Secure Medical Record ManagementUsing Blockchain Technology

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***Abstract*— Currently information on the internet is a threat, especially when it is personal information like our medical data. It is considered very crucial to maintain utmost privacy when it comes to medical data of a person. The main aim of this project is to build a robust and secured application which is used to store the medical records on a blockchain. In this project we build various smart contracts which are used to perform few operations on the medical data to keep it secured on the internet. Smart contracts are built and maintained using the Ethereum blockchain network. This application first registers hospitals which will act as authorized users to enter the medical details, only registered hospitals can enter the medical details and access them whenever necessary. In this way this application provides a lot of security to the medical records.**

Keywords: Smart contracts, Blockchain, Ethereum, Solidity programming, Meta Mask, Ganache, NFT, De-centralized application, Ethereum Virtual Machine, Ether, Remix IDE, Gas fee, Web3.

I. INTRODUCTION

These days information security has become one of the most overseen aspects in any field. Information security is considered important, as misuse of data can create a lot of problems and havoc situations. It is very important to keep information secure as data costs more to many people in society. Hackers and intruders try to get data from various sources by hacking databases and servers of various social media websites or any other application servers. Hackers try to misuse that data and benefit from it. So, it is very important to keep data secure so that there won't be any misuse of data. Information security is not only about protecting data from unauthorized users but also about storing, accessing and managing data without being corrupted and modified by others. Information security also deals with the disclosure, disruption, inspection and recording of data.

Among all different kinds of data related to a person, health data plays an important role in one's life. And many people don't want to disclose the details to others. People want to keep the data confidential and secured. Health data might include the personal details of the patient along with the diagnosis details and the treatment details which need to be kept secured and unmodified. It is important to make sure that one's data is unmodified and kept confidential particularly when it is medical data. Generally, much of the medical data of people is collected in hospitals which include both government and private hospitals. All these hospitals maintain the medical data of the patients in their databases which are independent of other hospitals and the data collected in them. The hospitals still use the traditional ways of storing and accessing the data which have a lot of security breaches. Also using third party servers and databases also does not provide security to the large extent. There have been many situations in the past where many servers and databases failed to stand firm to various security threats and lead to very large disasters. And recently cloud services or cloud technology have come up which provide large memory space and all other required facilities to manage data on the large scale. But cloud is also a third-party service which is payable. Cloud vendors charge for the amount of cloud storage that we use and for the services that we avail from them.

II. LITERATURE SURVEY

As an initial step, a comprehensive review of the existing literature was conducted.

Ayesha Shahnaz , Usman Qamar, and Ayesha Khalid[1] Blockchain has long been an interesting area of research, and the benefits it offers have been exploited by many different industries. Likewise, the healthcare industry will greatly benefit from blockchain technology due to its security, privacy, privacy, and decentralization. However, electronic health record (EHR) systems face challenges with data security, integrity, and governance. In this article, we explain how to use blockchain technology to transform EHR systems and how to solve these problems. We propose a framework that can be used to implement blockchain technology in EHR healthcare. The objective of our proposed framework is on the one hand to implement blockchain technology for the EHR and on the other hand to provide secure storage of electronic records by defining precise access rules for users of the proposed framework. Additionally, the framework addresses scalability issues that blockchain technologies typically face due to the use of off-chain storage of records. This framework provides EHR systems with the benefits of a scalable, secure, and comprehensive blockchain-based solution.

William J. Gordon, Christian Catalini [6] Interoperability in healthcare has traditionally focused on exchanging data between commercial entities such as different hospital systems. However, more recently, there has been a shift towards patient-centric interoperability, where the exchange of healthcare data is mediated and patient-centric. Patient-centric interoperability creates new challenges and requirements in terms of security and privacy, technology, incentives, and governance that must be resolved for this data sharing to succeed at scale. Blockchain technology can facilitate this transformation through five mechanisms: (1) digital access rules, (2) data aggregation, (3) data mobility, (4) identity of the patient, and (5) immutability of the data. Digital access rules ensure that only authorized users have access to patient data, while data aggregation enables the collection of all relevant patient data in a secure and tamper-proof manner. Data mobility allows patients to access their healthcare data from anywhere, while identity of the patient ensures that the data belongs to the correct patient. Finally, the immutability of the data ensures that once data is recorded on the blockchain, it cannot be altered or deleted. However, there are also barriers to patient-centric interoperability through blockchain, such as clinical data transaction volume, privacy and security concerns, patient engagement, and incentives. Despite these challenges, patient-centric data sharing is an exciting trend in healthcare, and blockchain technology has the potential to facilitate this shift from institution-centric to patient-centric data sharing.

Gulara Muradova, Mehran Hematyar [8] This paper explains about the increasing technology usage in the healthcare industry and rapid digitalization occurring across the world in the domain of healthcare. Blockchain is one of the trending technologies which helps in providing maximum possible security to the data and prevent the data from digital thefts and cyberattacks. The word "blockchain" is made up of two words "block" and "chain", which ultimately means a chain of blocks. Blockchain is a decentralized information and reporting system. In the blocks, any information can be entered and recorded. In the Blockchain, these blocks of information are linked together in a chain, forming a sequence of information. This technology is a distributed database that anyone can check in on those transactions. Most healthcare information, from electronic-based medical records in health systems to patient registries and histories, in these days grew up organically for example from custom in-house systems, little or Medium Medical department and largely standards or protocols-free. Databases of healthcare data containing the histories of many patients (medical records) are of enormous value. They can be mined for correlations between patients and a huge range of behaviors, seemingly unrelated conditions, and demographic factors to identify early warning triggers that can be used to bolster preventative care management. We need access to as much of this data as possible. The problem is accessing several claims sources in a way that's secure enough. Any information can be recorded in any block, from a person's crimes to the display of account information for assets. In the Blockchain, the information is contained in the blocks and linked together in a chain. The difference with other systems is that the information stored on this type of system is shared among all members of the network and it is almost impossible to delete and manipulate the recorded information using encryption. Consider the following blockchain, for example, each block showing a clinic where patient's names and records are recorded. If a character is added to the hospital's patient name information, the hash block will change and subsequent blocks will be invalidated, which is why this technology is called the blockchain.

Zhijie Sun, Dezhi Han, Dun Li, Xiangsheng Wang, Chin-Chen Chang & Zhongdai Wu [9] The importance of maintaining privacy and security of medical data in the public sector cannot be overstated. Medical information typically includes sensitive personal and diagnostic data of patients. With the recent advancements in technology, the healthcare sector is also undergoing transformation in terms of how medical information is managed and stored. Blockchain technology can be applied to medical information management, providing decentralized and secure storage with the help of distributed consensus and authentication mechanisms. This technology can improve security, user experience, and other aspects of the healthcare sector. Before the adoption of modern technology, the healthcare sector relied on paper-based systems to store medical records. This system was inefficient, unorganized, and insecure, and faced issues of data duplication and redundancy as multiple institutions had copies of a patient's medical records. Blockchain technology offers a decentralized approach that distributes information and provides shared ownership of data. Transactions on blockchains are hashed, providing them with security and they are managed by a peer-to-peer network. By implementing blockchain technology, medical data can be stored securely, and patients can have control over their medical records, allowing them to share it with healthcare providers as needed, while maintaining their privacy.

III. PROBLEM STATEMENT

Medical record maintenance application using blockchain technology will restrict certain users in modifying the data and in adding the data blocks to the existing blockchain network. This will be one the main objective of the application which is to provide access to only certain users so that authenticity of the data will be maintained. Another objective of the application is to maintain the transparency in the medical data which is entered into the network.

An analysis is done to know about the existing system. Comparison is made to check the difference between the existing system and the proposed system. The existing system suffers few disadvantages and the proposed system fights with all the problems of the existing system and gives a user-friendly proposed system. Blockchain network allows users to maintain the ledgers of all the transactions with every user in the network. This will help us to maintain the transparency of the data across the network. Also this property of the application will remove the redundancy of medical data of patients.

3.1 Existing System

Everyday large data gets accumulated in the medical field. It includes various details of the patients including their personal details, diagnosis details and treatment details. Traditionally all such data is either stored in hard disks/drives or in any third-party servers. These traditional systems as they rely on general servers and personal computers are very prone to the security attacks and breaches. Hospitals which depend on third party servers for the maintenance of the medical data, they barely use passwords for

authentication. But they provide very less security when we consider such systems in the long run. They give no promise that they will provide security to the great extent. So like this in the existing system we have a lot of disadvantages.

3.2 Proposed System

Taking all the disadvantages of the existing system into consideration, it is observed that blockchain technology can provide a lot of benefits. Blockchain technology has the capability to be safe from many cyberattacks and can work very efficiently even on a large scale. Here there is a web application which gives the basic interface for the users to interact with the blockchain network. And the entire data which is generated everyday will be stored on the blockchain network in the form of blocks.

The end users for this application will be doctors and the patients. All the details of the patients will be stored in the blocks and newly generated blocks are added on the blockchain network. Here the doctor will be the only user who has the access to change the data which is entered in the network. And only doctors can add the details of the patient to the blockchain network. The application also uses smart contracts to execute the backend transactions.

Smart contracts are used to verify the users on the blockchain network. They verify the ownership of the users in the network in order give them the access to the users to make necessary changes in the data. Smart contracts use the unique ids or hash value of every individual to verify their work in the blockchain network. In this way the proposed system provides a lot of security and is more advantageous than the existing system of maintaining the medical record.

IV. SPECIFICATIONS

Medical record maintenance application is intended to maintain the data of the patients that is generated every day in the medical field. Everyday there are many people who get hospitalized and have to get treated. They approach various hospitals and doctors will make the diagnosis and provide treatment to them. All these details will be basically stored on a hard disk or any third-party server traditionally. But all these methods are not very efficient and have many drawbacks. Also, they are very prone to cyber-attacks. Taking all these into consideration the main purpose of this application is to provide security for the medical data of various patients. The medical record maintenance application is designed to ensure the security of patients' medical data and personal information. This is achieved through the use of blockchain technology, which is decentralized and ledger-based. By utilizing blockchain technology, the application is able to provide a high level of security to the data entered into the network. Smart contracts are also used in the backend of the application to verify the ownership of doctors and patients. This verification process ensures that only valid users are able to access the network, which adds an additional layer of security to the system.

The main objective of the medical record maintenance application is to provide a secure platform for storing and accessing sensitive medical data. With the use of blockchain technology and smart contracts, the application is able to achieve this goal while also ensuring that all users in the network are verified and authorized to access the data. Overall, this innovative technology has the potential to revolutionize the healthcare industry and improve patient care by making medical data more accessible and secure.

Software Specifications

Backend:

- Solidity Programming (Smart Contracts)
- Meta Mask (Account)
- Ethereum Blockchain Network (Ganache)

UI:

- HTML
- CSS
- JavaScript
- Bootstrap

V. SYSTEM DESIGN AND ANALYSIS

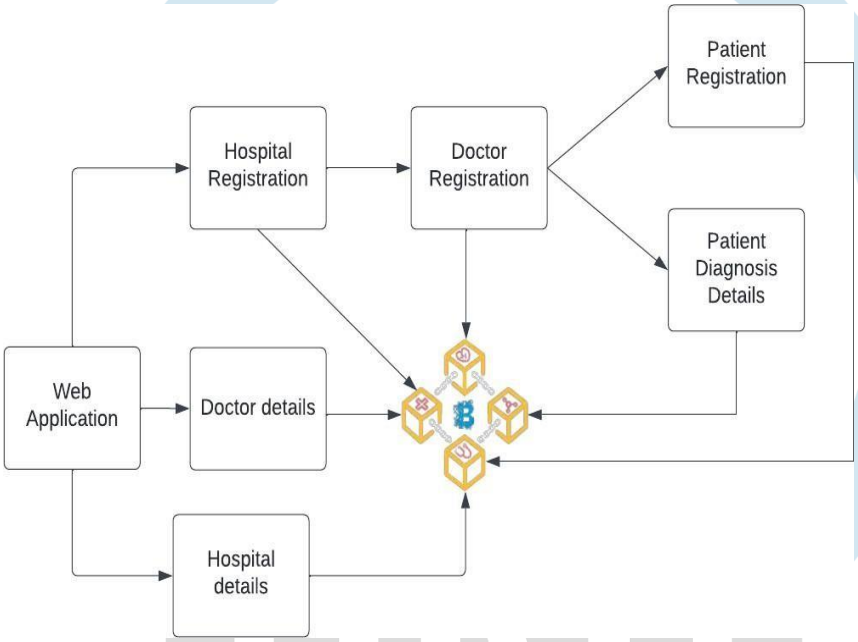
Medical record maintenance application is the web application which is intended to maintain the patient details, doctor details and hospital details using one platform. This application will be a great platform to maintain all that necessary information at one place by using one of the proven secure networking technologies called blockchain. Medical record maintenance application using blockchain will first allow a hospital to register itself by providing few details by which its ownership will be recorded by generating a hash or otherwise called as a unique ID. And then the hospital will get the access to register the doctor by entering a few of his basic details. And an unique ID or hash will be generated even for the doctor to identify him on the network. After that doctor will have complete access to add the patients on to the network. Doctor will be entering the details of the patient, before entering the details the ownership of the doctor is verified by using his id. After successful verification the doctor will be allowed to add the patient details which include his personal details along with the diagnosis details and the treatment related details. Here doctor only will have all the access to add or modify the patient details, no other participant on the network will have the access to the patient details if he is not a doctor.

Patients are also allowed to only view the details of their own but not others. Patients cannot view other patient details. Patients can access the details of their own by using their unique id or hash. Patients are not given any access to modify any kind of details

on the network, they simply have the option to view their own details. Only consultant doctors can change or modify the details of the patient. In case if any patient changes his doctor even then the new doctor can view the details of the patient's personal details and diagnosis details and make modifications accordingly, because the doctor will have the access to do that. However, a doctor who is there on the network can access the details of any patient available on the network.

As this application uses blockchain as a backend network to maintain and store the details of patient, doctor and hospital all the transactions which take place on the network will be stored in the ledgers and everyone will have a copy of the ledger. So the details of any patient will be stored in a new block and each block is added to the existing blockchain network by using the hash value. So any modifications in the data of the blocks can be easily identified and can be restored back easily using distributed ledgers.

This application is also intended to maintain the transparency in the data using the concepts of distributed ledger technology of the blockchain technology. Here every user in the network will maintain a ledger which logs every transaction on the blockchain and can be used at any point of time in case of any emergency. For such application backend is also not needed as copies of ledgers are maintained with all the peers involved in the network. If anyone loses the data can get that immediately using the copy of data with all other peers in the same network. Like this the application works in a way that uses all the advantages of the blockchain technology and helps in various ways to provide security to the medical data of the users.



The design of web application, which contains registration pages for hospitals, doctors, and patients, is a crucial part of the system. The registration process allows each user to create a unique identity and securely store their data in a blockchain-based database. This provides a high level of security and ensures that sensitive medical data is protected from unauthorized access. To retrieve data from the system, users can search for specific blocks using a block number. Each block contains a unique set of data related to a specific user or transaction, making it easy to retrieve and verify information. This design approach ensures that the medical record management system is secure, transparent, and easily accessible to authorized users.

An important aspect of our project design is the use of unique IDs to access data. Each hospital, doctor, and patient registration page generates a unique ID that is associated with the data they provide. This ensures that only authorized users can access their data and provides an additional layer of security to the system.

The unique IDs are used to authenticate users and grant them access to their specific data. This means that hospitals can only access data related to their patients, doctors can only access data related to their appointments and treatments, and patients can only access their own medical records.

This approach helps to prevent unauthorized access to sensitive medical data, ensuring that only authorized users can view and modify it. It also simplifies the data retrieval process by allowing users to easily locate and access their data using their unique ID.

Overall, the use of unique IDs in our project design is a crucial aspect of our secure medical record management system. It enhances security, improves data accessibility, and ensures that only authorized users can access and modify sensitive medical information.

VI. IMPLEMENTATION

6.1 Modules

Medical record maintenance system using blockchain will have majorly three modules to work with. All these three modules are supposed to perform different tasks and would have a significance. The module of the application are:

1. Hospital Module
2. Doctor Module
3. Patient Module

Module Description

Hospital Module:

The Hospital module is one of the basic modules that the medical record maintenance application has. This module maintains the basic details of the hospitals which are registered in the application. The hospital module takes the necessary details of the hospital while it is registering in the application. The details include the hospital name, contact no., address etc.. Hospital is the only user who will be accessing this module, no other user other than hospitals can enter any details using this module but just can view the details of the hospitals which are already registered.

Doctor Module:

The doctor module is also an important module in the medical record maintenance system. This module allows the hospitals to register the doctors. The doctor module will ask the hospitals to enter the details of the doctor. The basic details of the doctor like his name, age, experience, specialization, qualifications and contact details etc. Hospitals only have the access to verify the details of the doctor and have access to change any details of the doctor at any point of time. Doctors and other users can view the details of the doctor but have no access to change the details of the doctor. Even while entering the details of the doctor, the ownership of the hospital is verified whether to know that the hospital has the authority to make modifications to the details of the doctor.

Patient Module:

The patient module is the final module in the medical record maintenance application in which more no of users will be interacting. Large no. of patients everyday will be registered in this module. Doctor only has the access to add a patient and to make any changes to the details of the patient. The details of the patients like their personal details, diagnosis details and the treatment details. All these details will be stored in the blockchain network in the form of the blocks. The patients can just view the details of their own, they don't even have the access to view the details of the other patients. Any doctor with the ID of the patient can view the details and make modifications to the details of the patients.

6.2 Introduction to the technologies used:

Solidity programming:

Solidity is a widely used programming language used to write smart contracts, which are programs that are written and stored on a blockchain network and automatically executed when certain conditions are met. Solidity is an object-oriented and high-level programming language that is similar to Java and is targeted to run on the Ethereum Virtual Machine (EVM). One of the key features of Solidity is that it is statically typed, which means that all variables must be declared with their data type before they can be used. It also supports inheritance, libraries, and complex user-defined types. To develop smart contracts using Solidity, developers use Remix IDE, which is a free and open-source development tool specifically designed for Solidity programming. With Remix IDE, developers can write, test, and deploy smart contracts on the Ethereum blockchain. Overall, Solidity is a powerful programming language that enables developers to create complex smart contracts that are executed automatically on the blockchain network, providing a high level of security and trust.

Meta Mask:

Meta mask is a google chrome extension which is used to create a few accounts. It also acts as a software cryptocurrency wallet to work with the Ethereum network. It allows the users to access their crypto wallets using the chrome extension or mobile app, which can be used to interact with the decentralized applications. Meta mask will allow the users to maintain and manage the keys, broadcast transactions, send and receive Ethereum based cryptocurrencies and tokens. It also allows the users to securely connect with the decentralized application in simple terms blockchain based application.

Ethereum blockchain network:

Ethereum is one of the most widely used blockchain networks that offers a decentralized platform for deploying permanent and immutable decentralized applications. The network is built on the concept of smart contracts, which allows anyone to create and execute self-executing contracts. One of the most unique features of Ethereum is the ability for users to create and exchange special tokens called Non-Fungible Tokens (NFTs). These tokens are used to verify the ownership of a specific asset in the network, which

could be anything from digital art to virtual real estate. The Ethereum network has its own cryptocurrency called Ether (ETH), which is used to reward miners for successfully mining blocks and processing transactions. Ether is the only cryptocurrency available on the Ethereum network, and it is used to pay for transaction fees and smart contract execution fees. The Ethereum network also includes a separate virtual machine called the Ethereum Virtual Machine (EVM), which is responsible for executing the Solidity programs used to implement smart contracts. This virtual machine allows developers to create and execute smart contracts that are secure and decentralized. Overall, Ethereum serves as a powerful base network for building decentralized applications and creating new forms of value through the use of smart contracts and NFTs.

6.3 Process

Setting up the development environment:

We had set up the development environment by installing and configuring the necessary software tools and infrastructure, such as Ganache, Remix IDE, Metamask, and a web development framework like Bootstrap. This allows us to create and test our web application locally.

Step1: First we need to install the ganache which is an local Ethereum blockchain and add a new workspace for our project purpose and run it locally. Ganache by default generates 10 accounts with 100 ETH for development purpose.

Designing and deploying the smart contracts:

We had designed and deployed the smart contracts for hospitals, doctors, and patients using Remix IDE. This involves writing the Solidity code for each contract, compiling it, and deploying it on the Ganache blockchain. When we deploy the smart contracts, they generate a contract address which is used to interact with the contracts from our web application.

Step2: Add metamask extension to the local browser. Setup the metamask wallet.
Step3: Now add a new network and name it as localhost:7545 and the RPC url is “http://127.0.0.1:7545” and the chain id is 1337.

Step4: Now select one of the account from ganache and add it to the metamask wallet.
Ex: account = '0xd3dE8d3B384CAB3811cFFc252a55684E3d3E3f56'

Step5: Open the project files on Remix IDE. The project files are hospital.sol , doctor.sol and patitent.sol .

Step6: Connect the Remix IDE with metamask.

Step7: We need to deploy those project files on Remix IDE and for every deployment of smart contracts they generate a unique contract address.
Ex: Hospital.sol – “0x7368A83CBAA7637Ea739427476496586a67C30ad”
Doctor.sol – “0x466147A21E54F6a7A22Cc86004ab5841C00bE41f”
Patient.sol –“0x638bcbF6f5D6C2E44f3Fd9e873a0c34e15F65C9B”

Building the web application:

We had used HTML, CSS, and javascript and web development framework such as bootstrap to create our web application. This includes creating the registration pages for hospitals, doctors, and patients, and integrating them with the smart contracts on the Ganache blockchain. When users register on our web application, their data is stored in a new block on the Ganache blockchain.

Step8: Install Visual studio IDE (or any other IDE) and build the registration pages for hospital, doctor and patient to store the data and verification pages for hospital, doctor and patient to verify and retrieve the data from the blocks of local Ethereum blockchain.

Step9: Add the contract address that are generated by the hospital, doctor and patient smart contracts respectively to their registration pages.

Step10: Add only one sender account which is used to run the smart contract on Remix IDE to all the registration pages and verification pages to run transactions.

Step11: Web3.providers.HttpProvider("http://127.0.0.1:7545") this is the HttpProvider to run our web application locally, connected to our local Ethereum blockchain.

Testing and debugging:

we tested and debugged our web application to ensure that it functions correctly and securely. This includes testing different use cases and scenarios, identifying and fixing any bugs or errors, and conducting security testing to ensure that the system is secure.

Step12: Now our web application is connected to our local Ethereum blockchain, we need to test our web application locally and debug the errors occurred by viewing the browser console.

Step13: When need run our web application in our local browser. For every registrations we need to give an unique id, which helps us to verify and retrieve the data from local blockchain.

Step14: For every registration the data is stored on a new block of our local Ethereum blockchain. We can see the newly added block in our ganache.

Step15: We can retrieve the data from the local blockchain and display it in their respective verification pages by entering the correct unique id which is given at the time of registration. It will not display the correct details unless you had the correct unique id.

Running the web application:

Once our web application is built and tested, we run it on our local machine using localhost:7545 as the web address. The web application is connected to our local Ganache blockchain, which allows us to interact with the smart contracts and retrieve data from the blocks.

"http://127.0.0.1:7545" is the RPC url for ganache and localhost to run our web application

Gas fees:

Each transaction on the Ganache blockchain requires a certain amount of gas fee to be paid by the sender account. The gas fee is used to compensate the miners for processing the transaction.

VII. RESULTS

Test Case ID	Test Case	Description	Input	Expected Output	Actual Output	Status
1.	Hospital Registration	Hospital Registrationdone through Web Application.	Hospital Id, Name, Address, Specification .	Registration Successful	Registration Successful and Hospital details are added to the network	Passed
2.	Doctor Registration	Doctor RegistrationCan be doneonly by a registered Hospital.	Id, Name, Specification Address, Phone No.	Registration Successful	Registration Successful and Doctor details are added to the network	Passed
3.	Patient Registration	Patient RegistrationCan be doneonly by a registered Doctor.	Id, Name, Age, Address, Phone No., Attendant details	Registration Successful	Registration Successful and Patient details are added to the network	Passed

4.	Patient Diagnosis details Updation	Patient Diagnosis details updation done by registered Doctor	Record Id, Insurance details, Current illness details, Treatment Summary.	Patient Diagnosis details updated successfully	Patient Diagnosis details updated successfully	Passed
5.	Invalid Doctor Registration	Doctor Registration fails when done by Invalid user (Hospital).	Id, Name, Specification, Address, Phone No.	Registration Successful	Registration failed	Failed
6.	Invalid Patient Registration	Patient Registration fails when done by Invalid user (Doctor).	Id, Name, Age, Address, Phone No, Attendant details	Registration Successful	Registration failed.	Failed

Table 7.1 Test Cases

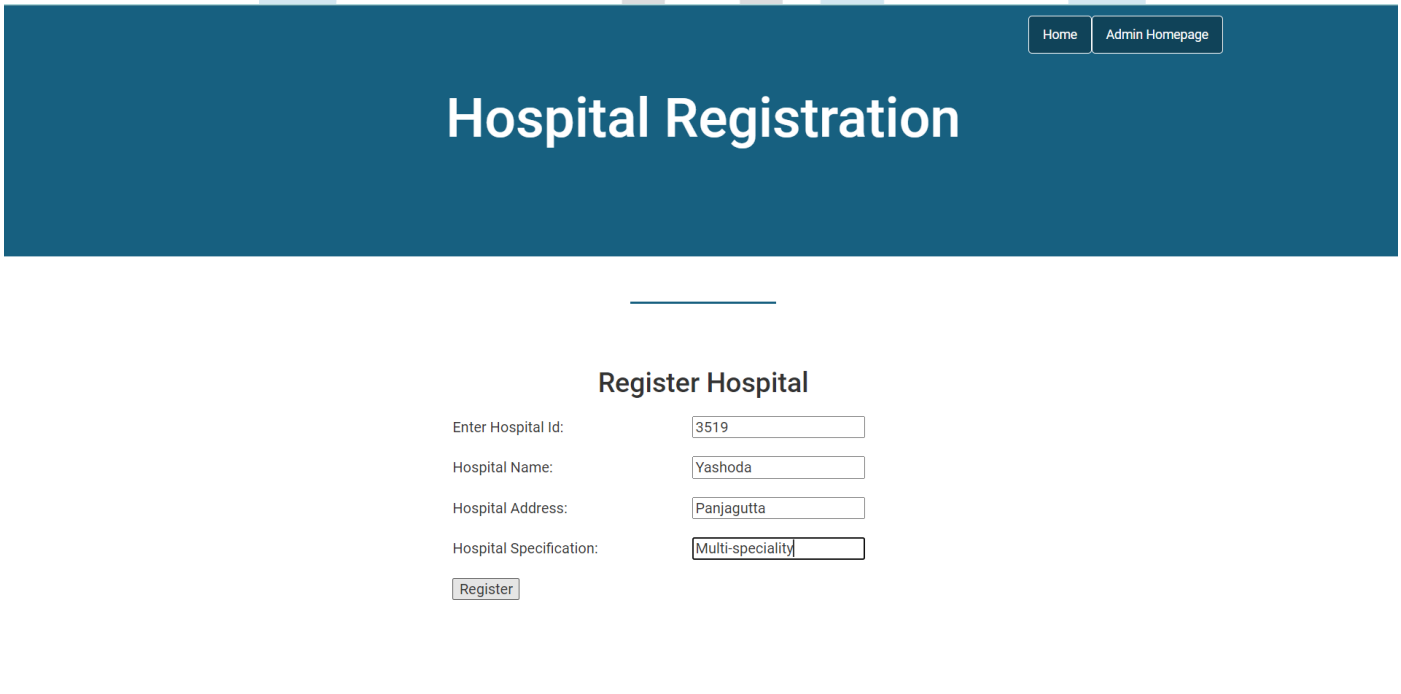


Fig 7.1 Hospital Registration

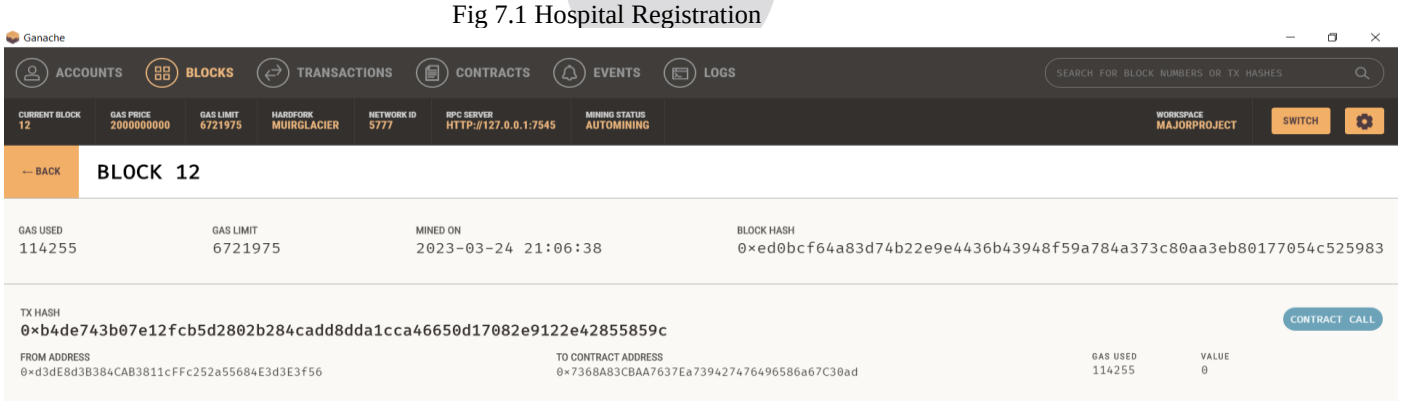


Fig 7.2 Block added for Hospital Registered.

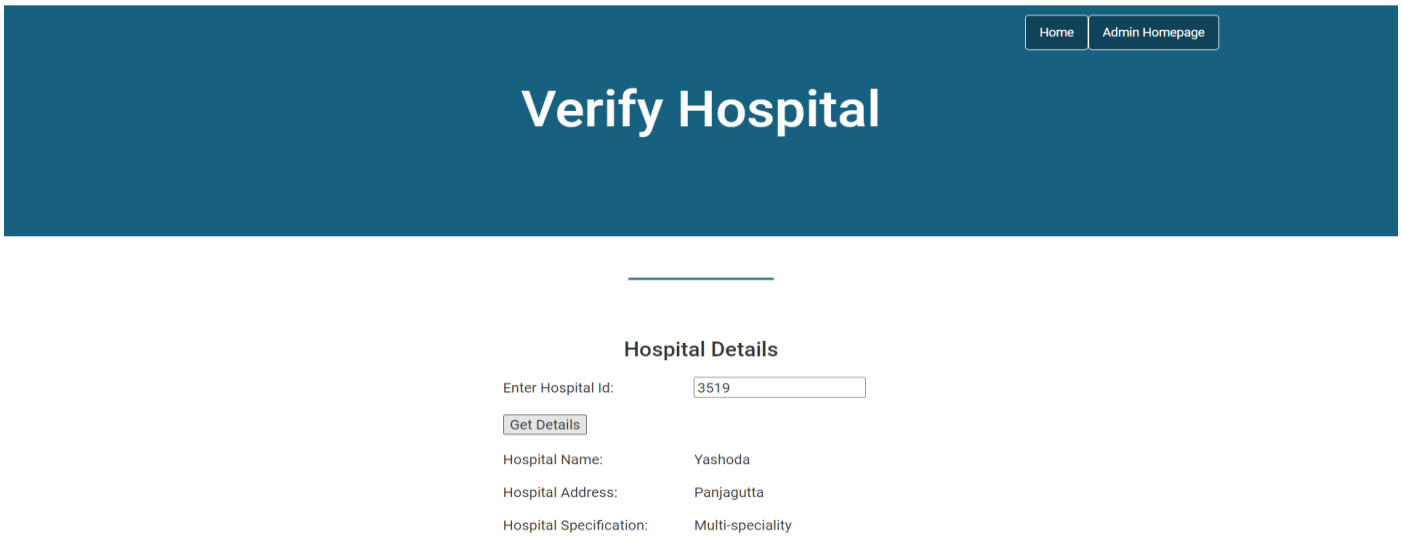


Fig 7.3 Hospital Verification Page

VIII. CONCLUSION

Medical record maintenance applications can be one of the sophisticated applications in maintaining the medical data of the patients. It works very secure and robust in dealing with the data. The application is a web application which makes it available to all the users so easily. Medical record maintenance application using blockchain work based on blockchain technology and smart contracts. Smart contracts are used to execute a few operations automatically to access and store data. Smart contracts are written and deployed on a test network to carry out various operations. Blockchain stores data in the form of records which are immutable, here every block is accessed with its unique hash or id assigned to it.

Blockchain keeps data decentralized so that it is available to all the hospitals but only authenticated people can change it. Any change in data by unauthorized users leads to drastic changes in hash and can be identified easily. In this way this application provides security to a great extent. The other benefits of blockchain technology are making the application more sensible and unique. The distributed ledger technology of the blockchain makes the application more transparent and trustworthy. The implementation of smart contracts will be an add on benefit to the application by verifying the ownership of various users in the network. Allowing access to the users to various modules of the application will keep few restrictions on the usage of the application, but it will avoid any misuse of the application. Application also maintains a hierarchy in registering the users or in accessing the details of the others.

On the whole, medical record maintenance applications using blockchain will provide all kinds of security that a patient and the hospital needs in maintaining the medical data. It can be used in a very great way possible in order to simplify the medical record maintenance methods by replacing the traditional systems. This application could contribute a lot to society.

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