Electronic Records Hospitals on Block chain

Major project report submitted in partial fulfilment of the requirement for the degree of Bachelor of Technology

In

Computer Science and Engineering

By

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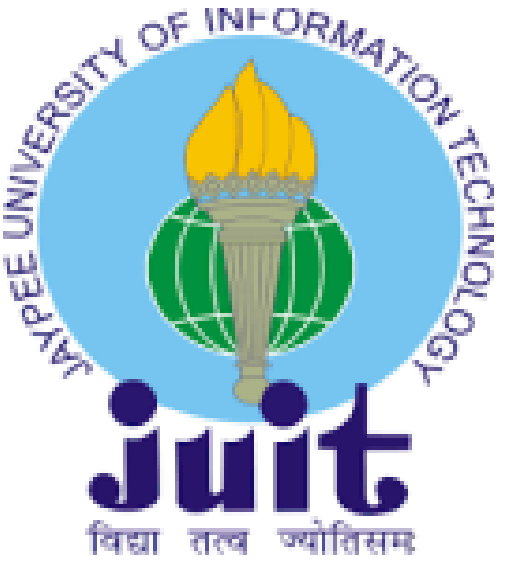
UNDER THE SUPERVISION OF

Mr. Praveen Modi

Assistant Professor, Deptt. Of CSE



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DECLARATION

I hereby declare that I worked on this project at Jaypee University of Information Technology under the guidance of Mr Praveen Modi, Assistant Professor, Department of CSE & IT. I hereby also declare that neither this Project nor any component of this Project has been submitted to any other institution for the purpose of receiving a degree or diploma.

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CERTIFICATE

This is to certify that the work being presented in the Project Report titled “Electronic Records Hospitals on Block chain " is an authentic record of work done by "Harsh Jain (191243)" and that it has been submitted to the Department of Computer Science & Engineering, Jaypee University of Information Technology, Waknaghat in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Computer Science & Engineering.

Harsh Jain (191243)

The above statement made is correct to the best of my knowledge.

(Mr. Praveen Modi)

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ACKNOWLEDGEMENT

First and foremost, I want to give Almighty God my sincere gratitude and thanks for His heavenly grace, which made it possible to finish the project work successfully.

I want to express my gratitude and deep debt of gratitude to my supervisor, Mr. Praveen Modi, an assistant professor in the department of computer science at Jaypee University of Information Technology in Waknaghat. To complete this project, my supervisor needed to have deep knowledge and a genuine interest in the topic of " Electronic Records Hospitals on Block chain." This Project was made possible by his never-ending tolerance, academic leadership, persistent encouragement, constant and energetic supervision, constructive criticism, insightful counsel, reviewing numerous subpar versions and fixing them at every stage.

I would like to extend my sincere gratitude to Mr. Praveen Modi of the Department of CSE for his thoughtful assistance.

A warm welcome would also be extended to everyone who has directly or indirectly assisted me in making this project successful. In this particular circumstance, I would like to express my gratitude to all of the staff members—teaching and non-teaching—who have provided me with practical assistance and made my task easier.

Finally, I must respectfully appreciate my parents' unfailing help and tolerance.

Harsh Jain

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ABSTRACT

In today's healthcare industry, the availability of genuine health advice and easy accessibility is crucial for patients to receive quality care. Our telemedicine application is designed to address these needs, providing patients with access to trusted healthcare professionals and medical advice from the comfort of their own homes.

However, accurate and accessible patient health records are also critical for healthcare professionals to provide the best possible care. Electronic health records (EHRs) have emerged as an essential tool for maintaining patient health records and sharing them across different healthcare organizations. However, current EHR systems face challenges such as technological limitations and legal obstacles like concerns about privacy and efficiency.

To address these challenges, we have developed and tested an experimental EHR block chain that aims to improve upon current EHR systems. By leveraging block chain technology, we can create a secure and decentralized system for managing patient health records. This allows healthcare professionals to access and share patient information in a more efficient and secure manner, while also addressing privacy concerns. Our goal with it is to provide a reliable and accessible platform for healthcare professionals to manage patient health records, ultimately leading to better patient outcomes and improved healthcare delivery. By addressing the shortcomings of current EHR systems, we hope to drive innovation in the healthcare industry and improve the quality of care for patients around the world.

Motivation

As Computer Science & Engineering department students, we have introduced and learned about different kinds of new world technologies. Also, learn to combine our software programming knowledge with technology like block chain. Our basic purpose is to make a Virtual product showcasing application by using the technology and benefits provided by block chain. We decided to apply our Product-Showcasing idea on a Healthcare Application to create something that helps the healthcare providers, and also to help patients (customers) maintain the ownership of health records.

The use of block chain technology in healthcare is revolutionary, as it offers unprecedented security, transparency, and accessibility to patient data. This innovative technology provides a decentralized database that allows healthcare providers to access patient records securely and efficiently. With block chain, healthcare providers can have real-time access to a patient's complete medical history, which can significantly improve the accuracy and effectiveness of diagnosis and treatment.

Furthermore, block chain technology can streamline the appointment process by providing a platform for voice and video appointments, reducing the need for patients to physically visit healthcare facilities. This technology enables healthcare providers to schedule appointments and make sure that patients receive the necessary care at the appropriate time, regardless of their location. This increased mobility and accessibility can lead to a more efficient healthcare system.

The convenience of block chain technology also extends to the patients themselves. Patients can have complete ownership of their health records, ensuring that they have full control over their personal information. They can share this information with authorized doctors and medical staff only, allowing for increased privacy and security. The use of block chain technology in healthcare has the potential to revolutionize the industry by improving efficiency, security, and accessibility. As more healthcare providers adopt this technology, it is likely that we will see a significant shift in the way medical care is delivered, with digital-based healthcare solutions becoming more commonplace. The use of block chain in healthcare also creates new job opportunities for those skilled in block chain technology, contributing to growth in the work market.

CHAPTER 01: Introduction

1.1 Introduction

Indeed, block chain technology has the potential to revolutionise the healthcare business by addressing the issues that existing Electronic Health Record (EHR) systems confront. As you indicated, security, privacy, and secrecy are critical in the healthcare sector, and block chain's decentralised and secure nature makes it a great answer to these challenges. Because block chain technology is decentralised and validated by a network of users, it provides a tamper-proof platform for storing sensitive medical records. This maintains the integrity of the medical records and provides healthcare providers with a dependable source of information. It can also provide consumers with data ownership and control. However, there are still problems to deploying block chain technology in healthcare, such as ensuring that the system is accessible and user-friendly for healthcare professionals, overcoming legal and regulatory impediments, and addressing data privacy and security concerns.

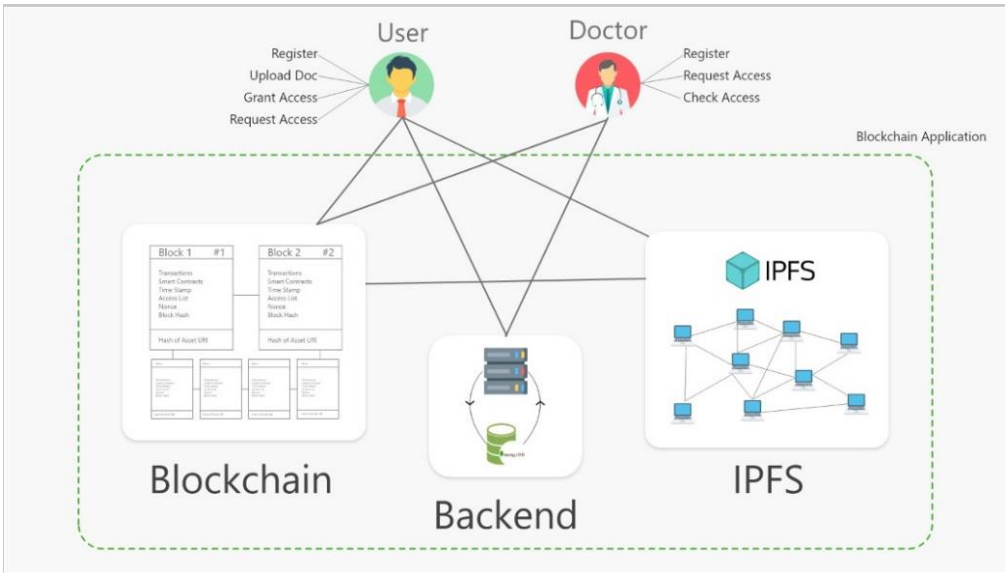

Fig 1. doctors and patients act as entities or nodes in this block chain network [1]

The potential benefits of block chain technology in healthcare are substantial, and as I have stated, the emergence of creative solutions like these shows great promise for enhancing EHR systems and, ultimately, patient outcomes.

Objectives

- **Storage of all previous Health Records**: All of the patients' medical information will be housed in highly secure servers using block chain technology. This ensures the patient's data's privacy and security while also making it easily accessible to authorised healthcare practitioners. Patients may simply maintain track of their medical history and share it with their doctors now that all previous health records are in one location.

- **Complete ownership of own health records**: This project intends to give patients complete control over their medical records. Patients who own their own data can make educated decisions about who gets access to their information and under what conditions. Patients can be ensured that their records are tamper-proof and cannot be altered without their knowledge or agreement by adopting block chain technology.

- **Encryption and Security Protocols:** It is critical to implement security and encryption mechanisms to maintain the confidentiality, integrity, and availability of patient data. This project is to provide cutting-edge security measures to safeguard against unauthorised access, data breaches, and cyber-attacks. Patients' data can be securely encrypted and kept on decentralised servers using block chain technology, making it practically impossible to hack.

- **Appointment Management:** Appointment scheduling is an important component of healthcare administration, and this project attempts to make the process easier for patients. Patients may simply view their doctors' availability and select a time that works for them by giving a user-friendly interface. This will aid in reducing wait times and increasing patient satisfaction. Furthermore, healthcare providers can more easily manage their calendars and appointments, freeing up critical time to focus on patient care.

Language Used

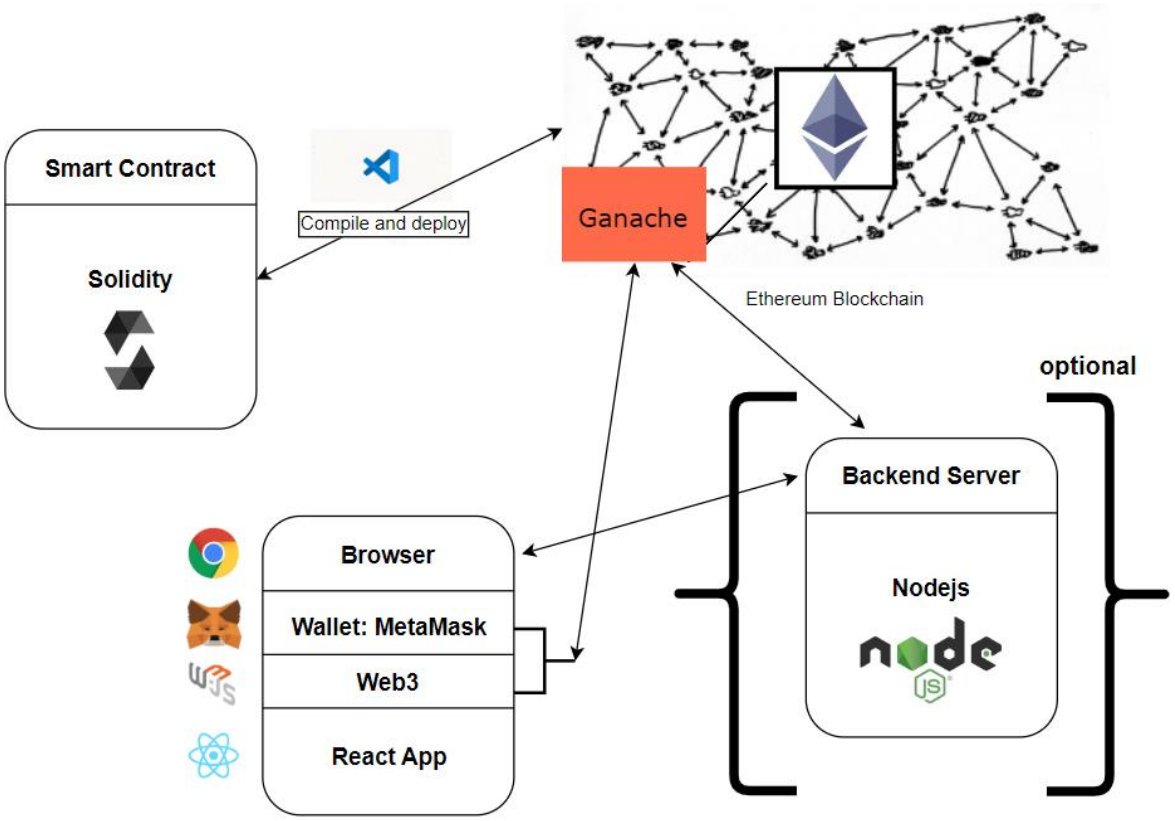

Fig 2. Structure of application

Frontend:

- **React**: React is a declarative, effective, and versatile Java language.React apps are constructed using a component-based design, with components serving as its basic structure. It offers a vast array of tools and libraries to enhance and extend its capabilities in addition to the ability to handle complicated state management. Additionally, it can be quickly added to a number of libraries and frameworks, including Angular, Vue, and Backbone, enabling developers to benefit from each one's distinct features and abilities.User interface creation using the aScript library. It enables you to build intricate user interfaces out of discrete, little chunks of code known as "components".

- **React-Bootstrap**: In response to the rise in popularity of single-page apps over the past several years, numerous front-end frameworks have been developed, including Angular, React, Vue.js, Ember, etc. Consequently, jQuery is not a prerequisite for

creating web applications. The most widely used JavaScript framework for creating online apps nowadays is React, while Bootstrap has overtaken it as the most widely used CSS framework. As a result, the major goal of this part is to teach you numerous ways that Bootstrap may be utilised in React projects.

- **Redux**: We employed Redux in our applications for a variety of reasons. For starters, Redux enables us to build applications that are predictable and efficient even in complicated and changing environments. Redux allows us to build powerful features like undo/redo and state persistence by centralising our application's state and logic. Furthermore, Redux facilitates debugging our programme by providing a precise record of how, where, and when our app's state changes. Finally, Redux is a versatile library that can be tailored and enhanced to match the specific requirements of our application.

Backend

- **MongoDB** - MongoDB is a NoSQL database noted for its scalability and flexibility. It is intended to manage massive amounts of data, making it an excellent solution for applications requiring quick and efficient querying and indexing. Data is saved in a JSON-like format called BSON, which stands for Binary JSON, in MongoDB. This enables MongoDB to map data directly to objects in our code, making development easier. It is also known for its high availability and fault tolerance, which ensures that data is always available to the application, even if hardware or network faults occur.

- **Node-Js** - Node.js is a framework for creating quick and scalable network applications that is based on Chrome's JavaScript engine. An open source, cross-platform runtime environment called Node.js is used to create networking and server-side applications. Applications for Node.js may be created in JavaScript and run on Linux, OS X, and Microsoft Windows using the Node.js runtime. An open-source, cross-platform runtime environment for JavaScript is Node.js. The heart of Google Chrome, the V8 JavaScript engine, is operated by Node.js outside of the browser. Node.js may be incredibly performant because of this. Without starting a new thread for each request, a Node.js application operates in a single process. JavaScript code cannot block thanks to a set of asynchronous I/O primitives that Node.js includes in its standard library.

- **Express** - A web application's front-end and back-end are connected through ExpressJS. Users are able to engage with the application in real-time thanks to it acting as the middleman that handles data and information between the two.The development and maintenance of a web application is also made simpler by the inclusion of a number of useful capabilities in this framework, including middleware, routing, and templating. It is a Node.js-based web application framework that is free and open-source. It is meant to make creating and maintaining server-side applications easier.

Others

- **IPFS** - Breaking down barriers between devices across borders is IPFS' primary function as a decentralised file storage system. With each computer holding partial ownership over important documents or multimedia content within this vast ecosystem without any central authority involved allows for secure collaborations without fear of third-party intervention or hacking threats reducing confidence in this form of sharing information among peers spread out across multiple locations worldwide exponentially so everyone's contribution matters equally regardless if located near or far away from others partaking in this endeavour making it unprecedentedly efficient due to its distributed structure hash table.

- **Ganache** - Ganache is a personal Ethereum block chain that allows developers to test and deploy smart contracts on a local block chain network. It has a graphical user interface that allows developers to design and manage block chain networks, as well as create test accounts and simulate transactions. Ganache also has a variety of important tools for debugging and testing smart contracts, such as the ability to inspect contract logs and state changes, as well as simulate various network situations. Ganache is very beneficial for developers who wish to test their contracts before distributing them to the main Ethereum network.

Technical Requirements

- **Microsoft Visual Studio:** Microsoft created the free open source text editor known as Visual Studio Code (often referred to as VS Code). Linux, macOS, and Windows all support VS Code. VS Code has recently become one of the most widely used development environment tools, despite the editor's relatively modest weight and robust functionality.VS Code supports a broad range of programming languages, including CSS, Go, and Dockerfile in addition to Java, C++, and Python. In addition, VS Code enables you to install new extensions like code linters, debuggers, and support for cloud and web development.

- **Ganache:** The high-end development tool Ganache is used to operate your own local blockchain for the creation of both Ethereum and Corda dApps. Ganache is useful during the entire development process. You may create, implement, and test your projects and smart contracts on the local chain in a predictable and secure setting. Developers may test and debug their code before uploading it to the open Ethereum network using Ganache's own block chain, which can be adjusted to imitate different network scenarios. It is an absolute necessity for developers building decentralised apps on the Ethereum network due to its user-interface simplicity and strong features, such as the ability to run automated tests.

- **IPFS:** Breaking down barriers between devices across borders is IPFS' primary function as a decentralised file storage system. With each computer holding partial ownership over important documents or multimedia content within this vast ecosystem without any central authority involved allows for secure collaborations without fear of third-party intervention or hacking threats reducing confidence in this form of sharing information among peers spread out across multiple locations worldwide exponentially so everyone's contribution matters equally regardless if located near or far away from others partaking in this endeavour making it unprecedentedly efficient due to its distributed structure hash table.

1.6 Deliverables

- Specialists from all over the world can evaluate patients: Medical care has never been so accessible thanks to the advent of remote consultation apps such as healthcare

applications. Now patients can easily connect with doctors through video calls or chats on their phones instead of having an arduous trip into town - no matter where they reside! The app even includes scheduling options saving valuable time all around and streamlining diagnoses by allowing users quick access at any given moment making it simple for them understand exactly what's going on medically whilst keeping up-to-date records all bundled into one strong package - perfect for those living far away from hospitals

- Web application can be installed on the loading page: It enables the installation of web apps on the landing page, enabling patients better access to the app's features. The page might include a summary of the application's features and benefits. The web application may then be installed by patients by clicking on an image or link on the landing page. This allows people to quickly and easily access the healthcare application without having to search for it on the internet.

- Patients can choose who has access to their health records: This feature gives patients more control over their health records. Patients have the option of granting access to their health records to healthcare practitioners, family members, or other trusted individuals. Patients can also deactivate their access to their health records at any time. The healthcare application can help patients safeguard their privacy while yet allowing them to share their health information with others who need it by including this functionality.

1.7 Methodology

The front-end is intended to UI/UX friendly along with a focus on healthcare and ease of use. It stores medical records in a decentralised manner using IPFS, which helps to ensure their availability and accessibility. The front-end platform also makes use of HTML, CSS, and React.js to build an easy-to-navigate and understand interface.

The website's backend is designed with Solidity, Node.js for server-side control, and Visual Studio Code (VSC) as an Integrated Development Environment (IDE) for writing and testing our smart contracts. For package installation and administration, we also utilise npm (Node Package Manager). These technologies enable us to build a secure, efficient, well-organized, and simple-to-maintain system.

Smart contracts are used to enforce access controls and ensure that only authorized parties can access patient data. Patients can grant or revoke access to their medical records at any time using MetaMask (as a wallet), VSC (as an IDE), npm (command-line interface), Ganache (account creation), and Local Web3 (web interface).

Below is a flowchart explaining the workflow behind the creation of a medical contract, its storage, transaction and encryption:

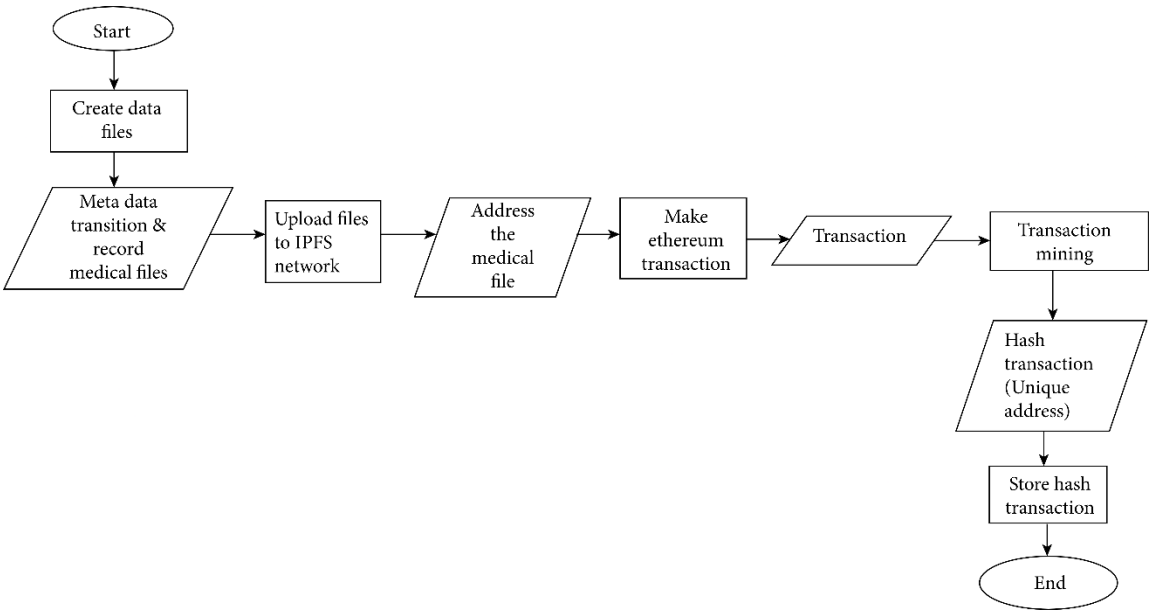

Fig 3: Step by step explanation of our smart contract's creation [2]

The use of block chain technology ensures that patient data is protected from unauthorized access, while also providing a transparent and immutable record of all transactions. The decentralized architecture allows for secure and efficient sharing of medical data between different healthcare providers.

Our proposed system design represents a significant step forward in the field of electronic healthcare data records management. By leveraging block chain technology, smart contracts, IPFS, VSC, NPM, Ganache, Meta-Mask, Local Web3, HTML/CSS/React.js we can create a more secure and accessible healthcare ecosystem that benefits both patients and healthcare providers alike. It provides

patients with greater control over their own medical records by using smart contracts to enforce access controls. Along with that healthcare providers can access patient data from anywhere in the world by using IPFS to store medical records in a decentralized manner. This helps to reduce errors and ensure that patient data is protected from unauthorized access.

Chapter 02: Literature Survey

Author(s): P. Esmaeilzadeh and T. Mirzaei (2019) [3]

Abstract:

This paper's major contribution is to investigate the possible benefits and problems of employing block chain technology for secured and effective health information exchange, or HIE, networks. The authors performed a review of previous studies on block chain and the HIE, along with a case study of an Iran-based block chain-based HIE network. They found numerous significant benefits of implementing block chain for HIE, such as enhanced security of data, confidentiality, interoperability, and patient sovereignty over their own health data. They did, however, highlight many problems that must be solved before broad implementation, including scaling, compliance with regulations, and client acceptability.

In terms of pertinent research, the authors highlighted numerous research studies that examined the use of block chain for health care applications. They discussed how block chain tokens may democratise healthcare entrepreneurship and innovation, as well as a variety of block chain use cases in biological and medical applications. The authors also cited government papers that discussed the potential benefits of using block chain to share health information.

The study discusses all of the potential benefits and drawbacks of integrating block chain technology in health data networks. It stresses crucial elements that must be solved prior to widespread deployment, but it also suggests that secure and efficient data transmission has the potential to greatly enhance healthcare outcomes.

Author(s): A. H. Mayer, C. A. da Costa, and R. da R. Righi (2019) [4]

Abstract:

The research paper provides an analysis of block chain technology's present condition in healthcare and recommends areas where it may be used to enhance patient outcomes. It emphasizes the importance of interoperability among various EHR systems and highlights the potential advantages of employing the technology of block chain in clinical studies. It suggests that governments collaborate with stakeholders from the industry to create open guidelines for block chain use in healthcare.

However, concerns have been raised concerning block chain technology's scalability and capacity to manage vast volumes of health data, as well as how it will be governed in the healthcare business and how it will be linked to currently operational EHR systems.

This research report provides insights into the benefits and problems of implementing digital currency in healthcare. It emphasizes the importance of further study and advancement in this field and advises governments to support innovation and the use of new technology in healthcare to improve patient outcomes, save costs, and improve the standard of care while protecting patient privacy and security.

Chapter 03: System Development

3.1 System Design

A critical feature of the proposed block chain-based system is the patient's right to access and manage their own health records. Patients have more control over their health information and can share it with whoever they want because they have direct access to their medical records. Encryption and block chain technologies are used to ensure that the data is secure and cannot be tampered with.

The suggested solution is open source and independently verifiable, in contrast to typical centralised EHR systems, which are frequently proprietary and managed by a single supplier. It fosters confidence and transparency among patients, doctors, and hospital administrators. The suggested approach encourages people to take an active role in their treatment by allowing them to control their own health records.

The deployment of this block chain-based EHR infrastructure is projected to considerably improve the success of the healthcare transition programme. The availability of internationally accessible EHRs for healthcare researchers and practitioners will increase collaboration, knowledge exchange, and healthcare outcomes. Overall, the suggested system promotes patient autonomy and enhanced treatment by providing a decentralised, secure, and transparent method of managing and sharing health records.

The design system for our study paper on EHR and healthcare was created with the purpose of achieving our goal of establishing an effective and secure EHR system in mind. To assure the security, reliability, and efficiency of our design system, we used Solidity, Web3, IPFS, and encryption approaches. We were able to design a solution that fulfils the special needs of healthcare environments while also providing a user-friendly experience for all stakeholders by incorporating these technologies. We can provide a solution that improves the functionality and usability of EHRs, improving patient outcomes and promoting more efficient and effective healthcare delivery since we leverage Solidity, Web3, IPFS, and encryption.

Below are diagrams that respectively represent the user flow of the technologies involved:

Patient user flow

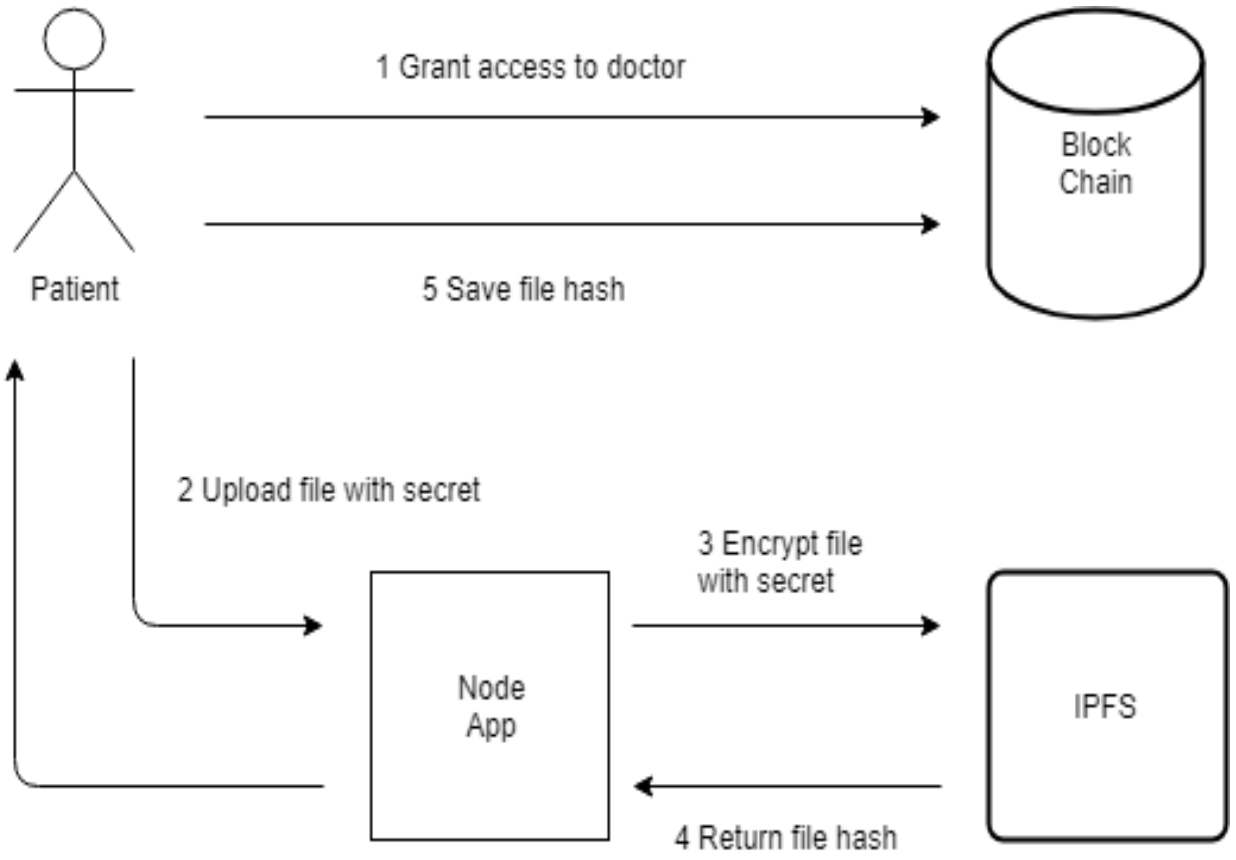

Fig 4 Process of creating and granting access of files to doctor

Below are the steps that defines the flow from a patient's prospective:

1. When registering for the EHR system, doctors are required to provide their name to create a secure profile in the system.
2. Patients are then required to provide their name and age during registration to create their profiles.
3. To ensure that patient data is protected, a secret is maintained in the Ethereum block chain, and patients can upload their files to the system using a random key to encrypt them. These encrypted files are then posted to IPFS, ensuring the secure storage and sharing of patient data.
4. Patients have control over who can access their files and can grant specific

physicians access to view their data.

5. Once a patient grants access to their files, the physician can view the patient's address on their home page, allowing them to access the patient's records.

6. Doctors can send a request to the node app to view the patient's files and receive all the files associated with the patient's IPFS hash.

7. To maintain the security and confidentiality of the patient's data, the node software will download the files via IPFS, obtain the block chain secrets, decrypt the files, and deliver them to the requesting doctor.

Doctor's Prospective

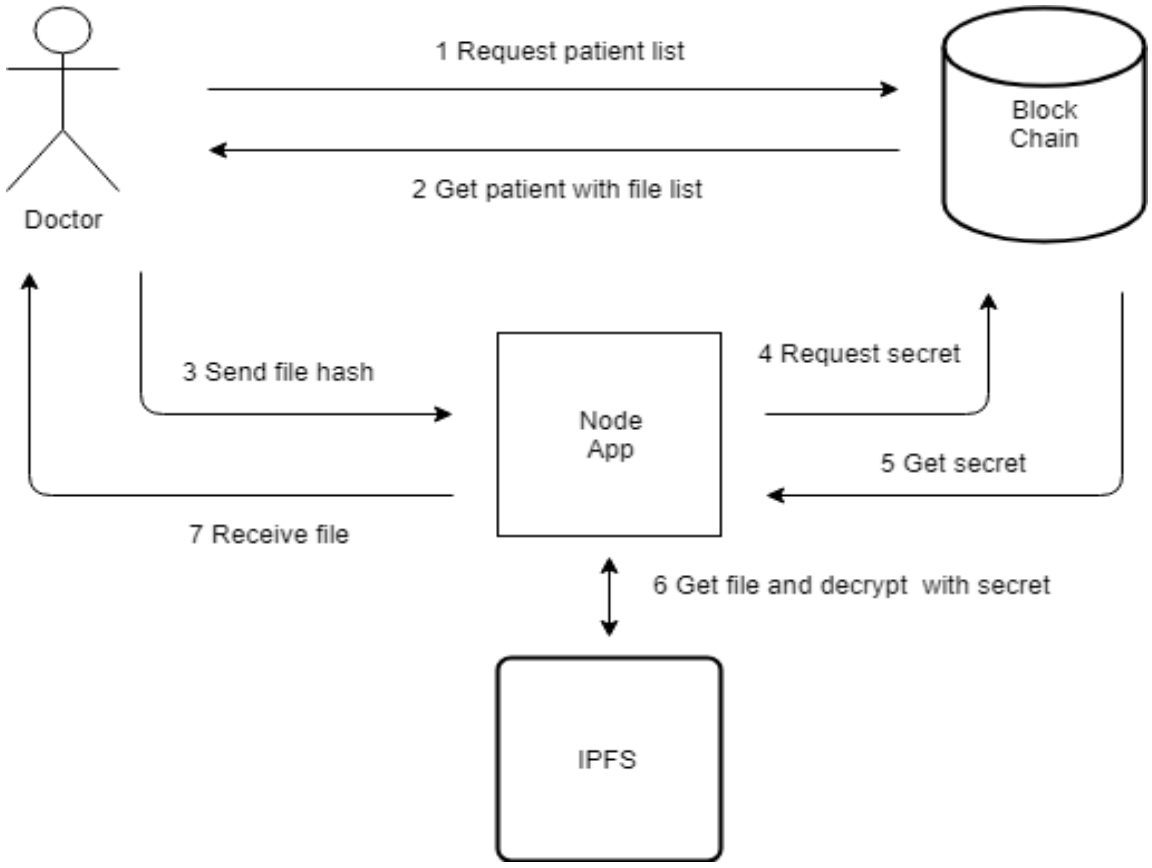

Fig 5 Process of requesting and receiving patient's files

Below are the steps that defines the flow from dctor's prospective:

1. To access a patient's records, doctor can request patient list from the blockchain using the metamask key.

2. The block chain returns the hash of the patient's record.
3. The doctor can then send the file hash to the application to authenticate and authorize the transaction of the JWT secret from the block chain.
4. The block chain then returns the JWT secret to the doctor.
5. Next, the application gets the patient's files/records from IPFS (Interplanetary File System).
6. After retrieving the files, the application decrypts them using the JWT secret obtained from the block chain.
7. Finally, the decrypted files are returned to the doctor for observation and use in patient care. This secure process ensures that patient data is protected while still allowing doctors to access the information they need to provide the best possible care.

3.2 Smart Healthcare Welcomes Block Chain Technology

The fast growth of software-based solutions has transformed the way medical care providers and purchasers interact. The use of block chain technology in the healthcare business is growing more prominent as the industry places a greater emphasis on personalised care. Decentralisation has traditionally been a big difficulty for the telemedicine sector. However, the introduction of block chain technology has aided in addressing this issue by bringing decentralised technology that reduces the possibility of a single point of failure and safeguards against data breaches, attacks, and hacking attempts.

Because of its decentralised nature, block chain technology provides a dependable and efficient option for managing medical records. The system assures that every network node verifies and checks all ledger copies. This makes ensuring the integrity and security of medical records easy. Medical service companies can increase the reliability of their services and provide customers more control over their health records by embracing block chain technology. [5]

In addition to offering greater transparency than traditional centralized systems, a block chain-based approach provides top-of-the-line security measures too. By maintaining confidentiality while keeping patient data secure and easily accessible to authorized staff only via distributed ledger technology; healthcare providers can collaborate effectively with each other whilst minimizing risk and maximizing accuracy - factors that

ultimately lead to better patient outcomes overall. As a remedy to decentralized health care issues currently faced by medical professionals everywhere; block chain adoption continues at an accelerated pace throughout the industry owing to its superior attributes when compared with older methodologies. As records are safely managed and potential errors minimized under such conditions; patients' satisfaction ratings stand to improve significantly in response to these changes. Moreover; as the field evolves further with refined iterations of current protocols; we can expect transformative health care solutions thanks to ongoing technological advancements.

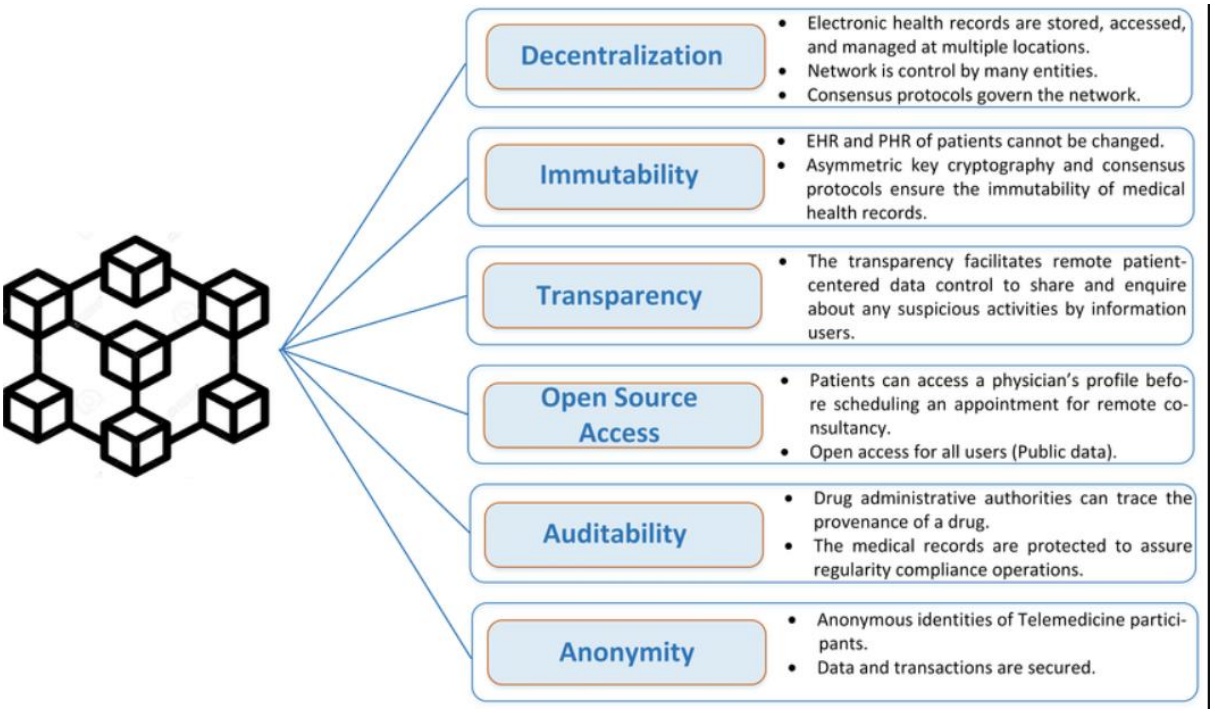

Fig 6 Benefits of Block-chain over servers [6]

The implementation of a decentralised ledger ensures that all transactions and records are securely stored and cannot be tampered with, removing the risk of fraudulent activity or medical identity theft. Smart contracts enable automated and fast claims processing, significantly reducing the time and expense involved with traditional insurance claim processing.

Furthermore, the accessibility of digital health records via block chain technology improves patient care by allowing healthcare providers to rapidly and accurately access a patient's complete medical history. This is especially useful in emergency situations where time is critical and having access to correct and up-to-date medical records might mean the difference between life and death.

Overall, block chain technology has the potential to transform the healthcare industry by increasing the security, efficiency, and accessibility of medical records. We should anticipate to witness a major improvement in patient care and a reduction in healthcare expenditures if block chain-based solutions become more widely adopted. More study is needed, however, to address the scalability and regulatory compliance of block chain-based solutions in the healthcare industry.

Opportunities for Block chain

- **Patient assent the board**

The traditional consent management approach has several drawbacks, including low trust in third-party servers, the inability to execute transparent audit trails, and others. These difficulties might result in breaches of patient privacy and trust issues in telemedicine. These issues are addressed by block chain, which provides a decentralised and immutable ledger that enables secure and transparent record-keeping. Patient consent can be recorded on a tamper-proof and verifiable ledger using block chain, ensuring that it cannot be amended or erased by any unauthorised entity. [7] This increases trust in the consent management process and ensures patients have complete control over their data.

Furthermore, block chain facilitates audit trials to ensure compliance with consent management standards. The openness and immutability of block chain technology allow for the tracking of every transaction and the enforcement of defined policies. Every transaction is recorded in the block chain, making it easy for auditors to follow and verify the legitimacy of every record. This contributes to the development of trust among patients, healthcare providers, and other players in the telemedicine business. Block chain can help mitigate the dangers associated with the old consent management strategy by providing transparency and accountability, allowing the telemedicine business to create a more secure and trustworthy platform for patients to manage their health information.

- **Recognisability of Medical equipment**

The usage of block chain in the healthcare business has also helped to resolve issues about the provenance of medical devices used at home. Doctors frequently doubt the dependability of home medical devices due to a lack of information regarding their origin and previous use. On the distributed ledger, block chain technology can give a permanent record of ownership and performance of testing devices, confirming the devices' legitimacy and dependability. [8]

Through the implementation of smart contracts, block chain technology can help to establish reputation rankings for each medical device and test kit, in addition to providing a record of ownership and performance. These reputation rankings can be utilised by both healthcare providers and patients to make educated decisions about which devices and test kits to use, resulting in higher quality of treatment and health outcomes.

- **Efficient Payment gateway**

Aside from secure payments, block chain technology provides various other advantages to the healthcare industry. It can, for example, serve to streamline the sharing of patient data between multiple healthcare providers while maintaining patient privacy and security. This is especially crucial when patients are being treated by many clinicians, since it allows for more coordinated and efficient patient care. Furthermore, by automating activities such as medical record-keeping, insurance claims processing, and supply chain management, block chain can assist reduce administrative overheads and improve the efficiency of healthcare operations. [9]. As a result of these benefits, an increasing number of healthcare organisations are investing in block chain development services to remain competitive and achieve long-term economic benefits. This comprises both big industry actors like pharmaceutical corporations, hospitals, and insurers, as well as start-ups and small businesses. With the continuous expansion of block chain technology, its applications in the healthcare industry are projected to rise and promote greater innovation and growth.

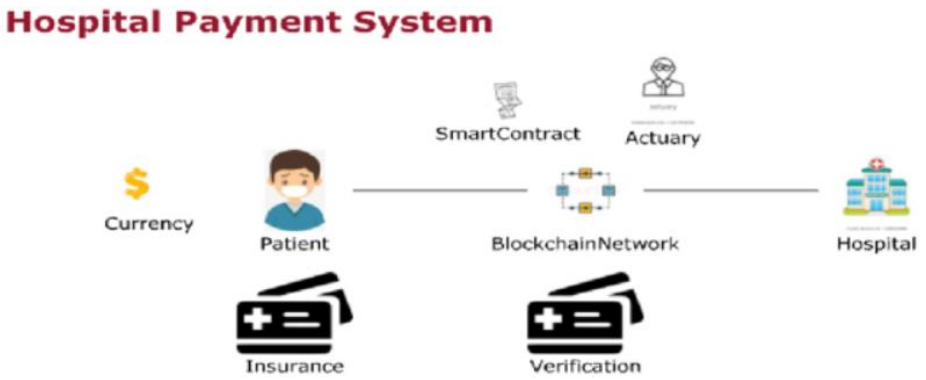

Fig 7: Payment system patients and hospitals are bound with smart contracts. [10]

Block chain and Telemedicine trends 2023

Block chain and telemedicine are two rapidly expanding technologies with the potential to transform the healthcare industry. Here are the tendencies we might expect in these two categories in 2023.

Telemedicine has grown rapidly in recent years, and this trend is likely to continue through 2023. The COVID-19 pandemic has hastened the use of telehealth visits, which experts expect will increase in quantity. More at-home testing kits and platforms are anticipated to be approved by the FDA, making it easier for patients to monitor their health from home. Telehealth platforms are also expected to become more linked with electronic health record systems, allowing healthcare practitioners and patients to communicate more seamlessly.

The application of block chain technology in the context of telemedicine is expected to alleviate data security and privacy concerns. Block chain technology provides a secure and transparent platform for storing medical data, lowering the risk of data breaches and protecting patient privacy. Block chain-based micropayments are also expected to grow in popularity, providing a more secure and transparent payment alternative for telemedicine services. Furthermore, block chain can facilitate the sharing of medical records among various healthcare providers and organisations, reducing administrative expenses and improving patient outcomes.

In conclusion, the telemedicine business is predicted to expand further in 2023, with

more at-home testing devices and platforms permitted and telehealth platforms becoming increasingly integrated with electronic health record systems. Simultaneously, block chain technology is projected to play a growing role in safeguarding patient data, facilitating medical record sharing, and enabling secure micropayments.

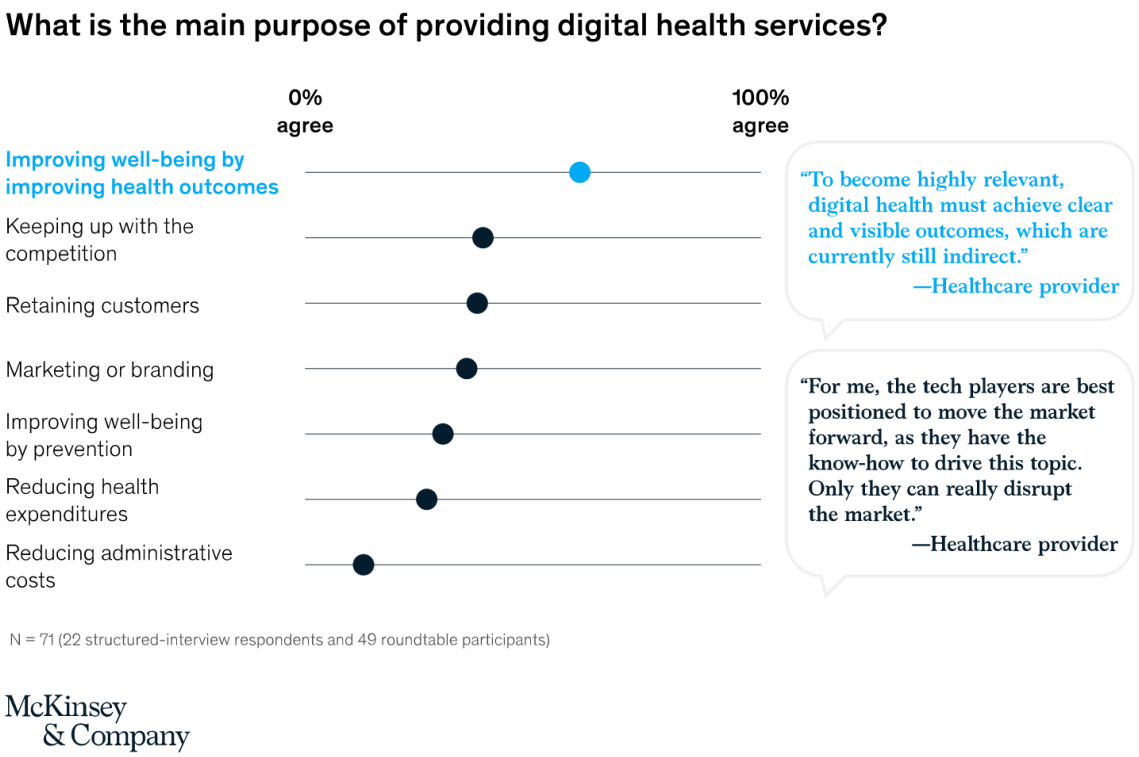

Fig 8: Survey that shows the main purpose of digital health services [11]

In the last year, the telemedicine market has observed potential market and prospects. According to Statista, the telemedicine market grew by almost $45 billion in 2019. By 2026, it is predicted to have grown by roughly four laps. This expansion will be fueled by a variety of critical variables such as higher one-to-one person prices, treatment costs, telehealth funding, and a significant increase in the number of virtual healthcare users.

More than 87% of leaders agree that the medical care business and the technologies it employs have proactively become inseparable. In the medical care sector, advanced change refers to the implementation of innovations, individuals, and cycles to deliver more achievable outcomes to patients and medical care. As a result, everything focuses around utilising imaginative approaches and the most recent advancements to acquire the most out of the business. The patient-driven system advancement concept resulted in improved execution in nearly 92% of medical care units. Below is

the spending on block chain and its trajectory in the coming years:

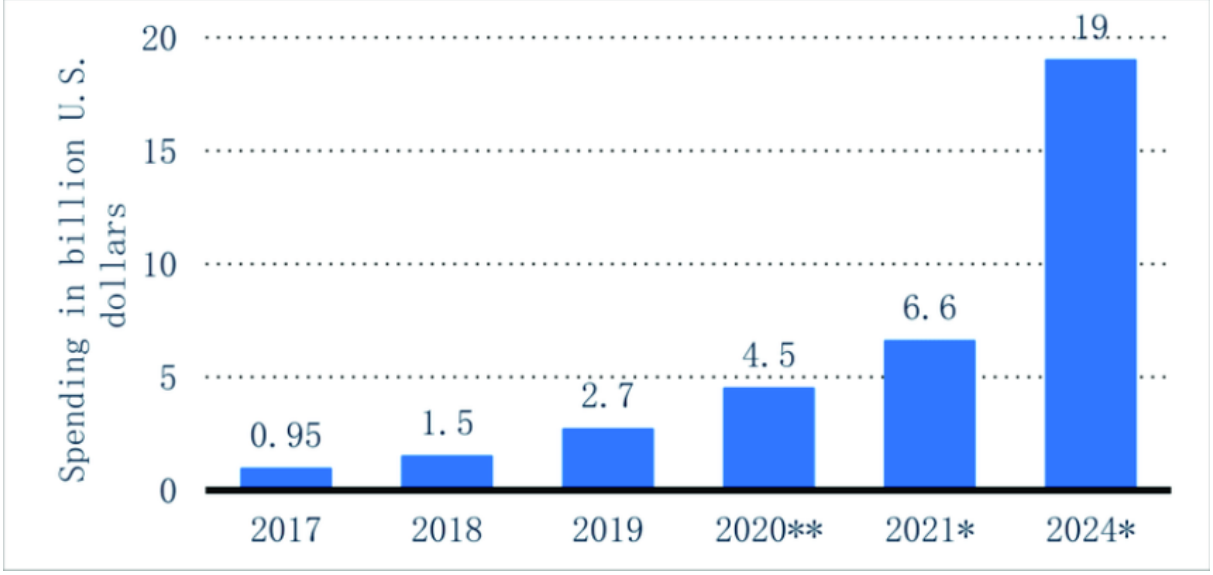

Fig 9: Worldwide spending on block chain solutions from 2017 to 2024 [12]

Authorization and Authentication through Block chain

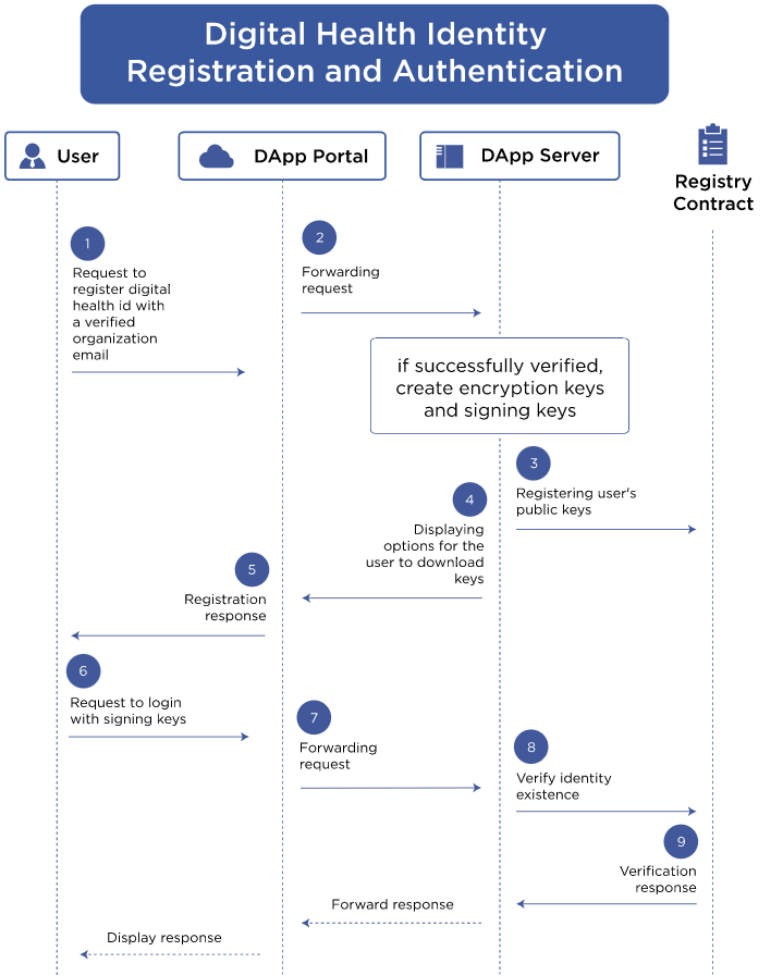

Figure 10: Working of the Registration and Authentication process of DApp [13]

The use of block chain technology for authorization and authentication in the healthcare business is an encouraging trend. This technology is built on a decentralised system that gives patients access to their personal health information. Users can use block chain to visit a site that allows them to securely and transparently share and examine their data with healthcare providers. Digital verification is used to verify the identity of users in order to obtain authorization and authentication utilising block chain technology. This is accomplished by producing a unique digital signature for each user and storing it on the block chain. When a user accesses or shares their personal health information with a healthcare professional, their digital signature is used to verify their identity. Passwords and other traditional forms of authentication that are vulnerable to hacking and data breaches are no longer required. Block chain

technology, in addition to digital verification, assures the integrity and confidentiality of patients' data. All data stored on the block chain is encrypted, making unauthorised users practically hard to access. Furthermore, because the block chain is decentralised, there is no central point of control, making it more secure against cyber-attacks and data breaches.

Security and Confidentiality in telemedicine

In order to efficiently treat patients, a facility or hospital in the future's smart cities will require data safety, integrity, and confidentiality. We are obviously on the route to advancement as a result of our country's rapid development and the way all of our municipalities are now developing into technologically proficient communities, but this also comes with a slew of perilous traps.

It is vital in smart cities to protect the privacy and security of medical data. By employing decentralised networks such as block chain-based platforms, it is possible to create a stable and safe environment for the storage and sharing of medical data.

To do this, block chain technology can be used to create a tamper-proof or irreversible ledger for recording medical data. Digital authentication on a block chain network might be used to authenticate and approve users, ensuring that only authorised personnel have access to private medical data.

Furthermore, smart contracts can be used to automate the transfer of medical information between patients, healthcare practitioners, and other interested parties, ensuring accountability and transparency throughout the process. The block chain-based solution can also verify the accuracy and authenticity of the data by keeping every transaction in a decentralised ledger distributed across numerous network nodes.

Finally, integrating block chain technology inside the framework of web 3 can provide a dependable and safe means for sharing and storing health-related data in smart cities. By employing decentralised infrastructure and block chain-based systems, it is possible to ensure the safety, secrecy, and confidentiality of medical data, allowing healthcare providers to provide vital care to patients without jeopardising their privacy. We'll discuss two options for dealing with this.

- Block chain ensures secure, intangible data transport, and its decentralised structure promotes transparency and trust. By eliminating middlemen, it reduces the risk of data breaches and increases productivity. Overall, it improves data transfer security, effectiveness, and transparency.

- Algorithms are used in the secondary layer to review blocks that are linked to patient records. Each node of the block chain has a collection of patient records. transporting a large number of patients to multiple hospitals. Suggestions for the recommended mode of care and block chain attachment may be sent from each institution to all nodes and treatment centres.

Figure 11: The trilemma of block chain [14]

Transparency, medical record accuracy, and fraud detection are all key aspects of data privacy and security that are usually overlooked throughout the integration of numerous healthcare and telemedicine systems. However, by improving data privacy, security, and traceability, the adoption of block chains offers the potential to address these issues.

Because of its decentralised and irreversible nature, block chain technology can provide dependable, trustworthy, and secure remote healthcare services. Healthcare professionals are proficient at detecting fake doctor credentials and medical test kits, which are widely used for home diagnosis.

Data encryption

It is critical to remember that encryption is required to prevent unauthorised access to patient information. Encryption ensures that only individuals with the necessary encryption keys can access the data by changing it into an unreadable format, shielding it from unauthorised access. One of the most serious security issues in telemedicine is the possibility of unauthorised use by those with malicious intent. If sufficient encryption is not used, these individuals may be able to obtain encrypted health information through unethical ways. To protect patient information from such threats, strong encryption safeguards must be implemented.

Secure video conferencing between medical experts and patients must use encryption to ensure that patient privacy is protected throughout transmission. It is possible to build decentralised storage systems and secure communication protocols to enhance information encryption both in transit and at rest. Users have more control over their data because to Web3's decentralised design, and decentralised storage solutions allow the storage of medical data on a network of nodes rather than a centralised server. On the block chain, encryption keys can be securely stored to deter unauthorised access.

Web3 can also be used to construct on-the-fly encryption mechanisms like Transport Layer Security (TLS) to secure communication between medical personnel and patients. Encryption shields patient data in transit from malevolent parties attempting to intercept or alter it, while also keeping it private and secure. Encryption keys can be held on a distributed ledger using block chain technology, increasing security and transparency. However, it is vital to remember that data encryption may not be sufficient to ensure comprehensive data security in the healthcare industry. To preserve the security and privacy of medical data, additional measures such as access limitations, verification, and frequent safety checks should be introduced. Block chain and Web3 technologies, when combined with the appropriate encryption and security mechanisms, can provide a solid solution for safeguarding medical data during videoconferencing.

Requirements

Functional Requirements

● A Web Application that interacts with the user intelligently and provides them with all the requirements that would be hosted on a private domain with MongoDB as a backend Database.

● A 24*7 Service will be provided and the patient's calls will be transferred to the Doctor On-Board at that present moment.

● The whole procedure would be even more efficient if the doctors make the necessary updates in the patient’s database simultaneously and one can do so by maintaining a unique patient ID.

● When a user logs into his/her account, he/she must be able to see his/her personal information on the screen.

● It must also prompt the user to ask for an appointment with the doctor.

● For each patient, the doctor must be able to see all the medical history and prescriptions and if there is any report, that the patient has sent.

Non-Functional Requirements

● Since the application must be accessible 24 hours a day, 7 days a week. So a PC with stable internet connection will be required.

● A good quality camera to ensure smooth video appointments.

● The system is accessed by multiple users simultaneously, so it has to offer a good response time (real time interaction), user interface. For that one must own a smart device or computer with good enough HD space, RAM memory, CPU etc

Use case 1: A Patient

A patient will receive a unique user ID and password and a message that he has started using the application.

Once the patient has logged in, it will be able to:

- See the prescription sent by the doctor
- Schedule an appointment

Use case 2: A doctor

This doctor will be an already registered user, so after logging will be able to:

- Read the information of the patient
- Check all the data sent by a single patient
- Send an email to the patient
- View appointment statuses and schedule or reschedule an appointment.

Health Chain Features

- **Convenience**

Patients have the convenience of receiving medical diagnosis and treatments in the privacy of their own homes. They can simply use a web application to schedule an appointment with a doctor and connect electronically, avoiding the need to wait in long lines or sit in crowded waiting rooms. This streamlined procedure enables healthcare providers to give patients with efficient and fast care, while also ensuring that individuals receive the therapy they require to recover from illnesses and ailments. Telemedicine has become a more popular and dependable choice for medical care because to web3 technology, giving a simple and safe means for patients to receive the attention they seek.

- **Medical Record Keeping**

The use of digital technology in healthcare has made getting medical information and histories easier and more efficient. Thanks to web3 technology, patients and healthcare professionals may now access medical data and histories with only a few clicks, resolving the issue of interoperability by allowing several physicians to access and retrieve patient information at the same time. Furthermore, patients may now simply grant access to their medical information and histories to their doctors, family members, and friends, leading in greater cooperation and care. This not only expedites the operation, but it also benefits the environment by removing the need to maintain paper medical records or reports in lockers or drawers.

- **Monitoring System**

Real-time patient monitoring may be accomplished using Web3-enabled monitoring equipment. To securely store and handle patient data, these solutions depend on the

decentralised and secure characteristics of block chain technology. Authorised parties, such as physicians and patients, may easily access and modify the data via smart contracts and decentralised apps (dApps) in a transparent and irreversible manner. Wearables, sensors, and Internet of Things devices can all be incorporated into the web3-enabled monitoring system. These devices may collect real-time patient data, such as vital signs and physical activity, and transmit it to a block chain network for storage and analysis. This gives doctors and healthcare staff a complete picture of a patient's health, allowing them to respond quickly.

Design of Problem Statement

The main goal of this project is to use the internet and cloud features to provide healthcare facilities in the comfort of your own home, saving you money on travel costs, as well as to make these health facilities available to the elderly or pregnant women, and to allow patients to use a web application to send/receive some information, avoiding or at least reducing the number of times per year that a patient must travel.

Patients can be digitally diagnosed with this application, and doctors can begin treatment right away. They can also provide their own information to the doctor (vitals, blood pressure, sugar levels, and so on). Doctors will be able to study their patients using this data. When a doctor notices something unusual, such as one of the vitals has to be handled promptly, he can send an email to the patient, initiating the medication and requesting that he come to the hospital for a check-up as soon as possible.

CHAPTER 04: RESULTS

Outputs

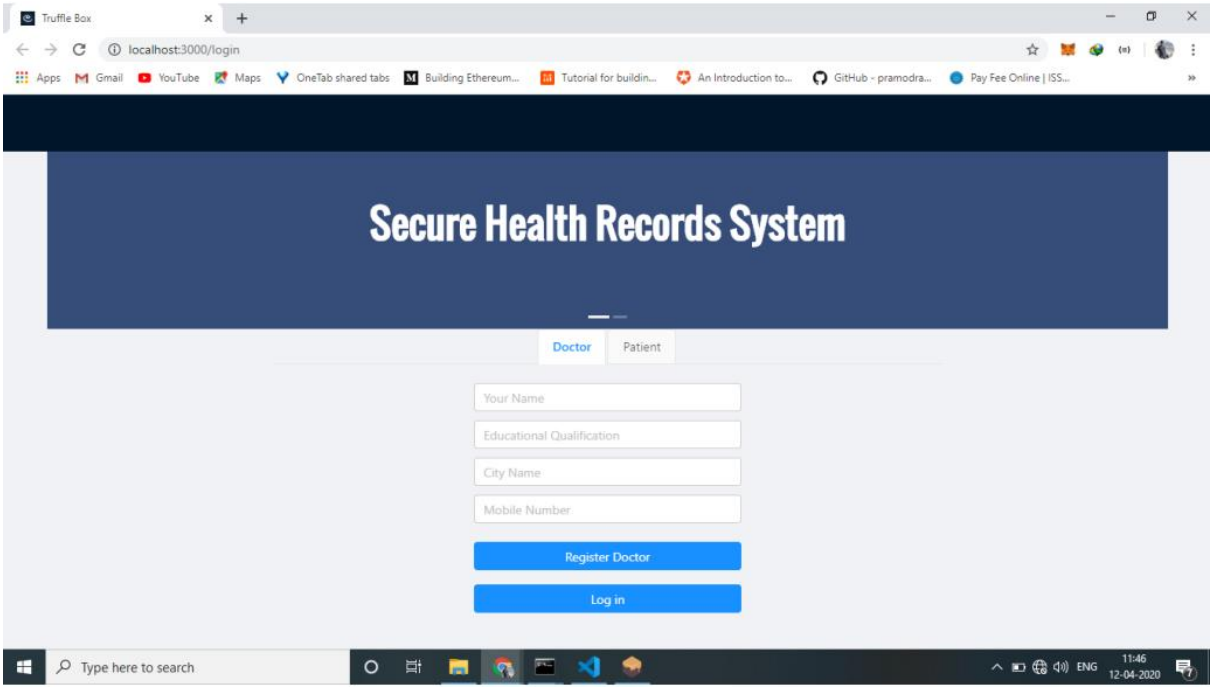

Figure 12: Log in/Registration Screen

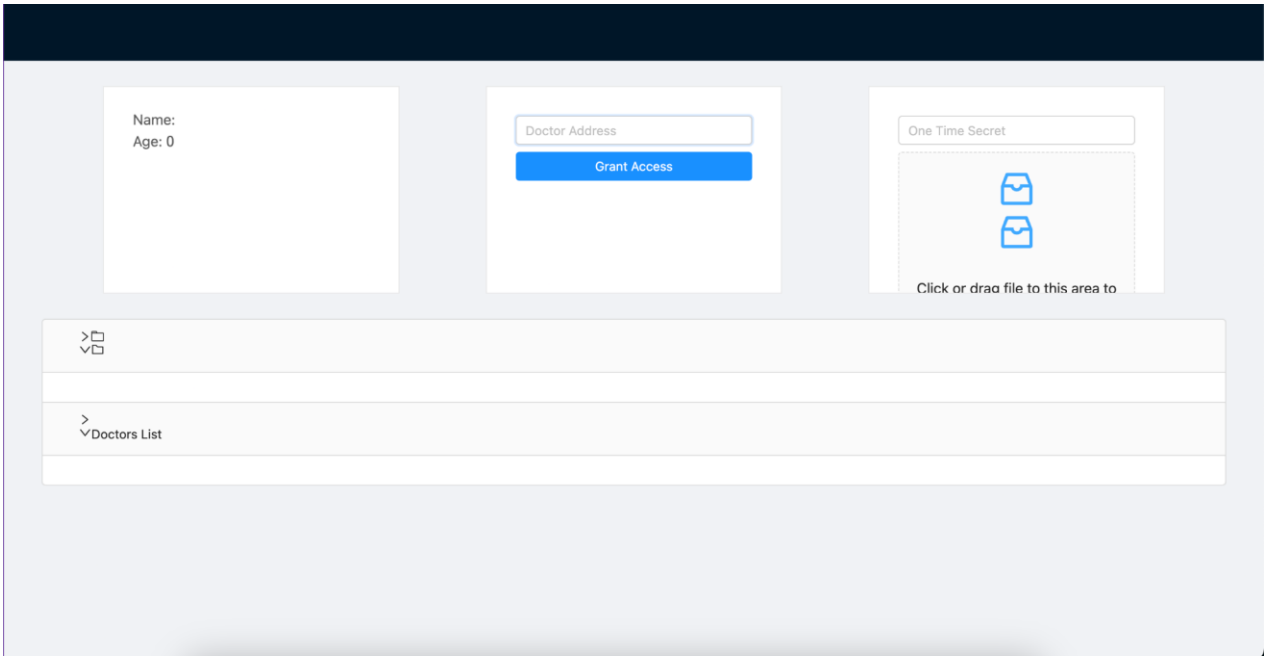

Fig 13: No data available before Doctor's Secret Key

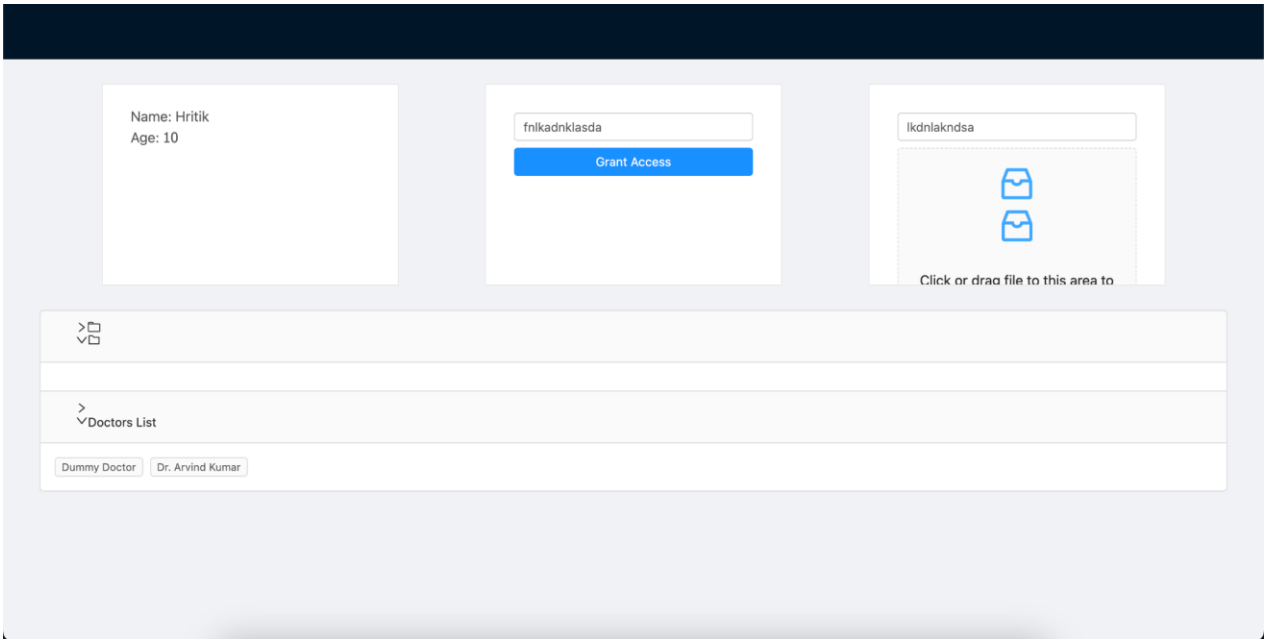

Fig 14: Modification/Read Rights granted after verification

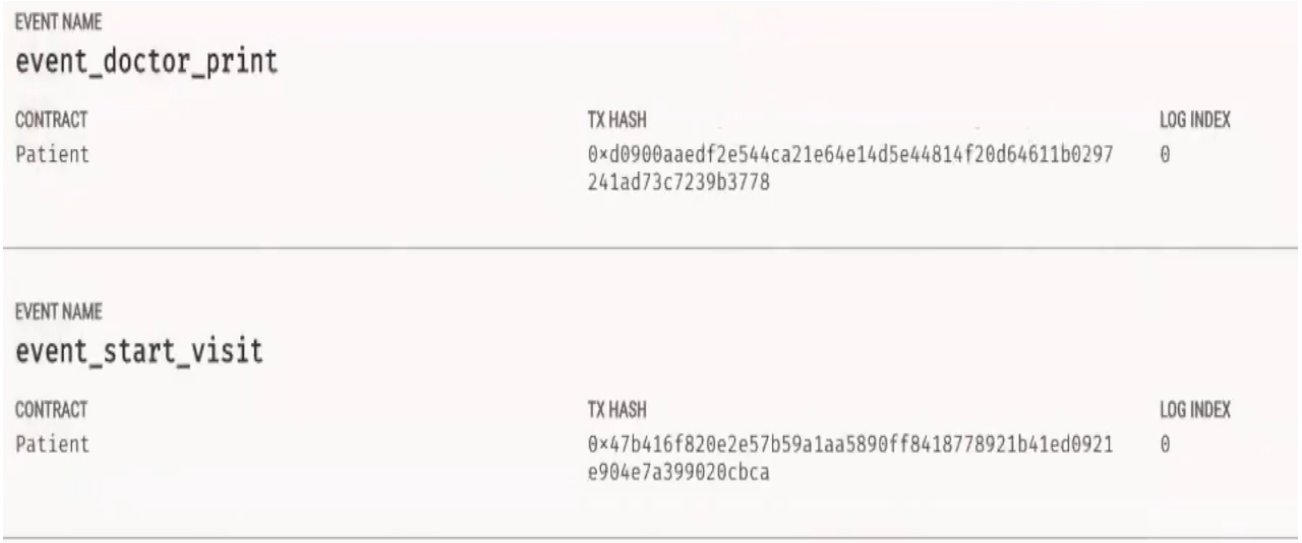

Fig 15: Contract Entries Inside our Database

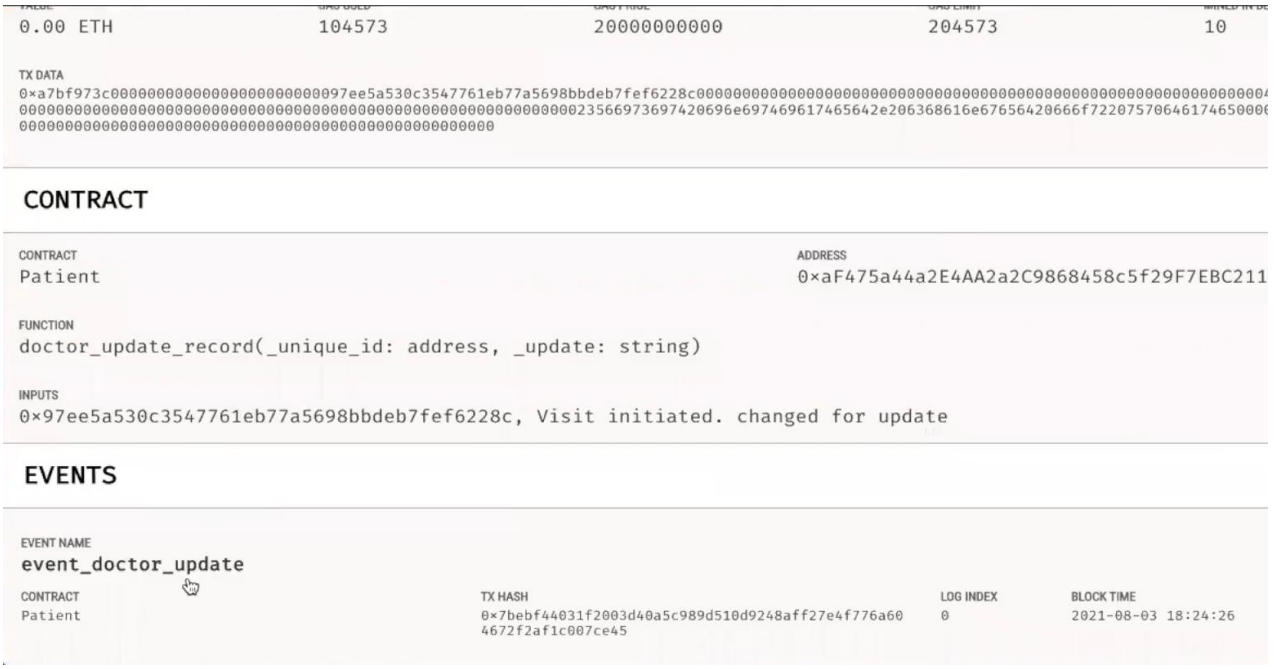

Fig 16: Individual Contract Entry and Information Stored Inside It

Discussion

The introduction of digitalization and telecare has resulted in remarkable growth in the healthcare industry. Telehealth technology have improved patient convenience, availability, and time factor, resulting in easier access to specialists and financial savings for the needy.

Telehealth technology is altering the healthcare business and ensuring life-saving efforts and preventative healthcare through the use of mobile apps, video consultation, sensors, and monitoring. Cloud computing technologies have simplified digital/virtual healthcare while also providing economic, operational, and functional benefits. Scalability, flexibility, and improved data security and privacy are all advantages of cloud computing. These advantages will have far-reaching consequences for the healthcare business, boosting its expansion and saving citizens' lives.

The cloud-based telemedicine application technology is always evolving, and enhanced research will provide healthcare professionals and patients with more knowledge on how telemedicine might change their lifestyle. While various technologies can be used to empower patients, more in-depth analysis and research are required to fully explore the possibilities of developing technology. The project's purpose is to explore deeper into emerging technologies and change patients' attitudes towards healthcare through technology.

Applications

Below are some practical applications of healthcare technology:

- **Digital Connect:** This App will attract new customer groups who are tech-savvy and provide a digital platform for healthcare services. Patients can access healthcare services at their convenience through the app, which allows them to communicate with healthcare providers and receive health-related information.

- **Monitoring healthcare:** This feature provides an eagle's eye view for medical organizations to monitor and track every action taken. The monitoring system ensures

that healthcare providers are adhering to standard practices and procedures while delivering patient care.

- **Patient Records and Monitoring:** When it comes to providing effective medical care having access to a patient's medical history is vital. Doctors can view a patient past medication and test reports, which helps them make informed decisions about how best to diagnose and treat their patients. This ability not only increases the overall effectiveness of treatment but also reduces the amount of time spent on diagnosis and lowers associated costs.

- **Ease and Convenience:** This function serves as a valuable aid for medical practitioners who need to monitor the progress of their long term patients regularly. Physicians can track critical health data such as vital signs and other essential information in real time with ease via this feature. The end result is an efficient solution that benefits both healthcare providers and their chronically ill patients alike.

- **Treatment Cost:** By utilizing our platform, the additional costs associated with monitoring patients within hospital walls are rendered unnecessary. As a result of this groundbreaking approach, patients can access healthcare services on their own terms - ultimately resulting in decreased healthcare expenditures and minimized hospital stays.

- **Customisation based on demographics:** Personalized services are delivered through the utilization of demographic data on this platform. Customization is supplied based on a variety of parameters including age, location and sex. Medical professionals can utilize this feature to provide customized diets for each patient they treat.

- **Authenticity:** Counterfeit drugs pose a serious threat to patient health and safety. That's why at our platform we're taking extra steps to ensure that all medications provided through us are authentic and come directly from trusted local pharmacies.

Limitations of the Major Project

Inaccurate diagnosis or treatment poses a considerable risk if the necessary validation process isn't enforced for all uploaded data in the system. Hence it becomes essential to implement strict verification procedures that help submit accurate data only - precluding all illegitimate entries from being incorporated in the system. Range checks, format checks along with consistency checks are critical measures that can ensure that only legit facts about patients are communicated through this system. It is also critical to guarantee that the application is secure and resistant to various forms of assaults. Data governance and security are major challenges that must be addressed. Because healthcare data is particularly sensitive and can be used maliciously. As a result, the application should be built with security in mind, and different security mechanisms, such as encryption, multi-factor authentication, and access controls, should be incorporated to safeguard data from unauthorised access and disclosure. Furthermore, performance is a crucial factor that must be considered when designing the programme. The amount of data being processed and stored will grow as more patients utilise the system, which may result in increasing latency and possible performance bottlenecks. As a result, it's crucial to build the system such that it can scale well to handle massive volumes of data while still giving people easy access. Overall, the application's security, accuracy, and performance are crucial issues that must be addressed in order for it to be useful in enhancing healthcare outcomes and offering benefit to both patients and medical professionals.

- **Performance**: Optimizing network infrastructure, software and database systems, and distributed computing systems can reduce latency and improve data transfer speeds. However, there is a risk of exposing sensitive patient data to potential security breaches, so it is important to strike a balance between performance optimization and data security and governance.

- **Data security and governance**: Data security and governance is essential for healthcare systems to ensure the confidentiality, integrity, and availability of data. Healthcare data is subject to HIPAA and GDPR regulations, so it is important to have appropriate data governance policies and procedures in place to ensure patient data is not compromised.

Future work

- One possible future work that could be pursued is to expand the reach of the healthcare application to even more remote and inaccessible locations. This could involve partnering with local organizations or governments to provide access to healthcare services in areas where there is a shortage of medical professionals or facilities. Additionally, efforts could be made to improve the usability and accessibility of the application for people who may not be familiar with technology.

- In terms of collaborating with medical organizations and NGOs, one possible future work is to establish more formal partnerships between these groups. This could involve creating networks or consortia that bring together different stakeholders in the healthcare industry to share knowledge, resources, and best practices. Additionally, efforts could be made to develop common standards or protocols for data sharing and interoperability between different systems.

- To enhance security measures for storage servers, future works could focus on developing new encryption technologies or improving existing ones. Additionally, efforts could be made to implement more robust authentication mechanisms that require multiple layers of verification before granting access to sensitive data.

- To promote better interaction and verification among healthcare personnel onboard, it’s imperative to focus on developing cutting-edge telemedicine technologies. By introducing virtual consultation rooms or other digital platforms where experts from varied locations can communicate effectively regarding patient care, the overall quality of medical services can be improved significantly. Not only this but also fresh training programs and certification processes need designing so medical practitioners' qualifications remain updated with constant advancements taking place within their specialty area.

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