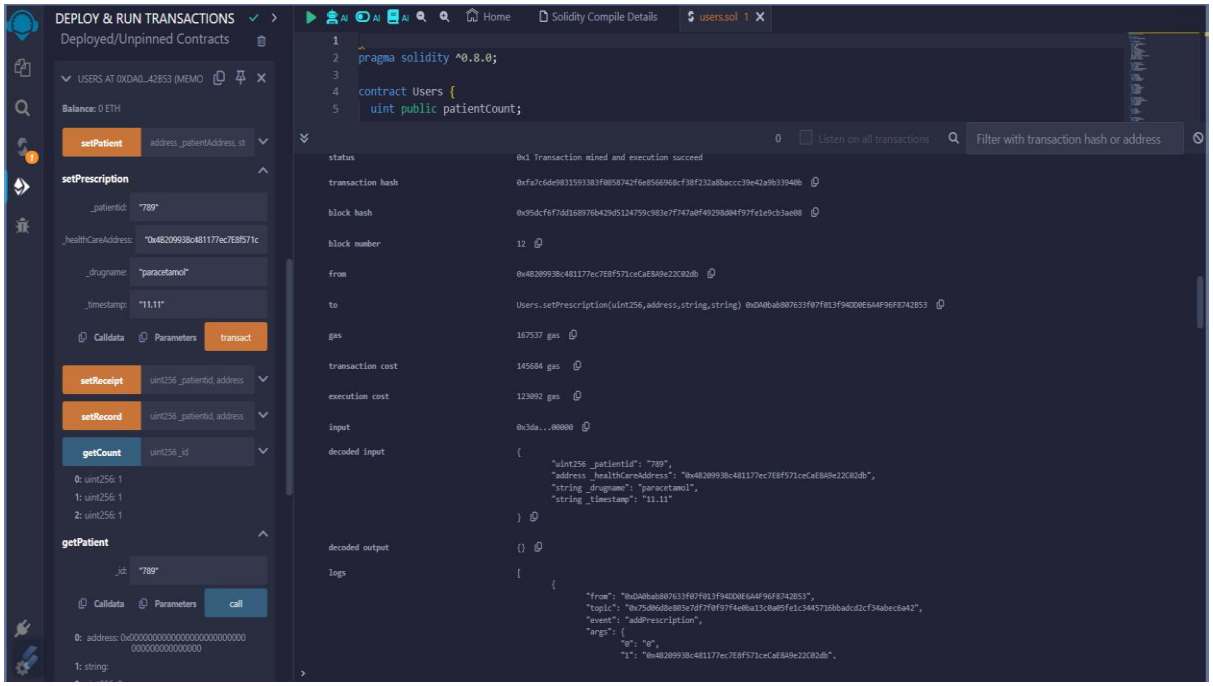

Fig 6: The "set Prescription" function in Ethereum would facilitate the creation and updating of prescription data within a decentralized and secure environment, enabling transparent and auditable management of patient prescriptions on the blockchain.

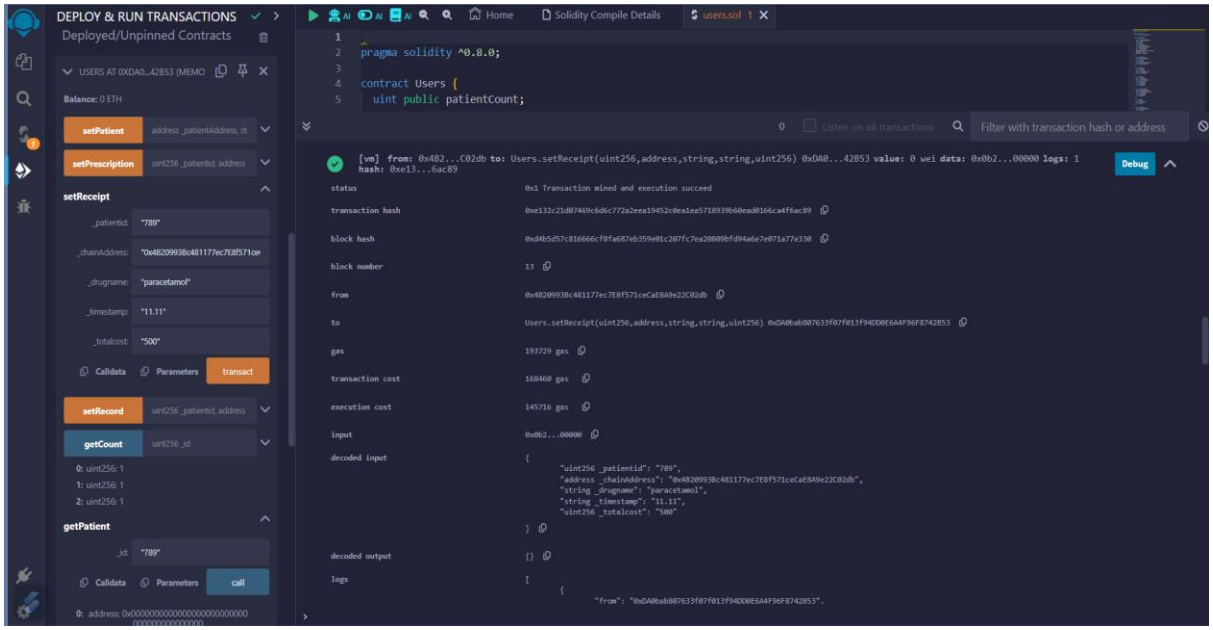

Fig 7: The "setReceipt" function in Ethereum would facilitate the recording and updating of transaction receipt data within a decentralized and secure environment, providing transparency and accountability for financial transactions conducted on the blockchain.

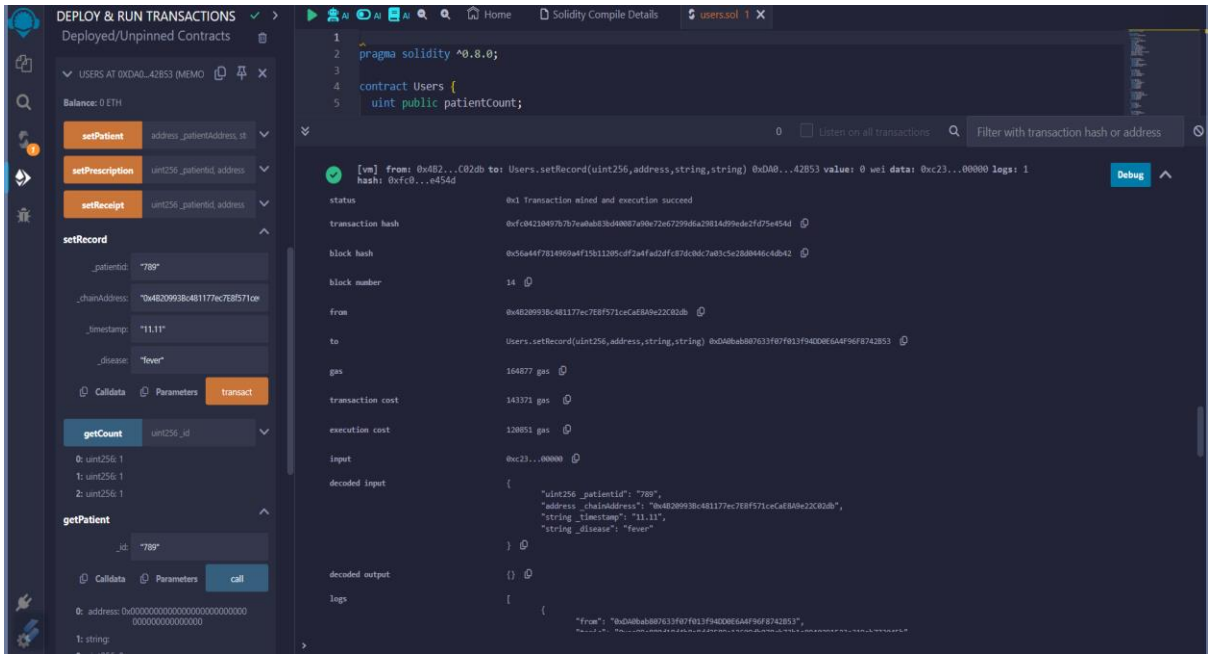

Fig 8: The "setRecord" function in Ethereum facilitates the creation and updating of various types of records within a decentralized and secure environment, providing transparency, accountability, and data integrity for applications or use cases built on the blockchain.

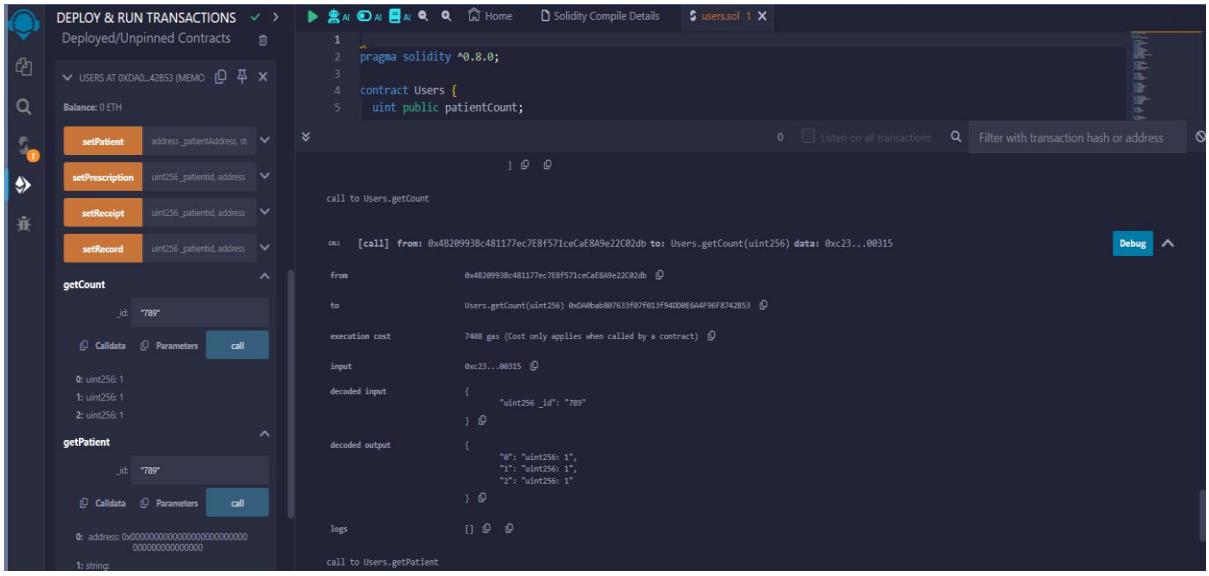

Fig 9: The "getCount" function in Ethereum enables users or other contracts to retrieve count information about specific elements stored or processed within a smart contract, facilitating data querying, monitoring, and analysis within decentralized applications and blockchain-based systems.

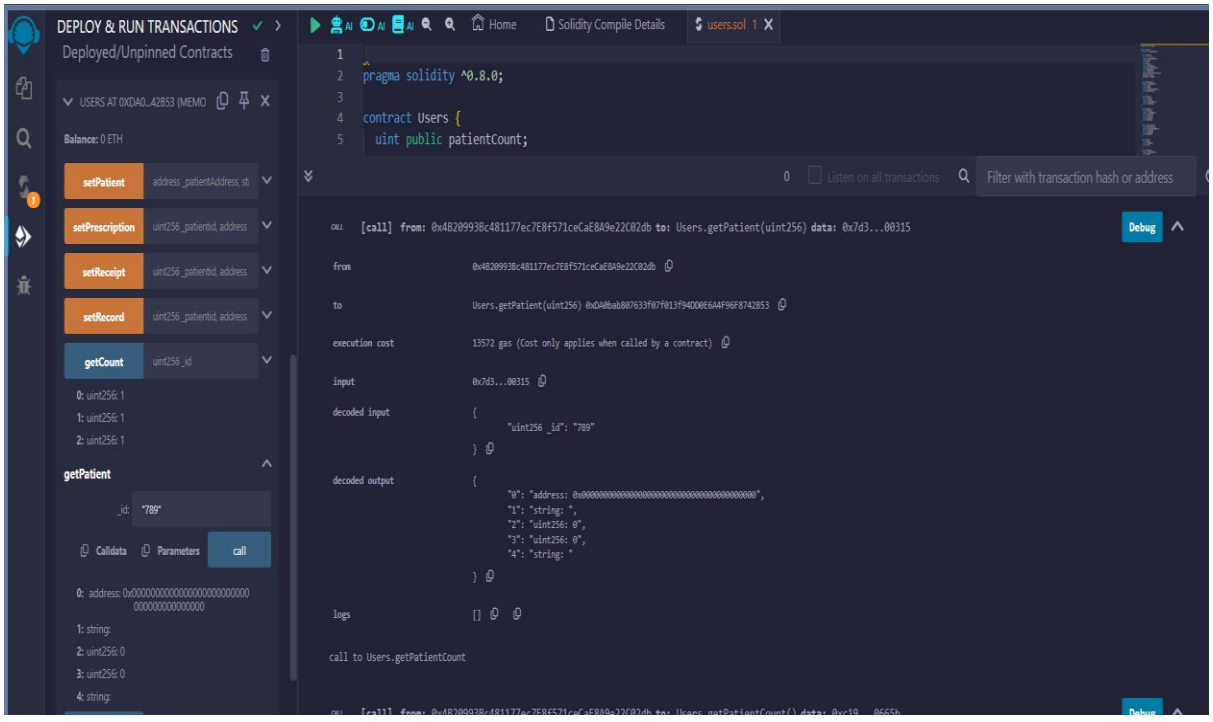

Fig 10: The "getPatient" function in Ethereum or blockchain-based healthcare systems facilitates the retrieval of patient information in a secure, transparent, and auditable manner, enabling efficient healthcare delivery, research, and analysis while ensuring patient privacy and data integrity.

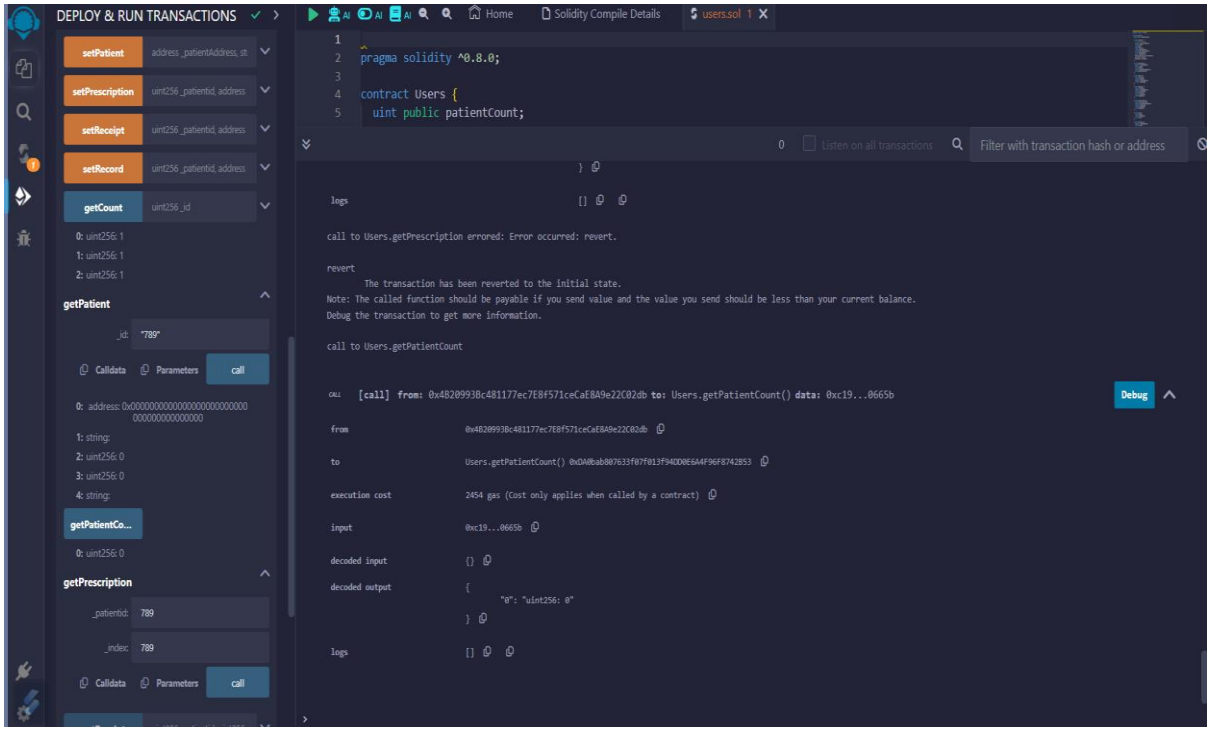

Fig 11: The "getPrescription" function in blockchain-based healthcare systems enables the secure and transparent retrieval of prescription information, facilitating efficient medication management, patient care, and compliance with healthcare regulations while ensuring data privacy and integrity.

Chapter 6

6.1 Conclusion:

In conclusion, this project has sought to address the critical challenges faced by the healthcare industry through the implementation of a blockchain-based healthcare system. The traditional healthcare systems have long grappled with issues of data security, privacy breaches, and interoperability, hindering the seamless exchange of patient information among different stakeholders. By leveraging the decentralized and tamper-resistant nature of blockchain technology, our proposed system aims to revolutionize healthcare data management. Moreover, our system addresses the longstanding issue of interoperability by enabling seamless data exchange among healthcare providers, insurers, pharmacies, and other authorized entities within the ecosystem. Adhering to open standards and decentralized protocols, our blockchain-based application facilitates the secure sharing of medical information across different systems, breaking down data silos and enabling more coordinated patient care. While our implementation represents a significant step forward, we recognize the need for continuous improvement and adaptation. Scalability remains a challenge, and future iterations should explore mechanisms to enhance the throughput and efficiency of the system while maintaining its decentralized integrity. Additionally, as blockchain technology continues to evolve, we must remain vigilant in addressing emerging security concerns, regulatory compliance requirements, and user adoption barriers to ensure the widespread acceptance and success of this solution. Ultimately, our blockchain-based healthcare system serves as a proof of concept, demonstrating the transformative potential of this technology in revolutionizing healthcare data management. By prioritizing security, interoperability, transparency, and patient empowerment, we have paved the way for a more resilient, collaborative, and patient-centric healthcare ecosystem. As we continue to refine and expand this solution, we are confident that blockchain will play an increasingly vital role in reshaping the future of healthcare delivery, fostering better outcomes, and driving innovation within the industry.

6.2 Future Work:

- **Addressing Limitations:** Discuss any limitations encountered during the project and propose potential solutions or improvements.

- **Scaling the System:** Explore opportunities for scaling the system to accommodate a larger user base and more extensive datasets.

- **Integration with Emerging Technologies:** Suggest potential integrations with emerging technologies such as AI and IoT to enhance the capabilities of the healthcare system.

Looking ahead, there are several avenues for future work and improvement. Addressing the scalability challenges, exploring integration with emerging technologies like AI and IoT, and conducting more extensive real-world testing are crucial for the continued evolution and success of blockchain-based healthcare systems. This project lays the foundation for future research endeavours that can further advance the adoption and effectiveness of blockchain technology in transforming healthcare data management.