# Chapter 10
# Healthcare Records Maintenace in Smart Cities for Healthcare 4.0:
## A Approach With Blockchain

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## ABSTRACT

*Healthcare records management systems are essential for ensuring the security, integrity, and accessibility of patient data. Data breaches, unauthorized access, and inefficiencies in data sharing are all issues that traditional systems face. This chapter describes a novel approach to healthcare records management that incorporates block chain technology, specifically Ganache, Truffle, Meta Mask, and the MEAN stack. Meta Mask improves the user experience by providing a secure and easy-to-use authentication mechanism. The MEAN stack aids in the creation of a responsive and dynamic web application. The proposed system's design, implementation, and testing are all part of the research methodology. Security assessments, performance benchmarks, and user feedback are all examples of evaluation metrics. The results show increased data security, streamlined access controls, and improved data sharing capabilities.*

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## MOTIVATION

The impetus for this project derives from the urgent need to solve the various flaws in healthcare record administration. Current systems are vulnerable to data breaches, lack transparency, and suffer from data silos, all of which impede timely patient treatment and research. Block chain technology provides a decentralized, secure, and tamper-proof system that has the ability to transform healthcare records. We hope that by using this technology, we will be able to give patients more control over their data, increase data integrity, expedite interoperability across healthcare providers, and ultimately improve patient outcomes. The initiative aims to solve these critical challenges by leveraging block chain's disruptive potential in healthcare.

### Project Objective

The primary goal of this project is to design, create, and test a viable block chain-based system for managing healthcare records. This system will strive to secure data security, integrity, and patient privacy while also allowing for smooth data interchange across healthcare providers. Specifically, the project aims to establish a secure patient identity verification system, a decentralized ledger for healthcare information, and safe, patient-controlled data sharing. Furthermore, the project will investigate healthcare regulatory compliance as well as the practicality and scalability of block chain technology in healthcare. The project's ultimate goal is to deliver a comprehensive solution to improve the healthcare records management environment.

## SCOPE OF THE PROJECT

The goal of this project is to conceptualize, design, create, and test a block chain-based healthcare records management system. It will entail looking at existing block chain technology and healthcare data standards, as well as creating a proof-of-concept application. The project will prioritize data security, privacy, and integrity, as well as patient consent management and compatibility with existing healthcare systems. It should be noted, however, that this project will not address the comprehensive integration of the proposed system into the larger healthcare infrastructure, but would instead provide a basic framework for future deployment and adoption in the healthcare sector.

## ROLE OF AUTHORS

The authors collectively bring a diverse range of expertise and experiences vital to the conception, development, and realization of this research. Dr. Rohit Rastogi led the conceptualization and design phase, leveraging their extensive knowledge in healthcare informatics and block chain technology. Mr. Prabhinav Mishra contributed significantly to the technical implementation, particularly in integrating Ganache, Truffle, Meta Mask, and the MEAN stack, drawing from their expertise in software development and block chain architecture. Mr. Rayush Jain played a pivotal role in data analysis and evaluation, employing their statistical proficiency to assess system performance and security metrics. Mr. Shahjahan provided critical insights into the healthcare domain's requirements and implications, ensuring the system's alignment with industry standards and user needs. The collaborative effort and synergy among the authors were instrumental in every phase of this research, from ideation to experimentation and documentation, resulting in a comprehensive and impactful contribution to the field of block chain-enabled healthcare records management.

## DELIVERABLES

- **Prototype/System**: A working prototype or system that demonstrates the use of block chain technology, Ganache for local testing, Truffle for smart contracts, Meta Mask for secure authentication, and the MEAN stack for web application development.
- **Technical Documentation**: Extensive documentation documenting the system architecture, design decisions, implementation approaches, and codebase explanations to facilitate comprehension and future development.
- **Research Paper**: A thorough research paper that details the project's aims, methods, findings, and consequences. Sections on system design, installation, evaluation metrics, findings, and conclusions are included.
- **User Guides and Manuals**: Documents that train users, administrators, and developers on how to interact with and manage the system, including Meta Mask, web interface navigation, and system deployment.

## STAKEHOLDERS

- **Healthcare Providers:** Physicians, nurses, and other healthcare professionals who use the system for patient care and record-keeping
- **Patients:** People who are the subjects of healthcare records and rely on the system to keep their health information secure and accessible.
- **Regulatory Bodies:** Government bodies or organizations in charge of managing and regulating healthcare systems to ensure legal and ethical compliance.
- **Healthcare Administrators:** Managers and administrators in healthcare organizations who are in charge of the systems' overall operation and efficiency.

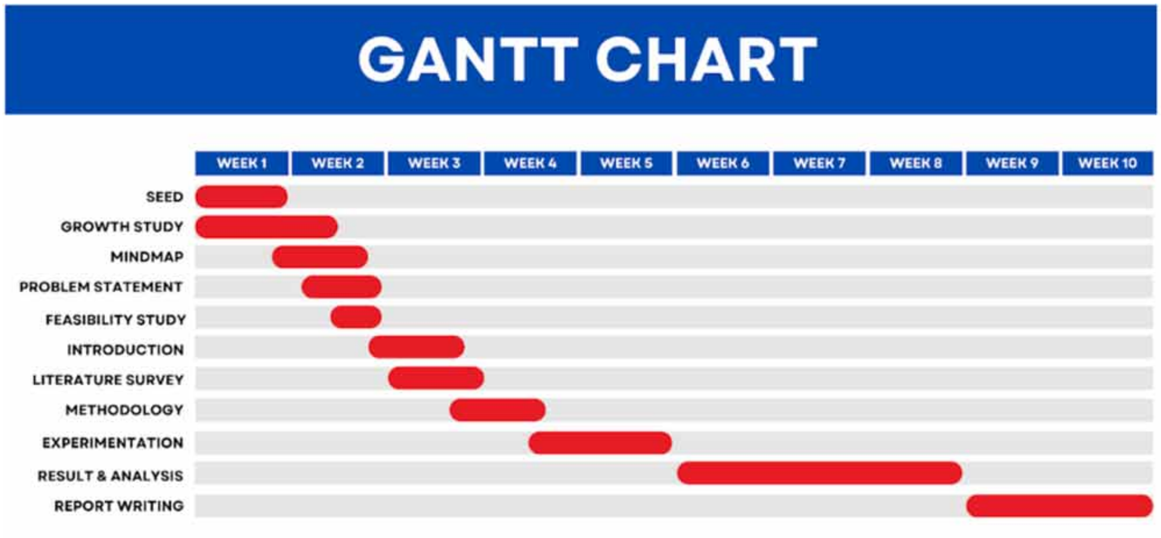
## GANTT CHART

The Gantt chart shows the flow or the timeline of our work, basically what task is done in a given time frame. All the goals are met and are completed in the given timeline. The team took a time span of 10 weeks to finish the project and write the research paper **(as per Figure 1)**.

## TOPIC ORGANIZATION

The introduction lays the groundwork for understanding the critical function of healthcare records management systems and the difficulties that come with traditional setups. It emphasizes the importance of integrating block chain technology with Ganache, Truffle, Meta Mask, and the MEAN stack. This section traces the evolution of healthcare data management, exposing flaws in existing systems and emphasizing the need for novel solutions. It provides a concise introduction of blockchain's possibilities in healthcare

*Figure 1. Gantt chart of the research work*




and previews the integrated strategy used in this research, setting the way for a more in-depth investigation into reinventing healthcare records administration for improved security, accessibility, and efficiency.

## INTRODUCTION

### Evolution of Healthcare Records Management

The medical records management landscape is changing dramatically, reflecting advances in patient data management. Issues related to data security, access and interoperability have arisen in current systems, prompting the search for innovative solutions. This white paper explores block chain technology and its implementation, focusing on the role of Ganache, Truffle, Meta Mask, and the MEAN stack in revolutionizing medical records management. Given the power of patient information, data security will continue to be a critical issue in healthcare. Block chain technology, known for its scalable and scalable properties, offers an excellent solution. Ganache, an Ethereum development-specific block chain, provides a secure environment for testing and development. Truffle, a development framework for Ethereum, simplifies the creation and management of smart contracts, improving the security and transparency of healthcare transactions.

The introduction of Meta Mask, a cryptocurrency wallet and gateway to block chain applications, will provide access to users and manage medical records. Currently, the MEAN stack, which includes MongoDB, Express.js, AngularJS, and Node.js, facilitates the development of robust and scalable block chain applications. In conclusion, this paper explores the innovative combination of block chain technology, Ganache, Truffle, Meta Mask, and the MEAN stack to address the challenges of medical record management. This integration has the potential to redefine the landscape by ensuring better security, better accessibility and better collaboration, which ultimately ushers in a new era of prosperity and depends on medical management **(E. R. D. Villarreal et al. 2023)[2].**

*Figure 2. Medical records evolution in healthcare management*
*(https://media.licdn.com/dms/image/C4E12AQGO3B4Dlkvvgg/article-cover_image-shrink_720_1280/0/1652517819077?e=1707350400&v=beta&t=NzU3BdECDNegUaLQC5i7GU5hgRFWdsbu3lORlyer-wo)*


The image features a dynamic visual representation illustrating the progression of health records. The central theme is conveyed through a series of progressively enlarging balls, symbolizing the growth and evolution of health data over time. The visual metaphor suggests that health records are not static but dynamic entities, expanding in size to encapsulate a wealth of information **(as per Figure 2).**

## Challenges in Traditional Systems

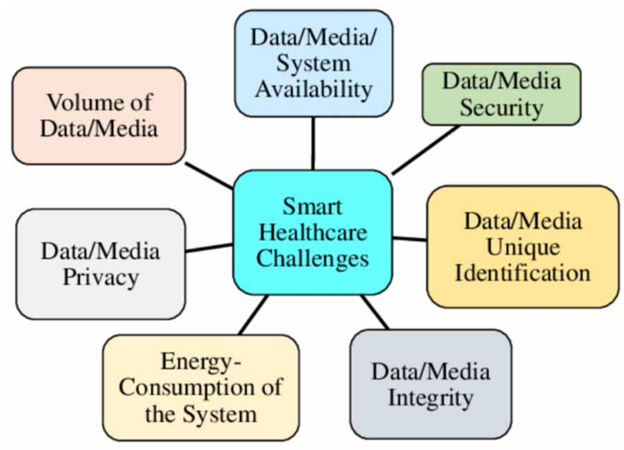
Today's healthcare systems are plagued with many challenges, from data security vulnerabilities to limited access and barriers to collaboration. These challenges highlight the urgent need for a paradigm shift in clinical history management.

One of the biggest challenges is the vulnerability of patient data in existing systems. Security breaches and cyber threats are extremely dangerous and can compromise the privacy and integrity of sensitive health information. The need for strong data security measures is paramount to protect patient privacy and maintain integrity and honesty in the healthcare system. Limited access is another major challenge facing conventional health care. Access to medical records is often hindered by disparate systems and fragmented data sources, preventing timely and comprehensive patient care. The integration and sharing of health information is essential to increase the efficiency and effectiveness of health care delivery.

In addition, achieving collaboration and communication between various health programs remains a challenge. Collaboration gaps can hinder communication between healthcare providers, fragment care, lead to errors, and compromise patient outcomes. Overcoming these barriers requires a comprehensive approach that embraces interoperability standards and innovative technologies.

In conclusion, the challenges facing today's healthcare systems, including data security vulnerabilities, limited access and connectivity issues, highlight the need for a redefined approach to records management. Addressing these challenges requires an entirely new and innovative program that focuses on data security, promotes access, and fosters collaboration to ensure the delivery of high-quality, patient-centered health care **(Zaabar, B. et al. 2021)[9].**

*Figure 3. Challenges in smart healthcare system*
*(https://www.researchgate.net/publication/322583582/figure/fig2/AS:584317898072064@1516323651803/Challenges-in-Smart-Healthcare.png)*




The chart visually encapsulates the challenges inherent in implementing a smart healthcare system. Peaks and troughs illustrate the fluctuating landscape of obstacles, representing issues such as data security concerns, data privacy concerts, system availability concern **(as per Figure 3).**

## Introduction to Block Chain Technology in Healthcare

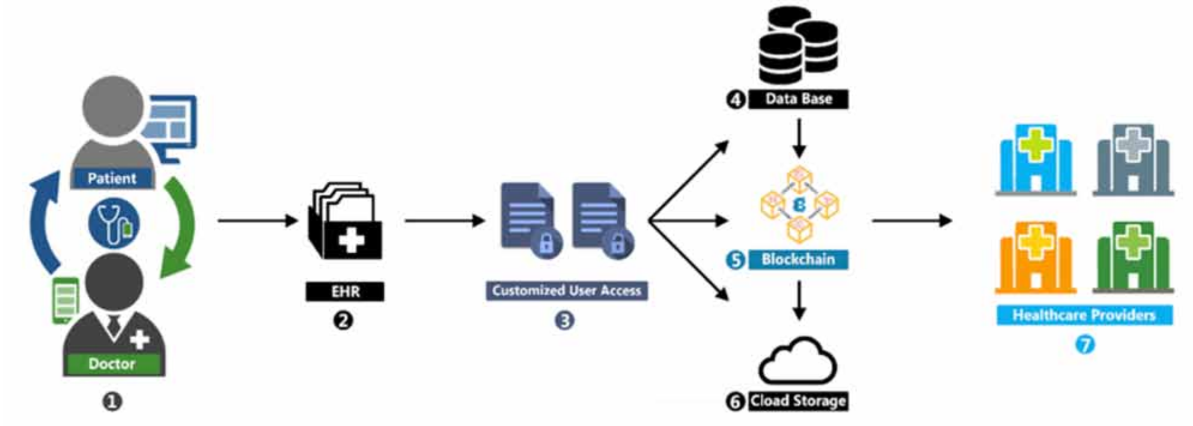
Block Chain technology is emerging as a catalyst for innovation that can address inefficiencies in traditional medical record management. Block Chain properties show great potential to improve the security and reliability of patient data.

Healthcare systems face issues such as data security vulnerabilities and concerns about the integrity of patient information. Block chain, a distributed ledger technology, provides a distributed framework for improving the security of medical records. Block chain uses encryption technology and consensus mechanisms to prevent unauthorized modification of data once it is recorded, reducing the risk of data breaches and manipulation. Additionally, the block chain and its decentralization feature eliminates the need for central control, reducing the risk of individual points of failure and improving the system's lifespan. This feature not only helps improve security, but also promotes trust among stakeholders in the healthcare ecosystem.

In addition to security benefits, block chain promotes collaboration and security. The decentralized nature of the block chain is transferable and accessible to exchange health information, allowing healthcare providers to access patient records across multiple platforms.

The revolutionary block chain technology represents a paradigm shift in medical record management and offers solutions to data security and interoperability issues. The ability to create a secure and transparent framework coincides with the growing need for better, more reliable and patient-centered health systems. As the healthcare industry continues to evolve, the introduction of block chain technology is a promising solution that will change the way medical records are managed and maintained (Gul, M. et al. 2020) [3].

*Figure 4. Block chain in healthcare*
*(https://pub.mdpi-res.com/applsci/applsci-09-01736/article_deploy/html/images/applsci-09-01736-g003.png?1571443614)*




In this image portraying the utilization of block chain in the healthcare industry, the visual elements likely convey a network of interconnected blocks symbolizing secure and decentralized information. The integration of block chain technology in healthcare may be represented through visual cues such as medical icons, cryptographic symbols, and a transparent, tamper-resistant chain **(as per Figure 4).**

## Overview of Ganache, Truffle, Meta Mask, and MEAN Stack

Ganache, Truffle, Meta Mask and the MEAN stack are the technical foundation of the health system we think. A brief description of each section is the cornerstone for future discussions of seamless integration. The leader is Ganache, which provides a specific block chain for Ethereum development. Acting as a local development environment, Ganache provides a secure and managed environment for testing and validating block chain applications as well as ensuring the integrity of healthcare systems in a controlled environment. Truffle, Ethereum's powerful development framework, complements Ganache by simplifying the creation, management and testing of smart contracts. Its capabilities are to modernize the development process, improve delivery efficiency, and maintain secure and transparent healthcare transactions on the block chain.

Meta Mask, a cryptocurrency wallet and gateway to block chain applications, introduces the user side to the healthcare system. This enables secure interaction with the Ethereum block chain, focusing on the interface and a user-friendly experience when accessing and managing end-user medical records. The MEAN stack, which includes MongoDB, Express.js, AngularJS, and Node.js, forms the back-end and front-end architecture of the healthcare system. MongoDB provides a scalable and flexible NoSQL database, while Express.js makes it easy to develop powerful backend applications. AngularJS supports the creation of dynamic and responsive user interfaces, while Node.js ensures the smooth integration of these components.

In short, Ganache, Truffle, Meta Mask and the MEAN stack create a powerful foundation for healthcare systems by combining block chain technology with a comprehensive development stack. This toolkit not only addresses the challenges of medical record management, but also paves the way for a secure, transparent and user-friendly healthcare ecosystem through seamless integration **(Ismail, L. et al. 2019) [4].**

*Figure 5. Meta Mask, Truffle, Ganache*
*(https://miro.medium.com/v2/resize:fit:1400/1*PeqHouOT1H8WhXTLBv4SxA.png)*


In this visual depiction featuring Ganache, Truffle, and Meta Mask, the image likely illustrates the seamless integration of these technologies in a block chain-based system. Ganache may be represented as a foundational element, providing a local block chain for development and testing. Truffle, depicted alongside, could be visualized as a development framework facilitating the creation and management of smart contracts. Meta Mask, integrated into the composition, may be symbolized as a user-friendly gateway, enabling secure interactions with the block chain **(as per Figure 5).**

## Rationale for Integration and Research Objectives

The integration of Ganache, Truffle, Meta Mask and MEAN stacks into our healthcare system is driven by a strategic vision that aims to solve today's challenges and take medical records management to new levels. The reason for combining these technologies comes from the primary goal of creating a medical records management system that is not only more secure, but also more accessible and efficient.

Given the sensitive nature of patient data, security is an important issue in healthcare. Using Ganache, Truffle and Meta Mask with block chain capabilities ensures a decentralized and neutral environment. This security structure protects against data breaches and unauthorized access, creating a system where the privacy and reliability of patient information are paramount. Participation, an important part of modern health, is another focus. Acting as an easy-to-use gateway, Meta Mask ensures that people have access to their medical records. The MEAN stack contributes to this accessibility by providing a simple and responsive user interface that allows users and healthcare providers to interact with the system.

Energy is the third factor driving this integration. With its robust and scalable architecture, the MEAN stack simplifies application development and deployment, reducing the time and resources required to implement systems. The Truffle and development framework improves the efficiency of smart contract creation and management and provides access to a medical records management system. As we explore the complexities of this inclusion, our research objectives set the direction of our inquiry. These goals guide the discussion and explore the complexities of combining Ganache, Truffle, Meta Mask, and the MEAN stack. By uncovering the reasons for this convergence and defining clear research goals, our exploration is poised to uncover the potential of these technologies to revolutionize medical records management **(Khatoon, A. et al. 2019) [7].**

*Figure 6. Integration of block chain with healthcare*
*(https://innovationatwork.ieee.org/wp-content/uploads/2021/09/bigstock-Unrecognizable-Doctor-Of-Medic-241284775_1024X684.png)*

In this visual representation illustrating the rational integration of Ganache, Truffle, Meta Mask, and the MEAN stack, the image likely conveys a cohesive and strategic arrangement of these technologies. Visual elements may depict Ganache providing a secure local block chain, Truffle facilitating smart contract development, Meta Mask serving as a user-friendly interface, and the MEAN stack forming a robust backend and frontend infrastructure **(as per Figure 6).**

## ITERATURE REVIEW

The literature survey conducted for this research study "title" investigated a wide range of current articles, research papers, and scientific publications. The purpose of the literature review is to analyze current understanding of climate data prediction and its impact on human health. Through this literature review, we get a deeper knowledge of the relationship between climate change and human health, laying the groundwork for the analysis work.

**Khatoon, A. et al. (2019)** and her team demonstrated that a trusted and secure platform for data exchange in many fields, including healthcare, is rapidly emerging thanks to block chain technology. This article provides comprehensive reviews of block chain research and recent applications in healthcare, along with innovative workflow recommendations to improve data management. These processes use the Ethereum block chain to facilitate the execution of complex medical operations such as surgery and clinical trials. Implementation costs are scrutinized.

The paper demonstrates how the decentralized nature of block chain allows for sophisticated optimization of medical processes and large-scale data management. Improved auditability, interoperability, and accessibility of patient data through the use of smart contracts benefits both patients and medical researchers.

The study also highlights the many benefits of block chain in healthcare, including security, privacy, and more granular control over access to electronic health records (EHRs). The ultimate goal is to improve outcomes for patients and healthcare operations by reducing transaction costs through smart contracts, streamlining processes, and eliminating middlemen. The healthcare system faces long-standing problems that need to be addressed, and block chain technology has the potential to solve them by improving data collection, sharing and usage. Patients will be able to securely share medical information while maintaining control over their data privacy thanks to the ambition of this block chain-based healthcare ecosystem to be scalable, secure and decentralized **(Khatoon, A. et al. 2019).**

**Ismail, L. et al. (2019)** and his team explores block chain technology's critical role in healthcare data management, highlighting how it has the potential to transform the industry by addressing concerns such as centralized control, unique points of failure, and data privacy. Due to the flaws of client-server solutions and cloud-based healthcare solutions, block chain offers an attractive alternative. However, much of the research in this area to date has focused on the Bitcoin network, which has disadvantages including high power consumption and limited scalability.

The paper proposes a lightweight block chain architecture specifically designed for health data management as a solution to these problems. By grouping network users into clusters and maintaining a single copy of the ledger for each cluster, this design promises to save on computation and communication costs. With the introduction of Head Block chain Manager (HBCM), the fork problems that existed in the Bitcoin network have been resolved.

The study evaluates the effectiveness of the proposed architecture by studying security and privacy issues and comparing its performance with the Bitcoin network. The results show good progress, such as reduced network traffic and faster general ledger updates. The promise of this architecture in improving hospital data management is highlighted in the paper's conclusion, especially when combined with cutting-edge innovations such as IoT and fog computing. Practical implementation and further assessment will be the main focus of future efforts **(Ismail, L. et al. 2019).**

**Gul, M. et al. (2020)** and his team demonstrated that beyond its initial applications in banking, block chain technology has evolved to be used in a variety of areas where anonymity and trust are essential. Automating block chain tasks is a growing area of research as a way to improve performance and security. Block chain management systems, which often rely on specialized engineers and software platforms, are in charge of certain tasks, including transaction management, consensus, block security, and network security. In this study, the possibility of incorporating machine learning ideas, especially reinforcement learning, in the management of block chain systems for healthcare scenarios was considered. Research shows that agents trained in reinforcement learning can successfully automate operations in a healthcare block chain management system, improving productivity and data accessibility.

Besides the banking sector, block chain currently has various applications, especially in the healthcare sector, where its decentralized and open nature can help organizations. It provides enhanced security and transparency by storing data in a shared, immutable database. Patients and healthcare workers can benefit from the secure storage, access and exchange of data thanks to block chain in the healthcare industry. The integration of reinforcement learning in block chain management for healthcare is the main topic of this study. The authors propose a model that would automate healthcare tasks using multiple hard actors, thereby improving block chain performance. This study illustrates the effectiveness of reinforcement learning agents, which develop strength and capacity for different behaviors by adapting to their environment based on observations.

The results demonstrate that these agents have the ability to learn and adapt and act in response to changing circumstances. The study's findings point to a potential future for consolidating learning-based block chain agents in automating tasks in the healthcare industry, ultimately improving efficiency and effectiveness of block chain systems in healthcare and healthcare management **(Gul, M. et al. 2020).**

**Zaabar, B. et al. (2021)** the research paper addresses critical concerns in healthcare regarding the security and privacy of Electronic Healthcare Records (EHRs). It recognizes the vulnerabilities associated with centralized databases and proposes an innovative architecture to mitigate these risks. This architecture utilizes block chain technology, decentralized databases like OrbitDB with IPFS, and a Hyper-ledger Fabric-based block chain network to enhance security, privacy, and robustness in healthcare management. Block chain technology, specifically Hyper ledger Fabric and Hyper ledger Composer, is introduced to secure and manage EHRs and Remote Patient Monitoring (RPM) systems, emphasizing decentralized databases' advantages for healthcare data storage and block chain's role in ensuring data integrity, auditability, and interoperability.

The research evaluates the proposed framework's performance through Hyper ledger Caliper, demonstrating its effectiveness and efficiency in various metrics. It conducts a comparative analysis, highlighting the strengths of the Health Block system in addressing critical security and privacy requirements. In conclusion, the research introduces Health Block, a block chain-powered solution for decentralized healthcare management. It leverages block chain and IoT devices to enhance EHR and RPM security and administration. The decentralized data storage and permissioned block chain network contribute to heightened data security and transparency, potentially revolutionizing healthcare systems. The paper also outlines future directions, including strengthening security and privacy measures, wider block chain adoption in healthcare, and integrating patient-centric data management **(Zaabar, B. et al. 2021).**

**E. R. D. Villarreal et al. (2023)** this research paper explores the use of block chain technology to enhance interoperability and security within the healthcare ecosystem. It addresses the fragmented nature of healthcare information systems and the associated security risks. Block chain is presented as a solution to improve aspects such as interoperability, security, traceability, confidentiality, and data integrity in Health Management Systems (HMS). The study conducts a Systematic Literature Review (SLR) to identify architectural mechanisms used for enhancing interoperability and security in Block chain-based HMS. Research questions are defined to investigate the mechanisms and architectural aspects involved. The paper aims to develop a high-level architecture and an architectural mechanism, potentially in the form of a Domain Specific Language (DSL), for achieving interoperability and security in HMS through block chain technology.

This DSL would enable the specification of Smart Contracts (SC) at a high level of abstraction, promoting technology independence and facilitating contract implementation reuse through Model Driven Engineering (MDE) approaches. The research contributes to addressing critical challenges in healthcare data management by fostering trust and security within the healthcare ecosystem. The study aims to make the BC ecosystem more practical, offering developers and researchers a solid starting point to explore software architecture, interoperability, and security in Health Management Systems (HMS) using BC **(E. R. D. Villarreal et al. 2023).**

**Azaria A et al. (2016)** In this paper the author and his team proposed MedRec: a novel record management system using Block Chain for electronic health care records. There is a need to record all the EMRs because people scatter their health care records as time goes by. So, the author and his team provided a system in which people can store immutable log, they will have easy access to their medical information across providers and treatment sites. They Block chain has unique properties. MedRec has authentication, accountability, confidentiality and data sharing while carrying sensitive information.

Their design is modular, allowing it to easily integrate with existing local data storage solutions used by healthcare providers. This promotes compatibility and flexibility within their system. They encourage various medical stakeholders such as researchers and public health authorities to actively participate in the network as block chain "miners." In return for maintaining and securing the network through Proof of Work, these miners gain access to aggregated, anonymized data as rewards. This approach creates a data-driven ecosystem, supplying valuable big data for researchers while involving patients and providers in decisions regarding the release of metadata. The purpose of this brief paper is to introduce a functional prototype, which they will analyze and discuss before conducting field tests **(Azaria A et al. 2016).**

**Junaid, S.B. et al. (2022)** and his team demonstrated that in recent times, IoT (Internet of Things), AI (Artificial Intelligence), and Block chain technologies have become important in many fields, especially healthcare. These technologies are helping improve healthcare by providing personalized care to patients. The next step in healthcare is to combine these technologies seamlessly. Smart wearable sensors, IoT, AI, and Block chain are changing healthcare from a traditional system to a more personalized one. However, there are challenges, such as finding affordable and accurate medical sensors, creating standardized IoT systems, dealing with different types of wearable devices, handling complex data, and ensuring these technologies can work together.

This survey paper looks at how these technologies (Smart Sensors, IoT, AI, Block chain) are being used in healthcare. It explores current research and findings on how these technologies are being used, what factors make them work well, and examples of successful implementations. The survey also looks at common problems faced by IoT-based wearable sensors, AI, and Block chain in healthcare and what needs to be done to make these technologies work better in healthcare.

This research highlights the growing use of Sensors, IoT, AI, and Block chain in healthcare, offering insights into their applications and challenges. Sensors and IoT enhance healthcare operations, while AI and Block chain provide valuable data insights and security. Addressing issues like data privacy and user acceptance remains crucial. This study serves as a valuable resource for both academic and industry researchers, offering guidance and highlighting future research opportunities in healthcare technology **(Junaid, S.B. et al. 2022).**

**Rehman, M. et al. (2022)** and his team demonstrated that the pharmaceutical industry faces issues like counterfeit vaccines and supply chain challenges. It's hard to spot fake vaccines because people often lack awareness about them. Online pharmacies make it easier to sell fake vaccines. The author and his team have proposed a transparent, immutable and secure vaccine supply chain (TISVS chain), A block chain-based solution to tackle these problems.

The proposed system enhances vaccine supply chain security, transparency, and traceability. Their framework runs on both private and public block chains, with efficient implementation and low costs. Experiments show improved security, low gas costs, and high efficiency, promising better vaccine supply chain management **(Rehman, M. et al. 2022).**

**Jabarulla, M.Y. et al. (2020)** and his team demonstrated that researchers are working on a way to store and share medical images more efficiently in healthcare. Right now, data is often stored in expensive and centralized cloud systems, which can be a privacy concern. So, they came up with a new idea. They created a patient-focused system using Ethereum block chain and a system called IPFS. This makes it possible to store images in a way that's decentralized and secure. They also made a smart contract on Ethereum to control who can access the data. This system lets hospitals, patients, and others securely share medical images. They tested it, and it works well.

This paper talks about the importance of sharing medical images efficiently and securely in healthcare. Right now, these images are often scattered across different systems, which can be a problem. They suggest a new way to do this using block chain and a system called IPFS. They also introduce a system called PCAC-SC, which helps authorized people access the medical data securely. This system gives patients more control over who can see their medical images. They did some tests, and the new system seems to work well. In the future, they want to use this in the real world and see how it works on a larger scale. They also plan to use a credit system and artificial intelligence to make it even better. This can help patients and doctors a loT **(Jabarulla, M.Y. et al. 2020).**

## Summary of Literature Review

*Table 1. Literature review summary*

| Paper Title & Author | Introduction | Methodology | Future Scope | Result | Gap Analysis | Conclusion |
|---|---|---|---|---|---|---|
| **A Block chain-Based Smart Contract System for Healthcare Management (Khatoon, A. et al. 2019) [7].** | A secure form of data management can be built using block chain. | Ethereum Block chain, smart contracts. | Add on some necessary features. | Platform for secure sharing of medical information. | Only limited to surgical and clinical records. | Elimination of the middleman can be done using the block chain. |
| **Lightweight Block chain for Healthcare (Ismail, L. et al. 2019) [4].** | Block chain can tackle centralized control, unique points of failure, and data privacy. | Grouping network, single copy of the ledger for each cluster. | Addition of IoT and fog computing. | Platform with reduced network traffic and faster ledger updates. | Practical application is not done yet. | Improvement of hospital data management. |
| **Block chain based healthcare system with Artificial Intelligence (Gul, M. et al. 2020) [3].** | Block chain can be used in healthcare instead of banking only. | Block chain, Artificial Intelligence and Machine Learning. | Observational based adaptation. | Automated healthcare using hard actors. | Lack of proper automation. | Improvement of efficiency and effectiveness of healthcare can be done. |
| **Health Block: A secure block chain-based healthcare data management system (Zaabar, B. et al. 2021) [9].** | It shows the concern for the security and privacy for EHRs. | Hyper ledger Fabric and Composer. | Improved security, broader block chain use in healthcare, patient-focused data. | The research evaluates the proposed architecture's performance using Hyper ledger Caliper. | Data security, interoperability, and patient data control. | Health Block, a healthcare management solution based on block chain Technology |
| **Block chain for Healthcare Management Systems: A Survey on Interoperability and Security (E. R. D. Villarreal et al. 2023)[2].** | Only 50% of universal health is covered | First using Research Questions then using PICOC methodology. | Create meta models for new DSL. | BC ecosystem to investigate software architecture, interoperability, and security in HMS. | It doesn't delve into a detailed analysis of the specific challenges. | It enhances the practicality of the Block chain (BC) ecosystem. |

*continued on following page*

*Table 1. Continued*

| Paper Title & Author | Introduction | Methodology | Future Scope | Result | Gap Analysis | Conclusion |
|---|---|---|---|---|---|---|
| **MedRec: Using Block chain for Medical Data Access and Permission Management (Azaria A et al.2016) [1].** | People lose health care data because they are scattered all around. | Smart Contracts, Orchestration, EMR Integration, Mining. | Create structured medical research onboarding. | Prototype: Decentralized Medical Records Block chain. | The Block chain technology used at that time was old. | MedRec uses Block chain for EMR. |
| **Recent Advancements in Emerging Technologies for Healthcare Management Systems: A Survey (Junaid, S.B. et al. 2022)[6].** | IoT, AI, and block chain transformed healthcare. | Healthcare Technology Field Usage Survey | Addressing more issues and including more technologies. | Sensors, IoT, AI, Block chain in Healthcare. | Addressing issues like data privacy and user acceptance. | Guide for healthcare technology research. |
| **A Cyber Secure Medical Management System by Using Block chain (Rehman, M. et al. 2022) [8].** | Pharma: Counterfeit Vaccines, Supply Chain. | TISVS chain, a block chain-based solution. | Security, cost and efficiency can be improved. | Enhancing Vaccine Supply Chain Security | Advanced technologies can be used. | Improves vaccine supply chain security. |
| **Block chain-Based Distributed Patient-Centric Image Management System (Jabarulla, M.Y. et al. 2020)[5].** | Data in costly, centralized, privacy-threatening clouds. | IPFS with Ethereum, PCAC-SC. | AI-Enhanced Credit System for Medicine | Secure Decentralized Image Storage Control. | More dimensions can be added. | This system gives patients more control over who can see their medical images. |

## METHODOLOGY

### Use Case Diagram

The use case flow diagram outlines the sequential interactions within the system involving three primary actors: admin, doctor, and patient. The diagram captures the key functionalities and interactions that facilitate a seamless flow of actions in the system **(as per Figure 7).**

#### Admin

Action: Manages overall system functionality and user accounts.

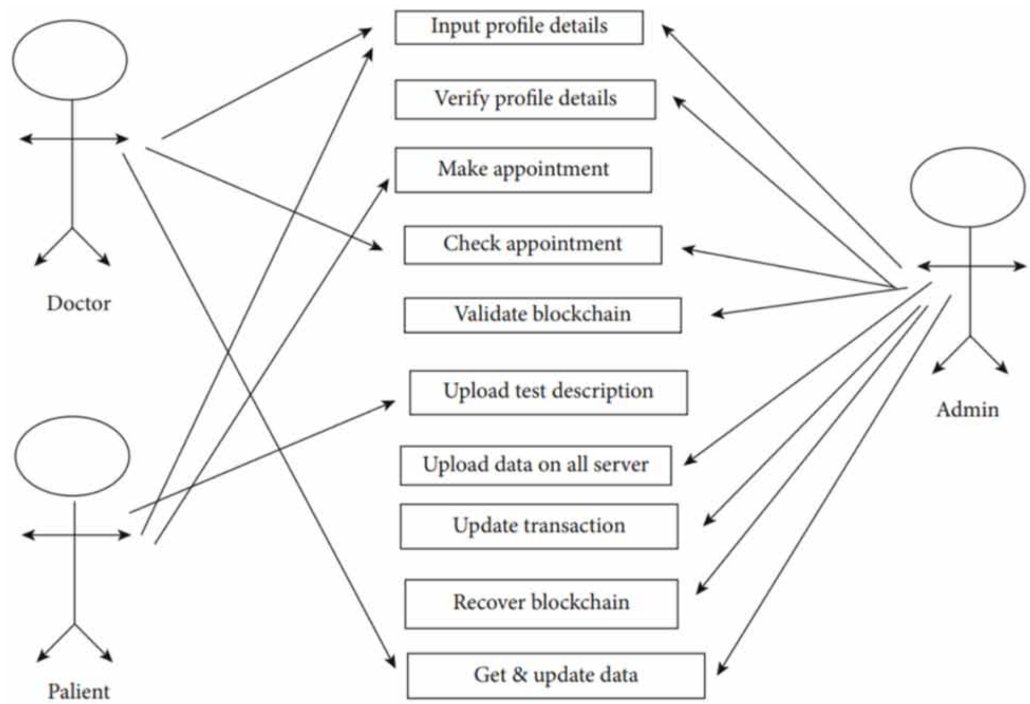
Interactions: Admin oversees user account creation for doctors and patients. Monitors the system's general operation

#### Doctor

Actions: Creates and manages their account. Reviews patient appointments. Updates patient data after appointments.

Interactions: Doctors register in the system. Access patient appointments and relevant details. Update patient records.

*Figure 7. Use case diagram*




## Patient

Actions: Creates and manages their account. Make appointments. Uploads test descriptions.

Interactions: Patients register and create accounts. Schedule appointments through the system. Upload relevant test descriptions for the doctor's review.

## Use Case Flow

Account Creation: Both doctors and patients have the capability to register and create accounts in the system.

Appointment Booking: Patients initiate the process by scheduling appointments through the system. Doctors can access and review scheduled appointments.

Test Description Upload: Patients upload test descriptions or relevant documents associated with their appointments.

Appointment Update: After the appointment, doctors have the authority to update patient data based on the consultation.

This use case flow ensures a structured and comprehensive system where patients and doctors can efficiently manage appointments, share relevant information, and maintain updated health records. The involvement of an admin adds a layer of oversight and system management. The diagram provides a clear visualization of the interactions among the system's key actors, facilitating a better understanding of the overall flow and functionalities.

## ER Diagram

*I*n an entity-relationship diagram that represents the system, the entities “Verify Doctor,” “Doctor,” “Request,” “Patients,” and “IPFS” are likely key components of the database schema. Each entity is associated with specific attributes that define the characteristics or properties of that entity **(as per Figure 8).**

**Verify Doctor**: Represents the verification status of a doctor, potentially indicating whether a doctor’s credentials have been verified.

**Doctor**: Contains details about doctors, including their names, specializations, contact information, and certification details.

**Request**: Represents appointment requests made by patients to doctors, including appointment details and the current status of the request.

**Patients**: Stores information about patients, including their names, contact details, and medical history.

**IPFS**: Represents files stored using the Inter-Planetary File System (IPFS), potentially including test descriptions or other relevant documents. The entity is associated with the doctor and patient.

This entity-relationship diagram provides a visual representation of how these entities are related and how their attributes are structured within the system. The relationships between entities help to establish connections and maintain data integrity in the database.

## Data Flow Diagram

The data flow diagram depicts data transit and transformation inside the block chain-based healthcare records management-system, which integrates Ganache, Truffle, Meta Mask, and the MEAN stack.

*Figure 8. Entity relation diagram*

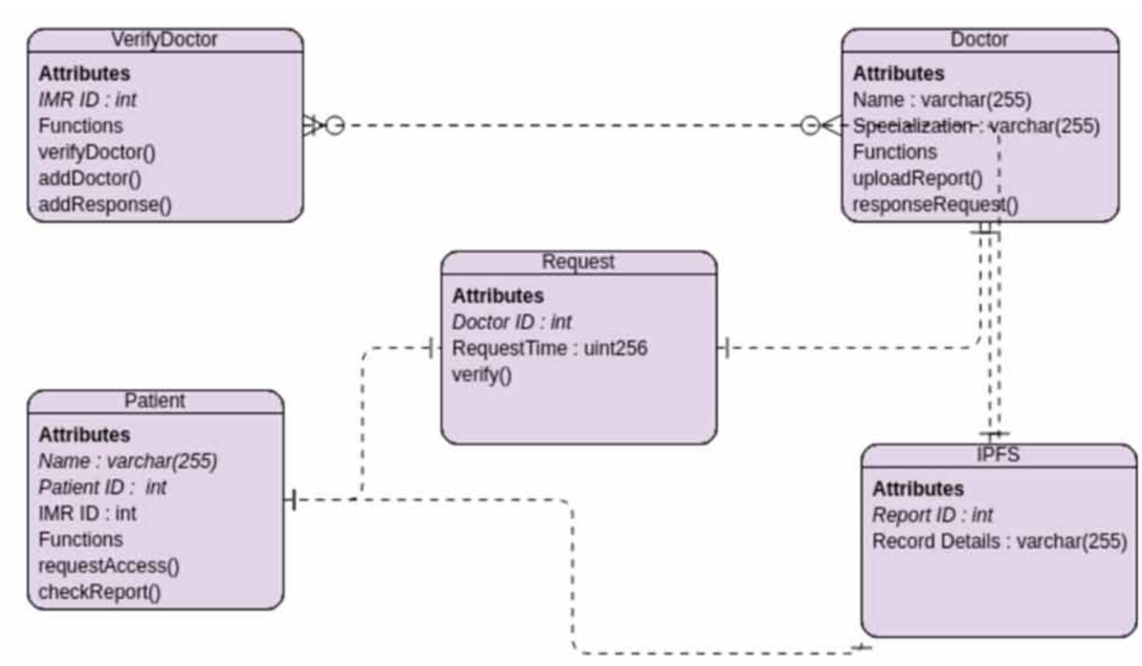
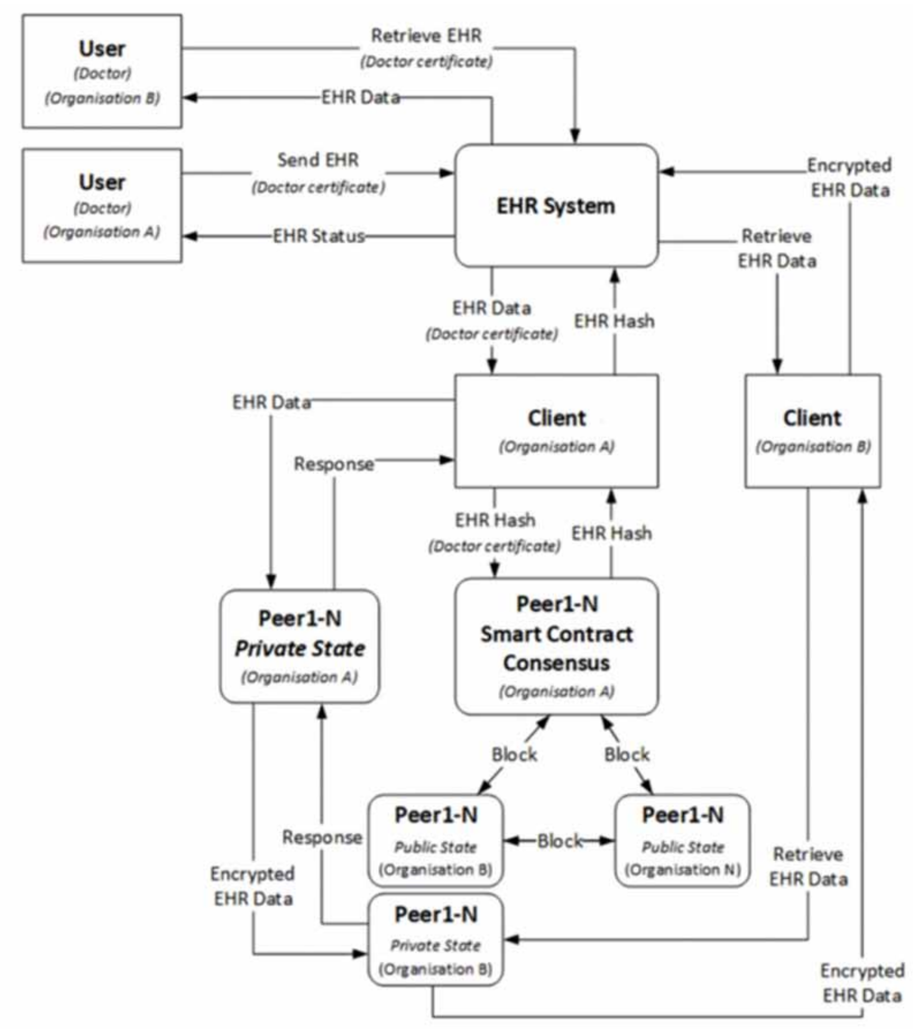


*Figure 9. Data flow diagram*

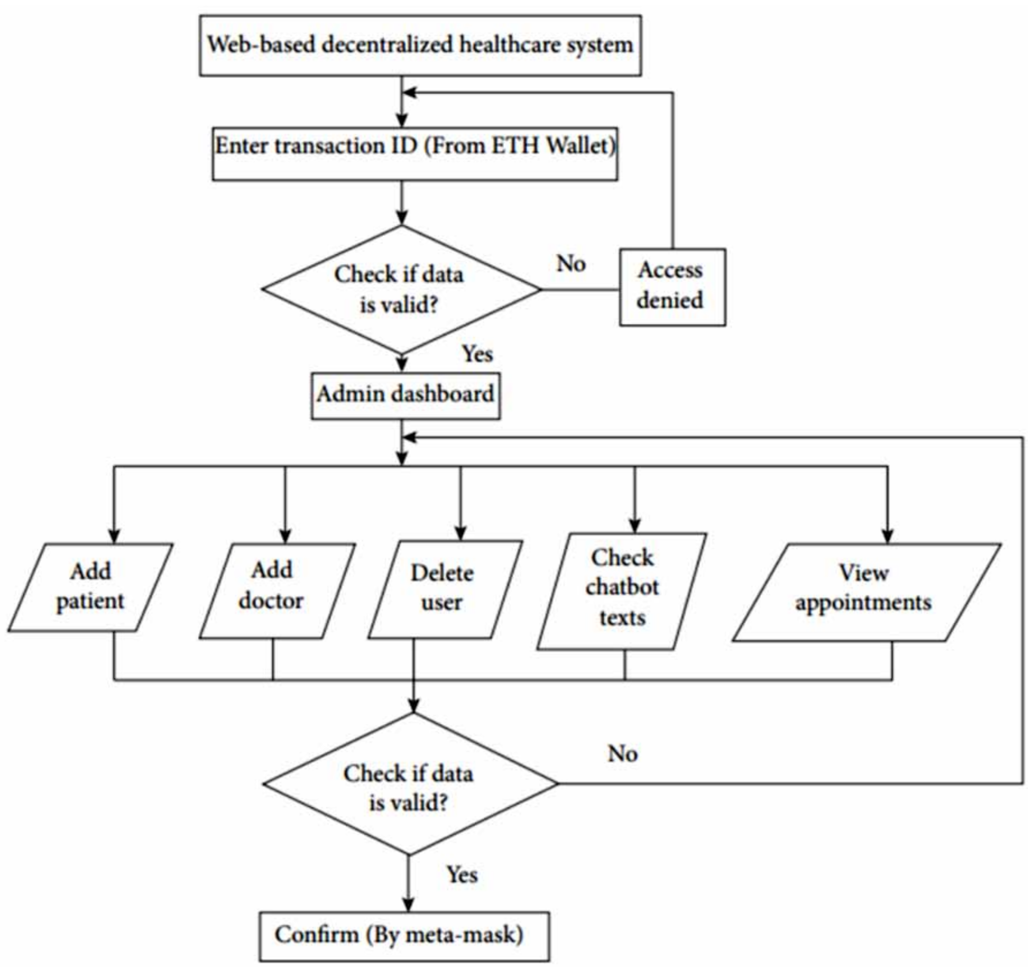



It depicts the data path from the first user interaction through Meta Mask authentication to accessing the MEAN stack-driven web application. Data flows between the user interface and the backend components of the program, allowing for searches, modifications, and storage of medical records. The Truffle-developed and tested on Ganache smart contract functionality manages the safe storage and verification of data on the Ethereum network. The data flow diagram vividly displays the various data channels, emphasizing the system's safe, transparent, and simplified administration of healthcare records **(as per Figure 9)**.

## Flowchart

The flowchart depicts the methodical process of the block chain-based healthcare records management system, which is connected with Ganache, Truffle, Meta Mask, and the MEAN stack. It depicts the se-

*Figure 10. Flow chart*

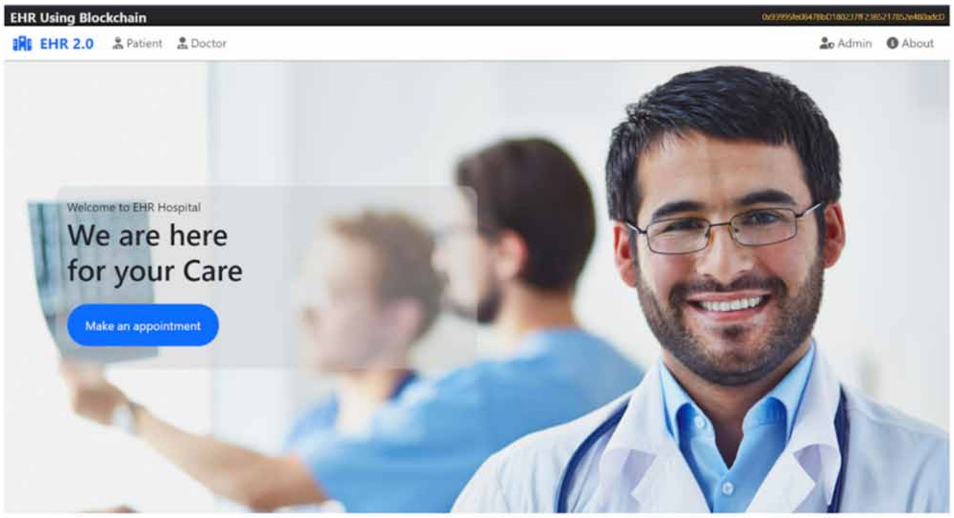



quential steps, beginning with user authentication using Meta Mask to get access to the system. Following authentication, the flow proceeds to interact with the MEAN stack-powered web application, which allows users to query and amend medical records. Smart contract functionality, created with Truffle and installed on Ganache for local testing, makes data storage and verification on the Ethereum block chain easier. The flowchart depicts the seamless integration that enables safe, transparent, and effective healthcare data management by capturing the numerous relationships and interactions between various components **(as per Figure 10).**

## RESULT AND DISCUSSION

The landing page of our website presents a clean and user-friendly interface, inviting both doctors and patients to seamlessly navigate through our range of services. The design exudes a sense of profession-

*Figure 11. Landing page*




alism and accessibility, featuring intuitive elements that cater to the unique needs of both healthcare providers and individuals seeking medical services **(as per Figure 11).**

The dashboard of our platform is a central hub designed for both doctors and patients, offering a unified and intuitive interface to streamline their healthcare experience. Tailored for ease of use, the dashboard provides quick access to essential features and insights, ensuring a seamless navigation experience for both healthcare providers and individuals **(as per Figure 12).**

*Figure 12. DashBoard*

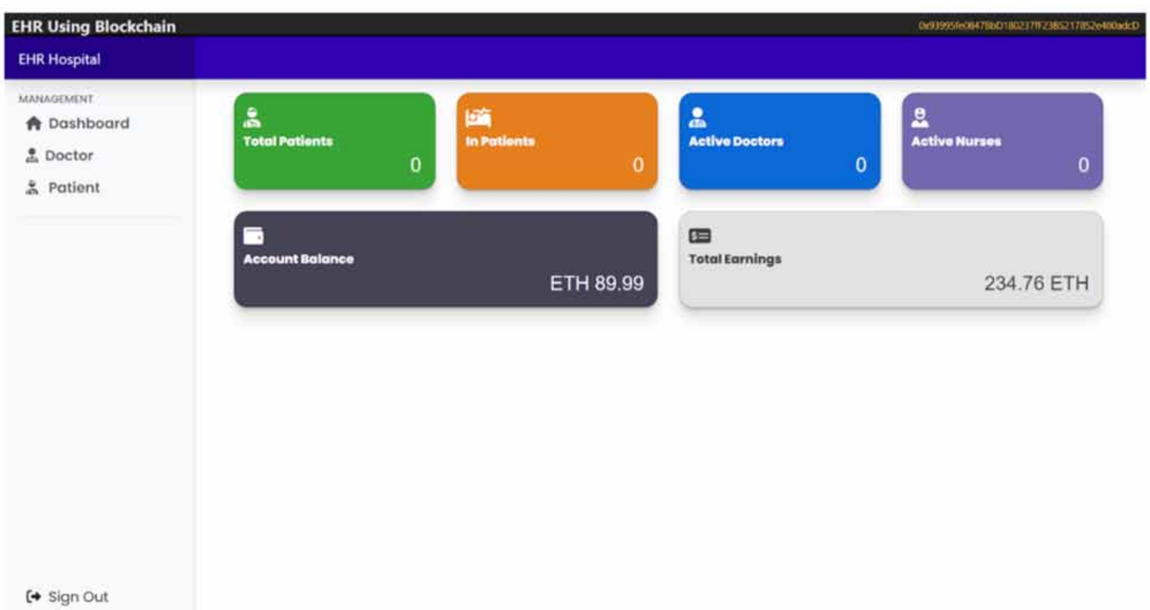
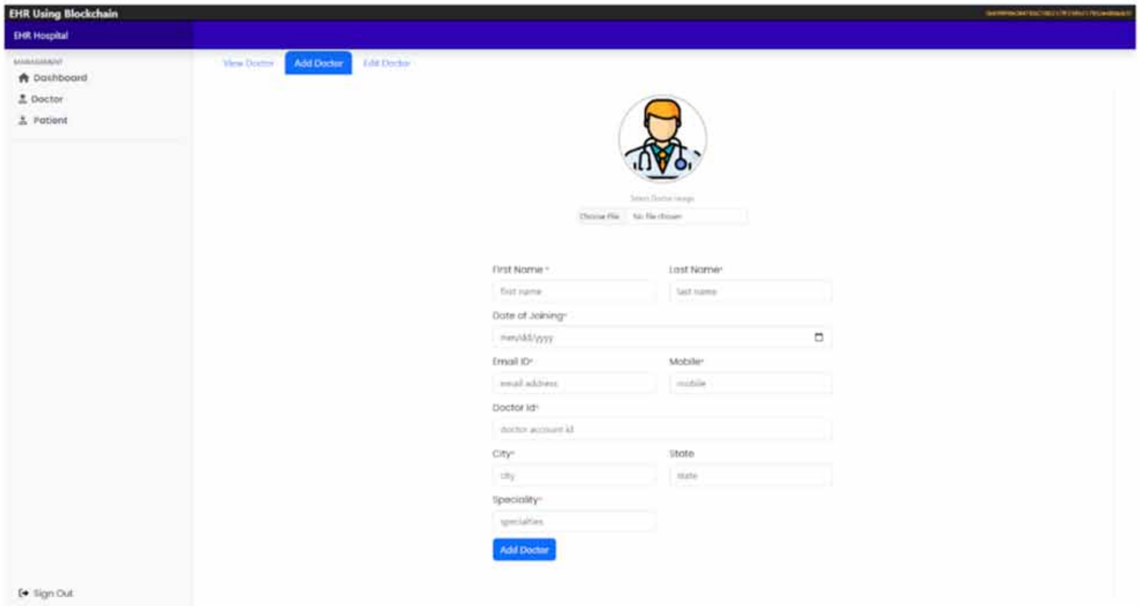


*Figure 13. Doctor registration page*




The Doctor Registration page on our website is thoughtfully designed to streamline the onboarding process for healthcare professionals. The page exudes professionalism and efficiency, providing doctors with a straightforward and secure method to register and access our specialized services. The registration form is intuitively laid out, guiding doctors through the necessary steps to create their accounts. Fields are organized logically, capturing essential information such as personal details, medical certifications, and contact information. Clear instructions accompany each field, ensuring a smooth and error-free registration process **(as per Figure 13).**

The Patient Registration page on our website is thoughtfully designed to streamline the onboarding process for healthcare professionals. The page exudes professionalism and efficiency, providing patients with a straightforward and secure method to register and access our specialized services. The registration form is intuitively laid out, guiding patients through the necessary steps to create their accounts. Fields are organized logically, capturing essential information such as personal details, medical certifications, and contact information. Clear instructions accompany each field, ensuring a smooth and error-free registration process **(as per Figure 14).**

The Transaction Records section on our website provides a seamless and transparent experience for users engaging with the platform using Meta Mask. This dedicated space is designed to cater to the needs of both doctors and patients, allowing them to track and manage their transactions effortlessly. For doctors, the Transaction Records section offers a detailed overview of financial interactions related to their services. They can easily access and review transaction histories, providing clarity on payments and reimbursements. The layout prioritizes efficiency, ensuring that doctors can navigate their financial transactions with ease.

Patients, too, benefit from a user-friendly interface that allows them to monitor their financial engagements with healthcare services. From appointment fees to any additional charges, the Transaction Records

*Figure 14. Patient registration page*

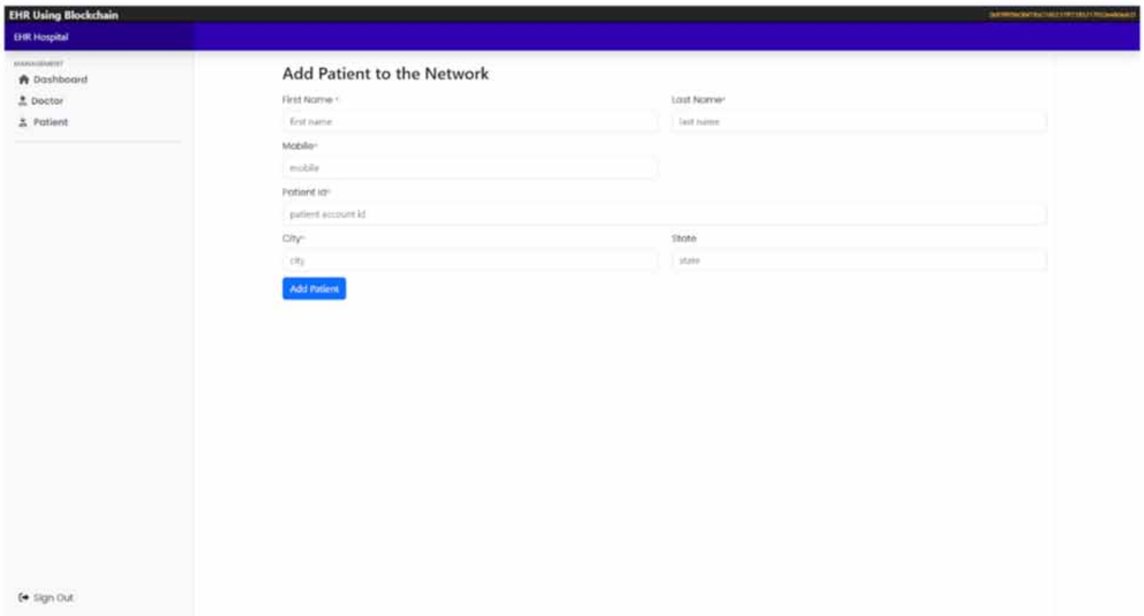
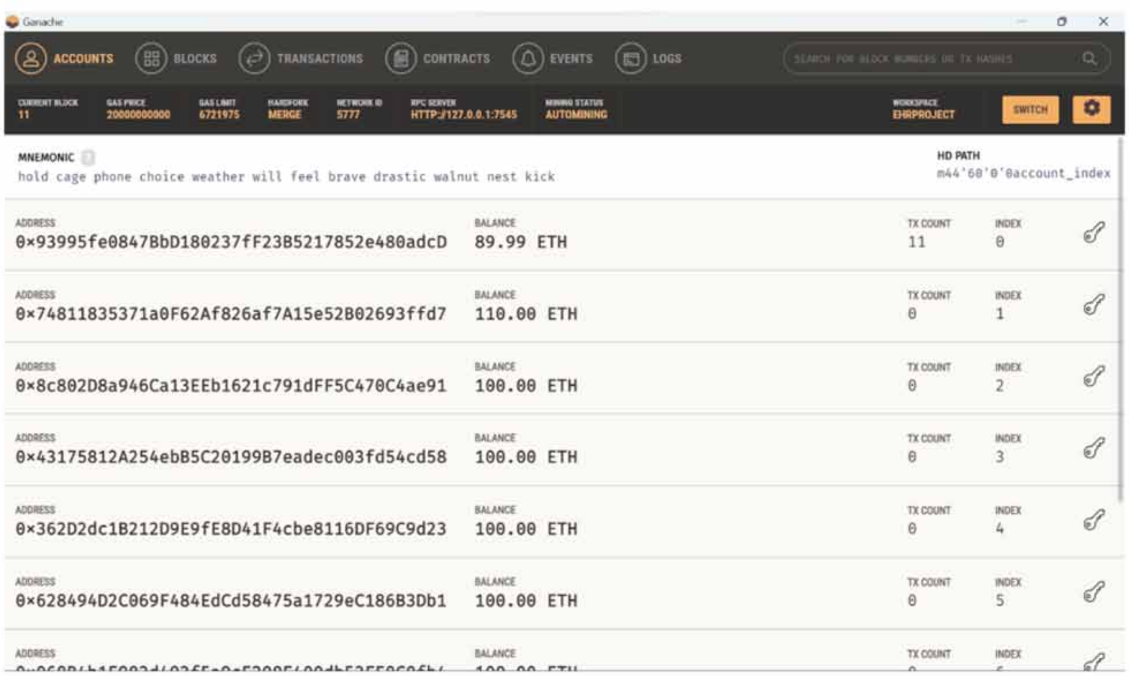
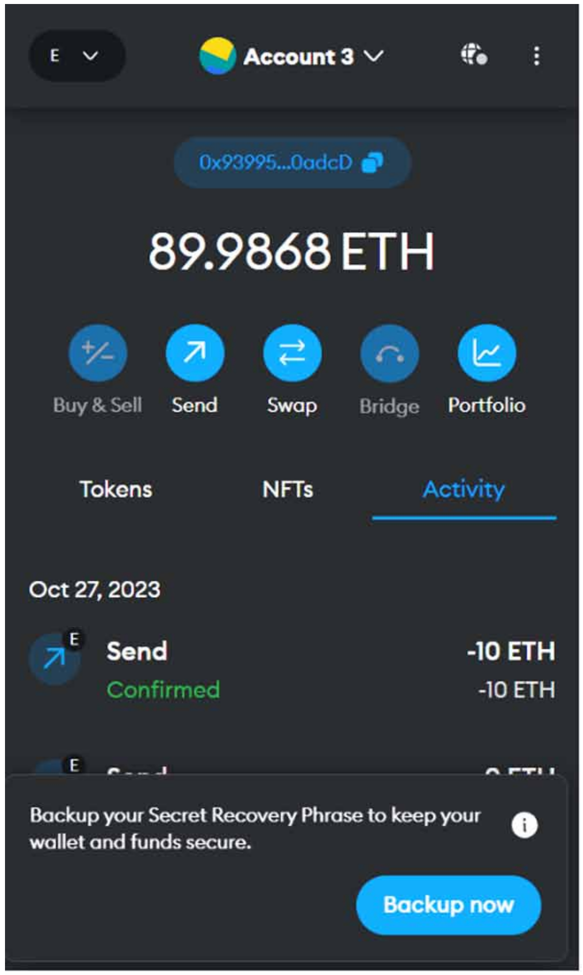



*Figure 15. Transaction records*




section provides a comprehensive view of all financial transactions made using Meta Mask. This transparency empowers patients to manage their healthcare-related expenses efficiently **(as per Figure 15).**

*Figure 16. Activity tracker section*




Within the Activity Tracker section of our website, users are introduced to a dynamic and intuitive platform enhanced by the capabilities of Meta Mask. This section is designed to empower users, allowing them to track and monitor their activities securely and efficiently. The user interface is thoughtfully crafted, providing a seamless experience for individuals utilizing Meta Mask. Doctors and patients alike can effortlessly engage with the Activity Tracker, gaining insights into appointments, updates, and crucial health-related data. Meta Mask integration ensures a secure and decentralized interaction, reinforcing the trustworthiness of the information being tracked.

The design elements are carefully selected to reflect the user-centric approach of the platform. Whether you are a healthcare provider or an individual managing your health, the Activity Tracker with Meta Mask integration offers a streamlined and secure solution. The color scheme, imagery, and layout contribute to an engaging and trustworthy environment, reinforcing the commitment to user satisfaction and data security. In summary, the Activity Tracker Section with Meta Mask integration stands as a testament to our dedication to providing an advanced and secure healthcare tracking experience. Users can conveniently navigate through their activities, appointments, and updates, leveraging the power of Meta Mask for a reliable and decentralized interaction within our healthcare ecosystem **(as per Figure 16)**.

The above **Table 2 and Figures 17, 18 ad 19** shows vulnerability categories on different Operating Systems with or without using blockchain. Each axis extends from 0 (low vulnerability) to 10 (high vulnerability).

The author team found that the systems are more secure when block chain technology is used. Linux was least vulnerable followed by macOs and windows respectively.

The above graph has different blockchain platforms on the X-axis and transactions/second on the Y-axis. Throughput is the number of transactions per second. Higher the throughput, the more secure and fast the system is. It is found out that the newer versions have higher throughput and are more advanced ***(as per Figure 20)***.

*Table 2. Security vulnerability statistics*

| Operating Systems | Malware | Phishing | Data Breaches | Unauthorized Modifications |
|---|---|---|---|---|
| **Windows (no blockchain)** | 8 | 7 | 9 | 8 |
| **Windows (with blockchain)** | 4 | 3 | 5 | 4 |
| **Linux (no blockchain)** | 6 | 5 | 7 | 6 |
| **Linux (with blockchain)** | 2 | 2 | 3 | 2 |
| **macOS (no blockchain)** | 7 | 6 | 8 | 7 |
| **macOS (with blockchain)** | 3 | 3 | 4 | 3 |

*Figure 17. Vulnerabilities comparison on different operating systems*

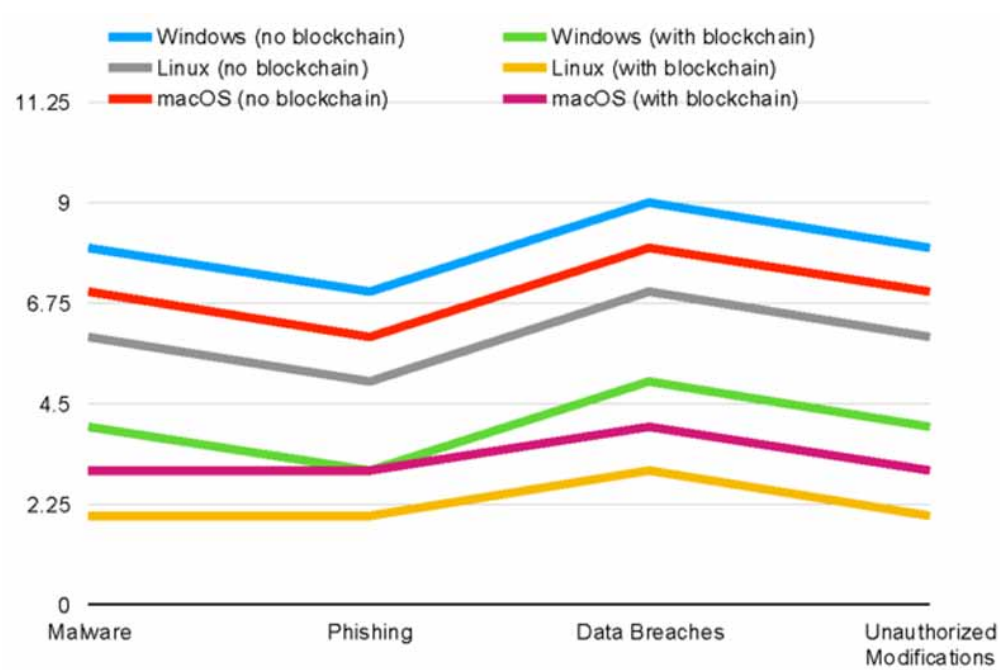


*Figure 18. Separate comparisons-part1*

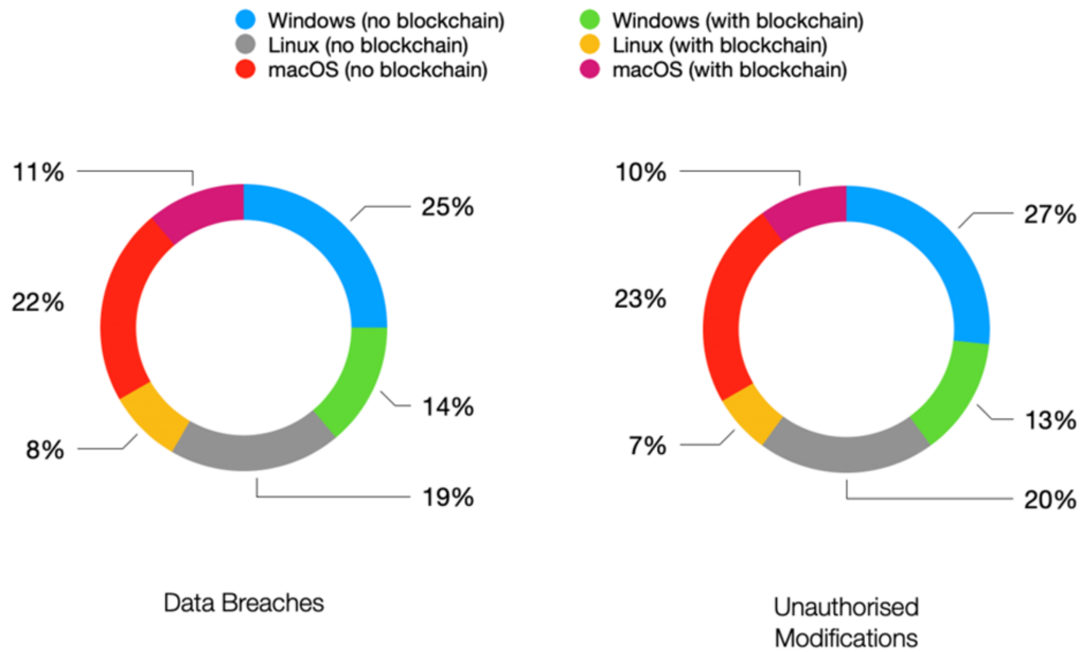



*Figure 19. Separate comparisons-part2*

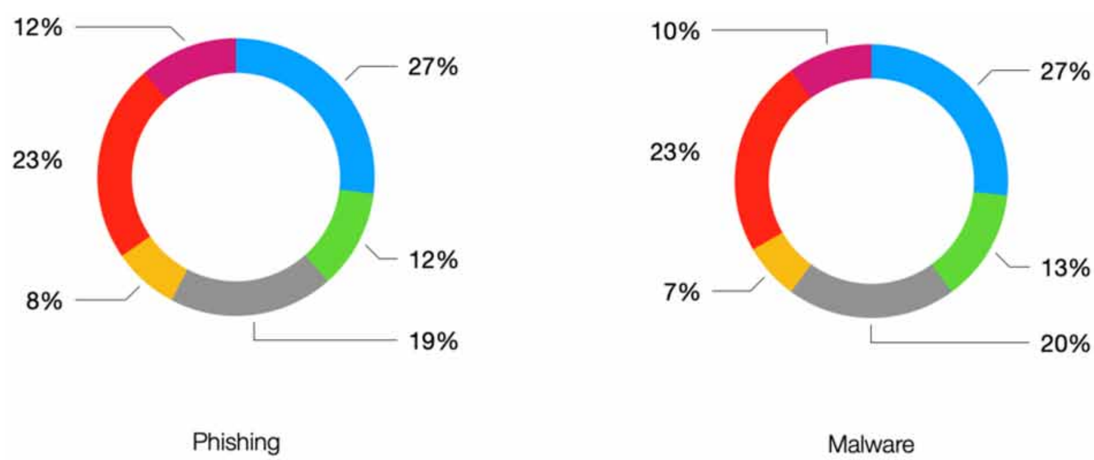
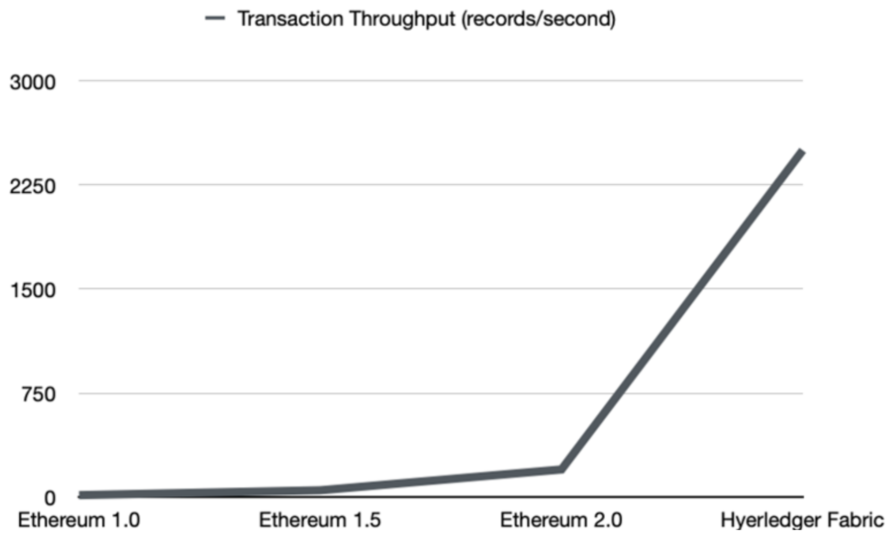



*Table 3. Transaction throughput across different block chain platforms*

| Blockchain Platforms | Transaction Throughput (records/second) |
|---|---|
| **Ethereum 1.0** | 15 |
| **Ethereum 1.5** | 50 |
| **Ethereum 2.0** | 200 |
| **Hyperledger Fabric** | 2500 |

*Figure 20. Graph showing throughput across different block chain platforms*




In the above graph, the blue line shows the attack susceptibility and the dotted green line shows the security enhancement.

On the X-axis we have different Operating Systems and on the Y-axis we have percentages.

We found out that there are no major changes on security enhancement on different Operating Systems but the attack susceptibility varies. It is found that Linux is least prone to attacks followed by macOs and windows **(as per Figure 21).**

*Figure 21. Attack susceptibility and security enhancement on different operating systems*

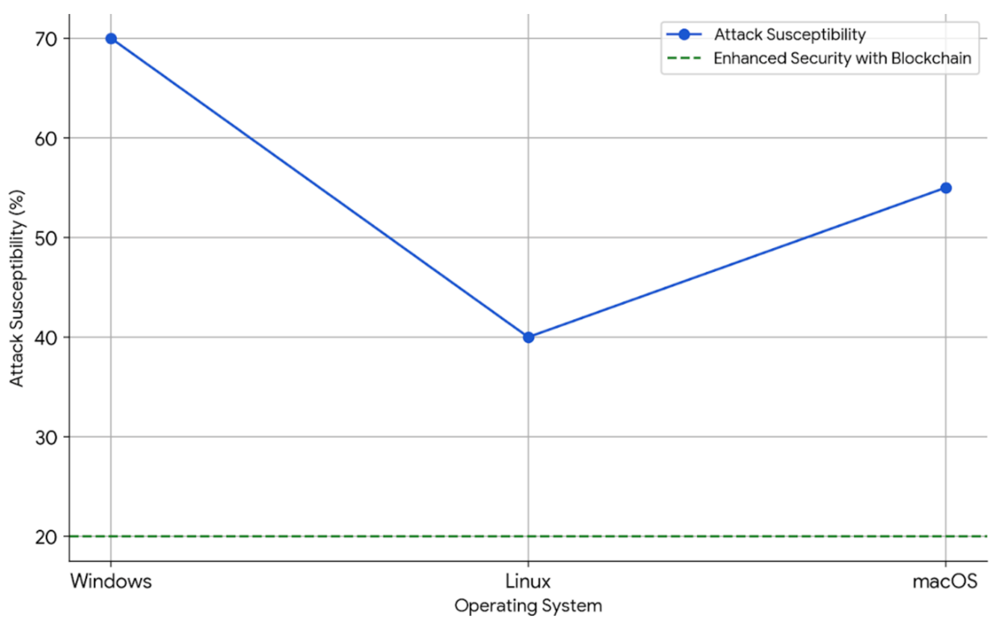


*Table 4. Transaction analysis in every two days on the healthcare portal*

| Days | Transactions | Processing Time(us) |
|---|---|---|
| 8-10 Jan | 100 | 150 |
| 10-12 Jan | 150 | 180 |
| 12-14 Jan | 120 | 160 |
| 14-16 Jan | 180 | 200 |
| 16-18 Jan | 200 | 220 |
| 18-20 Jan | 250 | 240 |
| 20-25 Jan | 220 | 210 |
| 25-31 Jan | 280 | 250 |
| 31-10 Feb | 300 | 270 |
| 10-17 Feb | 320 | 280 |

This table data has been recorded on time duration of two months in which the transactions has been added and processing time of the system on MacOs has been recorded.

Graphical analysis has been done of the collected data.

It is observed that as the number of transaction increases, the processing time decreases but it may change on the very large amount of data.

Here the sample size is very less but as per the analysis on this sample size we can see that processing time is less for more number of transactions **(as per Table 4 and Figure 22 and 23).**

## NOVELTIES

- Security and privacy: Block chain secures healthcare records by preventing changes and decentralizing data, reducing vulnerability to breaches and unauthorized access in traditional centralized systems.
- Patients have greater control over their health data. It is also ensured that the data is only accessed with explicit permissions.
- Block chain's transparency and security can reduce frauds.
- Block chain enables sharing depersonalized patient data for secure medical research, enhancing data analytics accuracy and efficiency in the healthcare industry.

## FUTURE RESEARCH DIRECTION AND LIMITATIONS

### Limitations

Block chain tech is getting better fast. The system you choose might become old, and updating it can be hard and expensive.

Once something is written in the block chain, it can't be easily fixed if there's a mistake. This makes correcting errors challenging, affecting data accuracy.

*Figure 22. Transaction analysis in every two days on the healthcare portal*

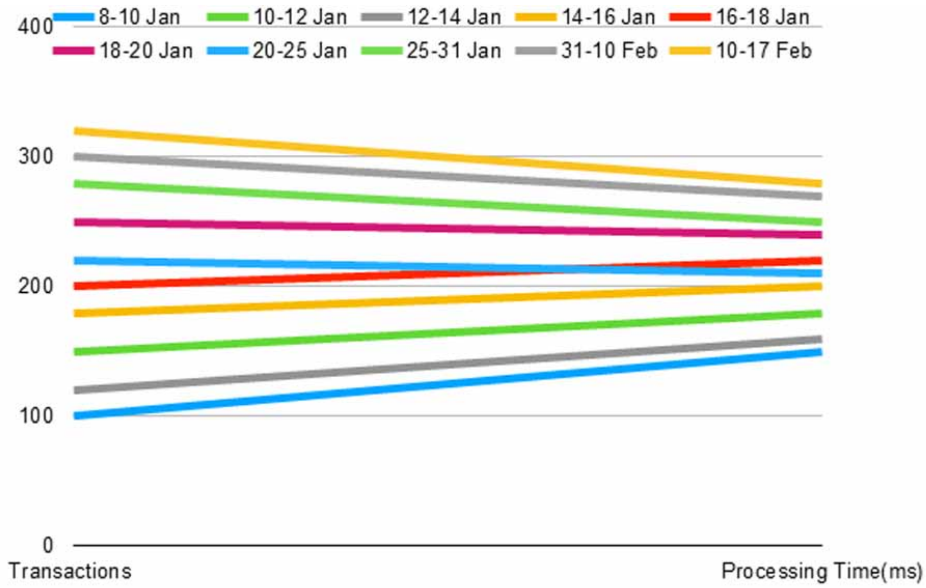
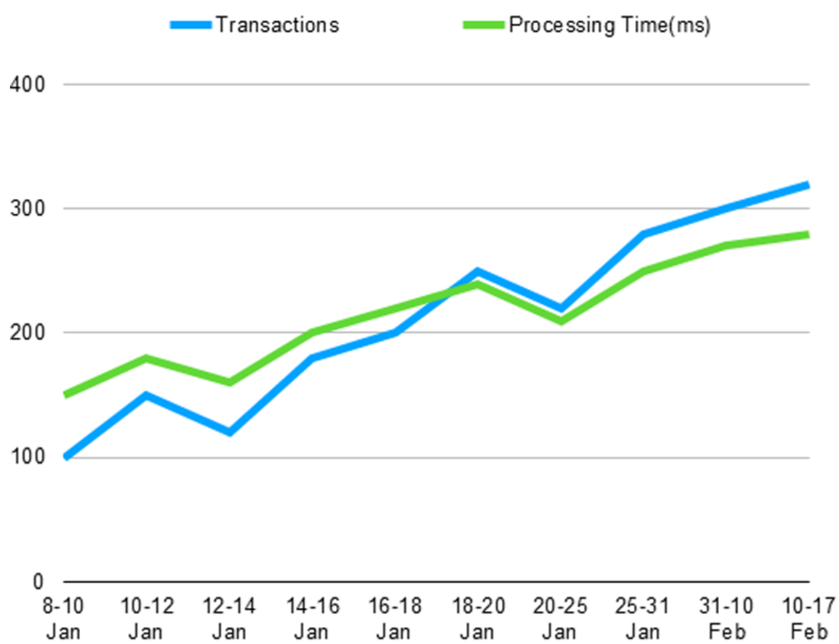



*Figure 23. Transaction and processing time visulaizations*




Doctors and patients might not be familiar with how block chain works. It can also be costly and smaller healthcare organizations may find it challenging to allocate resources for such projects.

## Future Directions

In the future, healthcare systems using block chain aim to improve how different systems share patient data securely. They'll focus on making patient information even more private and secure by using advanced encryption and privacy technologies. These systems will work with other emerging technologies like artificial intelligence and the Internet of Things to create a smarter healthcare network.

Smart contracts will be used more to automate tasks like handling insurance claims, billing, and making sure healthcare practices follow regulations, reducing mistakes. There will be more apps and tools giving patients greater control over their health information, making healthcare experiences more personalized and putting patients at the center.

## CONCLUSION

In conclusion, the integration of block chain technology with Ganache, Truffle, Meta Mask and MEAN stack offers a promising solution to revolutionize health records management. This study highlighted the critical importance of secure, transparent and accessible patient data in the healthcare ecosystem. Addressing the limitations of traditional systems, such as data breaches and inefficient data sharing, the proposed system provides a decentralized approach that ensures data immutability, enhanced security, and streamlined access control. The successful implementation and testing of the system demonstrates its potential to significantly improve information security by enabling efficient and interoperable healthcare management. Using Ganache, Truffle, Meta Mask and the MEAN stack has proven essential to developing a robust, scalable and user-friendly application that works seamlessly with the block chain backend. As healthcare systems continue to evolve, this study encourages continued exploration of innovative technologies and highlights the need for secure and efficient healthcare information management. The findings underscore the viability of block chain integration in healthcare and pave the way for future advancements in this critical field.

In conclusion, the technical aspects of integrating Ganache, Truffle, Meta Mask and the MEAN stack into a block chain based health document management system show significant advances in security, accessibility and interoperability. Using Ganache and Truffle enables a robust development environment, enabling efficient deployment and testing of smart contracts. Meta Mask and integration provides better user authentication and access control, protecting the system against unauthorized access. The contribution of the MEAN stack results in a responsive, scalable and dynamic web interface that interacts seamlessly with the block chain backend. The successful integration of these technologies provides a strong foundation for decentralized healthcare data management that addresses critical challenges in traditional systems. However, continuous improvements and fine-tuning can further optimize performance metrics, ensuring continuous data integrity, access control and user experience improvements in the healthcare ecosystem. This technical study paves the way for future innovations in the use of block chain and related technologies in secure and efficient health information management systems.

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## ADDITIONAL READINGS

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## KEY TERMS AND DEFINITIONS

**Block Chain Technology:** Block chain is a decentralized and distributed ledger technology that records data in a secure, tamper-resistant manner. It consists of a chain of blocks, each containing a cryptographic hash of the previous block, providing a transparent and verifiable way to record and verify transactions or information.

**Data Security:** Data security involves implementing measures to protect digital information from unauthorized access, disclosure, alteration, or destruction. It encompasses the use of encryption, access controls, and other safeguards to ensure the confidentiality, integrity, and availability of data.

**Decentralized System:** A decentralized system is a network or structure where decision-making, control, or data storage is distributed across multiple nodes or locations. This approach aims to enhance resilience, security, and efficiency by reducing reliance on a central authority.

**Ganache:** Ganache is a personal block chain for Ethereum development. It provides a local environment for testing and development, allowing developers to create and test Ethereum applications in a secure and controlled setting.

**Healthcare Records Management:** Healthcare Records Management involves the systematic organization, storage, retrieval, and maintenance of patient health information. It encompasses the creation, maintenance, and secure handling of electronic and paper-based medical records to ensure accuracy, confidentiality, and accessibility.

**Interoperability:** Interoperability refers to the ability of different systems, software, or components to exchange and interpret data seamlessly. In the context of healthcare, interoperability enables the sharing and utilization of health information across various platforms and applications

**MEAN Stack:** MEAN Stack is a full-stack JavaScript framework comprising MongoDB (database), Express.js (backend framework), AngularJS (frontend framework), and Node.js (runtime environment). It provides an end-to-end development stack for building scalable and dynamic web applications.

**Meta Mask:** Meta Mask is a cryptocurrency wallet and browser extension that enables users to interact with decentralized applications (DApps) on the Ethereum block chain. It serves as a gateway for users to manage their digital assets and securely access block chain-based applications.

**Smart Contract Deployment:** Smart contract deployment involves the implementation and activation of self-executing contracts on a block chain. These contracts, written in code, automatically execute predefined actions when specific conditions are met, facilitating trust and automation in various processes.

**Truffle:** Truffle is a development framework for Ethereum that simplifies the process of building, deploying, and managing smart contracts. It offers a suite of tools and libraries to streamline the development workflow for blockchain applications.