A study on Application Of Blockchain Technology In Health Care Records

1DR.S.Deepika, 2DR.NEENA GUPTA, 3Dr. AKANKSHA SINGH

1MASTERS IN PUBLIC HEALTH 4TH SEMESTER , 2HEAD OF THE DEPARTMENT, DEPARTMENT OF PUBLIC HEALTH , 3ASSISTANT PROFESSOR

1SAM HIGGINBOTTOM UNIVERSITY OF AGRICULTURE TECHNOLOGY AND SCIENCES ,

2SAM HIGGINBOTTOM UNIVERSITY OF AGRICULTURE TECHNOLOGY AND SCIENCES

ABSTRACT

As the clarity of the notion is critical for information sharing between systems running on various platforms. And one of the most important industries that seeks clarity, confidentiality, and integrity of stored data is healthcare. Beyond the security concerns of the-health-sedulity interoperability is a big issue, and current trends show that systems operating within the medical centre circle are unable to communicate with other health institutions in order to share information. This makes it difficult for health interpreters to access patient data and medical records, clogging proof-based decision-making at all levels of the system, particularly at the point of origin. This investigation intended to determine why hospitals utilising traditional systems and inventors attempting to automate confront difficulties in maintaining consistency. To achieve interoperability, legacy systems must be integrated with ultramodern platforms. Interviews were done to get general information on patient data exchange. According to the findings, present systems do not allow for the participation of health data. As a result of this thesis work, a platform was established that uses Block Chain technology and distributed train systems to integrate existing health information systems in order to facilitate quick and safe data sharing, hence facilitating interoperability. The frame prototype allowed cases to store data and share it with different croakers on demand, according to a performance study conducted with key end users. It also ensured that an infinite reference to the data is saved in a distributed tally that is sharable and interoperable across several platforms frontends for operations.

INTRODUCTION

Data security and data ownership are two key issues that must be handled in today's healthcare environment. Sensitive medical records now lack a safe structure, resulting in serious data breaches. Many data breaches were reported to the Department of Health and Human Services' Office for Civil Rights (OCR) in 2018, resulting in the exposure of 13 million total healthcare records [1].

Furthermore, the average total cost of a data breach in the United States was $7.91 million, according to a recent study performed by the Ponemon Institute on behalf of IBM Security, with the health sector having the highest per capita cost (Ponemon Institute, 2018). Another issue is that individuals do not yet have complete control of their medical data, which is becoming more important as tailored medicine and wearables become more prevalent. Both of these situations have substantial moral implications that must be addressed.Satoshi Nakomoto invented the technology for the cryptocurrency Bitcoin in 2008, and it provides a verifiable, persistent, and attack-resistant way for recording data [2]. Blockchain is a distributed, decentralised digital ledger that stores transactions in an ever-growing chain of immutable blocks linked by cryptographic hashes. Figure 1 depicts how a blockchain system, such as the original Bitcoin, performs its functions. A user starts by making a transaction request (a transaction may involve cryptocurrency, contracts, records, or other data). The user signs the transaction with his private key,

allowing others to verify its authenticity using the public key (a public key is produced from a private key via a one-way mathematical function, typically elliptic curve multiplication) [3]. Satoshi Nakomoto invented the technology in 2008 for the cryptocurrency Bitcoin, and it provides a verifiable, permanent, and attack-resistant approach for recording data [2]. Blockchain is a distributed, decentralised digital ledger that records transactions in an ever-growing chain of immutable blocks linked by cryptographic hashes. Figure 1 shows how a blockchain system, such as the original Bitcoin, works. A user begins by making a transaction request (a transaction may involve cryptocurrency, contracts, records, or other data). The user signs the transaction with his private key, allowing others to verify its authenticity using the public key (the public key is created from the private key via a one-way mathematical function, usually elliptic curve multiplication) [3]. The transaction is then broadcast to the whole peer-to-peer network, and miners choose a batch of transactions to form a block. (A miner is always a full node; however, a node is not always a miner.) Each miner is now competing to find a valid hash output for the transactions in his block.

Objective

The main idea of this study is to use the Blockchain and ensure security of medical information. assuring the Transparency, integrity and confidentiality of medical records.
•To design a decentralised application (dApp)to store electronic health care data on block chain

REVIEW OF LITERATURE

This section provides an overview of the blockchain technology's essential fundamentals as well as many applications in the healthcare field. This section also includes a table and discussion of existing review papers

BLOCKCHAIN

A distributed ledger, or blockchain, is a series of time-stamped blocks containing a set number of validated transactions. The previous block's hash value is used to link blocks cryptographically. Each transaction generated by a user or node is digitally signed and published to the network using a private key. A validation/mining node takes the transaction and wraps it up in a block, which is subsequently broadcast to the rest of the network [14]. By implementing the consensus protocol, each network node verifies that the block is valid. The validated block is added to the chain, and the updated ledger is replicated across the network's permissioned nodes. The consensus protocol replaces the central authority or a trusted third party. The difference between a centralised and a distributed ledger is illustrated in Figure 1 [1] [15] [16] [17]. The ledger ensures security, auditability, and transparency while maintaining identity

Features of blockchain technology

Decentralization- Blockchain is a distributed digital ledger consisting of a chain of blocks containing transactions. The decentralized database is shared and open to all parties through network nodes [6], [19], [20], [12]. Architecture like end-to-end replicas eliminates dependency on a single point of failure

Consensus mechanism: Blockchain is a distributed peer-to-peer network without any middlemen. Each digitally signed block is sent to the mining pool, where it is chosen by network nodes known as miners and verified using a consensus algorithm [4]. The winner among miners will broadcast the block to all other nodes who validate and validate the block by consensus and append the block to their ledger. The winner also receives a financial reward for his work [21]. Many alternative consensus protocols have also been proposed, such as Proofofstake, Proofofburn, Proofof Elapsedtime [6], [12], [17]. Data integrity is maintained by calculating these consensus algorithms as an alternative to trusted third parties.

Immutable

Blockchain is immutable and tamper-proof, so it ultimately provides security [15]. making the blockchain a tamper-proof ledger. The hash is calculated by implementing hashing algorithms (SHA256, RSA, RIPEMD160, etc.) on a block of transactions [20]. The hash is then used to generate a block chain. In this way, blockchain brings robustness. If someone intends to modify previous transactions , it will require modifying the hash value, which requires network consensus and high computing power, which is an impractical approach in this computational model. The hash value is also used to represent a hidden user's real identity used for security purposes [17], [22].

Traceability: Blockchain is a digital ledger made up of a continuously evolving chain of blocks. A block is made up of a complete list of transaction records. In this blockchain, each block has a parent block. The first block in the chain is called the root block. The genesis block block hash is added to the header of the second block, then the second block hash is calculated on the genesis block hash and the block's transactions with each other. The second block's hash becomes the third block's block header, and so on. This way the blocks are related to each other by also having a timestamp. This link can be traced to the root block or the root block [1], [20]. This blockchain feature provides data origin to keep a chronic record of activities and can also help with reverse tracking in the chain.

Blockchain's **Potential** in **Medical Data Management**

The biggest thing that makes the use of blockchain revolutionary in healthcare is the absence of a central administrator. Why? Because a database has always been a tangible thing made up of bits and bytes. If the database contents are stored in the physical memory of a particular system, anyone with access to that system can corrupt the system data. With blockchain, all users control all their information and transactions. Furthermore, thewill not need a central administrator to be eliminated by smart cryptography. From healthcare to managing confidential patient information and requesting quick access to information, the blockchain can streamline these medical records and enable their secure sharing. Blockchain, in a single, provides access security, scalability, and data security. In most medical facilities, patient histories are stored by the data staff, meaning manually and anyone with access to the health data records This physical health can either have the right to manipulate the data or in the worst case, to destroy it. .The same work for the current electronic health system applies in hospitals with the plug-in and database for the data warehouse and there will be one person to manage, migrate and back up the system is the system manager. Everyone has access to all system logs. So somehow, the security or privacy of a patient's medical history is at risk**.**

What is interoperability in healthcare?
Das and mahapatra consider e-government as a complex context as it has to deal with political, legal, political and sociocultural issues. They identify legal and policy factors among other factors that affect system interoperability. According to ISO (2004), a standard is a document established by consensus and approved by a accredited organization that provides universal and applicable rules, guidelines and guidelines for use. renewable. directives or characteristics of over its activities or results, in order to achieve optimal control within the framework of Several organizations around the world have developed standards for the exchange of medical information related to medical procedures, terminology, and electronic health record systems. Some standards have been revised to ensure the security of health information systems (Ministry of Health,2010).

NETWORK ACTORS	know each other	Don't know each other
NATIVE TOKEN	Necessary	Not necessary

The platform works by building an abstract base class based on Blockchain with a built-in full Turning programming language called enabling solidity anyone to

write smart contracts and decentralized applications where they can create rules, transaction formats, and state transaction functions. Figure 3 illustrates the state of Ethereum transactions. Smart contracts are data sharing agreements between patients and healthcare providers is applied automatically. Blockchain can put patients at the center of healthcare data ecosystem, allowing them to organize their own subscription and control providers' access to it. This can include clinical images and flexible control over who accesses them and in what context (e.g. diagnosis, research, before and after, study plan, activity).
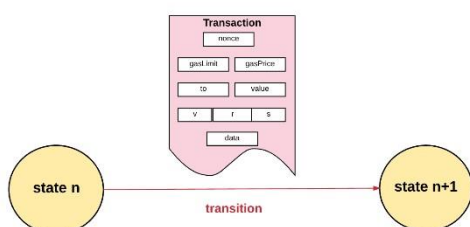
Consensus in Blockchain

Consensus is a mechanism or method by which all nodes in a Blockchain network agree which block (transaction) is added to the chain. As discussed previously about P2P . networks Distributed computing existed long before Blockchain, but it is these consensus mechanisms makes Blockchain a new technology in which all nodes in the network agree on what is very powerful. This technology gives nodes the ability to create faithfully self-regulating systems without the need for the need for a third party to enforce the rules is what makes Blockchain so powerful. To execute rules, several variations of consensus algorithms/protocols are used, each with its pros and cons.

METHODS AND METHODOLOGY

METHODS – A sample is collected from simple ramdom method from purposely selected hospitals as they are structured . Pretested questionnaires were given in the form of handouts and google forms Area of Study – Apollo, Sunshine , Nakshatra Hospitals , Visakhapatnam, Andhra Pradesh

Respondants – All the medical professionals including physicians, paramedicals and patients who were ready to communicate were selected as respondants during study period.

Duration of Study – March to April

Size of Sample – 80 (10Doctors ,20 paramedics , 50 Patients)

The study follows a design-scientific research approach for all work in this research. the researcher, in the following sections he discussed the what, how, and why of each phase of research. detailed implementation process. The basic principles of design science research are knowledge and the understanding of a design problem and its solution acquired through construction and application an artifact [48]. This study aims to explore the challenges healthcare organizations may face in keep and share medical history among patients and how to develop platform can request data from Blockchain system and get records at your fingertips. This chapter explain the research method used, the study site, the population studied, and sampling, the stages of the study and the purpose of the study, and the data collection techniques used. The general model used in this study is the one provided by Omar ValdezdeLeon. It was used as a general guide to further identify specific criteria questionnaires suitable for seven sizes given.
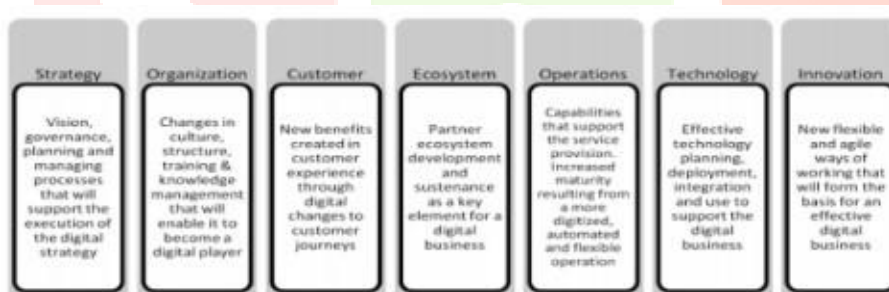
multi stage research model by Omar Valdez-de-Leon

Study Design

The research design used in this thesis is an experimental research design, which allows prior cognitive analysis to establish an equivalent solution for the study (Ross & Morrison). Coming up with this design was a difficult task because of the requirements for Does the proposed system have very few previous implementations because the technology is so new? the The analysis forms the basis of system requirements.

Since the primary user of the system is the patient, the research used is object-oriented analysis approach, this approach combines data and processes into single entities known as an object. This approach is most commonly used in application development. Research use use cases modeling and sequence diagrams. It helped to understand the functions system requirements. System requirements are collected through document analysis, interviews with experts in the field and also completed the questionnaire. Experts in the field were interviewed from different organizations and different sectors,
i.e. doctors, paramedics, pharmacists, data salespeople, patients and software developers last but not least to realize the global skeleton of the system. This is done to strike a balance in the type of solution being developed. The

analyzed material includes standardized guidelines and specifications for implementation of previously developed systems. This analysis gave us a foreign perspective on developed solution including added functions and obsolete.

Researchers used Functional Oriented Design (FOD) technique to refine the functional requirements are determined during system analysis and decompose the design into sets of interacting units where Each unit has a clearly defined function. Data flow diagrams were used to show how the system would manage the various data flows between processes and entities. The system sequence diagram shows that the information traverses the main entities used for modeling system flow. He showed how objects interact, which helps us explain different system components work together. Use case diagrams are used for modeling system function. This allows the researcher to separate system actors from use cases.

For this project researcher have used different components that help realize certain functions. NodeJs provides server-side scripting using JavaScript. JavaScript was chosen because it is the most widely used programming language today, especially when it comes to applications are running on a server, advancing to the pillar of Blockchain is smart applications contact, it is written in the special programming language "solidity" of Ethereum which is only used to write smart contracts that run on the Blockchain. Blockchain is used as a public ledger due to its tamper-proof nature and also costly to put data on Blockchain, this means the number of network spammers will not be high. In our case, anyone who needs talk to Blockchain using a regular browser like Firefox or Chrome with the addition of "Metamask" on it is used to turn a regular browser into a Blockchain browser for it to communicate with Blockchain.

Tools and Technologies Used

NodeJs is a server-side JavaScript scripting language. NodeJs uses a non-blocking, event-driven I/O model, which makes it lightweight and efficient (Nodejs Foundation, 2016). This technology is used to interface a middleware application with the Bitcoin Blockchain

Suit + Ganache Ganache is a truffle framework that works locally by building virtual nodes and acts as a blockchain that works locally. Truffle Ganache is used to quickly launch a personal Ethereum chain that you can use to run tests, execute commands, and check status while monitoring chain activity.

React (also known as React.js) is a JavaScript library for creating user interfaces. It is maintained by Facebook and a community of individual and corporate developers. React can be used as a base for developing single page or mobile applications. However, React is all about displaying data in the DOM, and so building React apps often requires the use of additional libraries to manage state, routing, and interacting with the API. Redux, React Router and Axios are respective examples of such libraries

IPFS
The Interplanetary File System (IPFS) is a new, content- and identity-resolved, hypermedia delivery protocol. IPFS allows the creation of fully distributed applications. It aims to make the web faster, more secure, and more open (Protocol Labs, n.d.). IPFS is a distributed file system that has been used to store electronic health records of individual patients. The distributed nature of the platform allows records to be replicated across multiple geographies.

INFURA

Infura is a scalable backend framework for creating Dapps on the Ethereum blockchain. This is a method to connect to the Ethereum network without having to run a full node and in this project Infura is used to connect to the IPFS network.

System Architecture
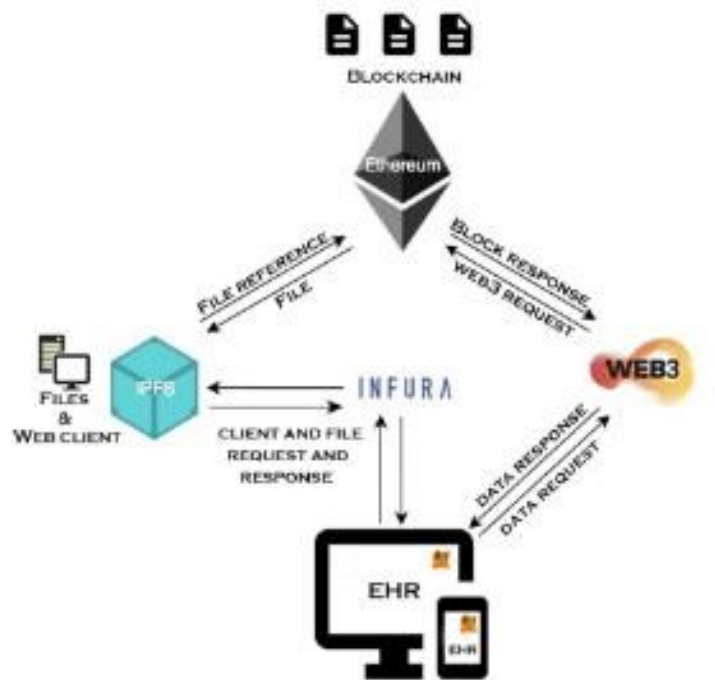
This section explains the key components that help heterogeneous eHealth systems interact. Figure shows how the different components of the system will communicate. The system consists of 4 main components plus INFURA as middleware:

I. EHR system client The first layer is electronic medical software. This software works on differentplatforms and databases. The main components of this class are the clients that institutions use to manage their electronic data. And any browser with an Ethereum wallet can access the app instantly.

II. Web3 API Web3API provides an interface between an EHR system running distributed on IPFSand the Ethereum Blockchain. It is the main data exchange point between systems and two components that store reference data (Blockchain) and actual data (IPFS).

III. Ethereum blockchain Using the Ethereum Blockchain and its own ledger, the platform serves tostore permanent references to health data. This ensures data integration This ensured data integrity is in place and a public tamper proof record for every patient file was created.

IPFS We use IPFS to store patient records which are very large and cannot be stored on blockchain. IPFS provides a distributed file system that ensures stored data is accessible across different geographical locations. This allows files stored on different network nodes to come together to form a complete file. IPFS provides an EHR client and files are stored on the system while referencing the files located on the Ethereum Blockchain.

Stored data format and structure.

All health files are stored on the Ethereum blockchain inside solidity structures and on the client besides, they are converted to plain JavaScript objects and sent to the client as plain JSON objects. The figure below shows what the EHR data sent to the client stored in json looks like Format.

```
/**
 * Share the patient record with doctor
 * @param {composers.healthrecords.shareRecordWithDoctor} record - the shareRecord transaction
 * @transaction
 */
async function shareRecordWithDoctor(record) {
    //payBill.patient.balanceDue -= payBill.bill.amount;
    return getAssetRegistry('composers.healthrecords.PatientRecord')
        .then(function(assetRegistry){
        record.patientRecord.doctor = record.doctorId;
        console.log(record.patientRecord.doctor);
        let factory = getFactory();
        let shareRecordEvent = factory.newEvent('composers.healthrecords', 'shareRecordWithDoctorNotification');
        shareRecordEvent.patientRecord = record.patientRecord;
        emit(shareRecordEvent);
        return assetRegistry.update(record.patientRecord);
    })
    .catch(function (error) {
    // Add optional error handling here.
    });
}
```

SECURITY

DESIGN

The data is transmitted on the web application and each publication of each Input fields are encrypted before being stored on the Blockchain because EHR data is very sensitive and by all means, it must be protected against eavesdropping during transmission and storage. Several components have been incorporated to ensure complete data security. ESA The encryption algorithm is used to encrypt the health file. Health data owners get all transactions and blocks the hashes of his own records so that he can only see his own medical data. While dealing with the security of any application, we need to focus on the CINA rule where Confidentiality, integrity, non-repudiation, and authentication play a key role. Say one Application is proof, these parameters must be met.

DATA INTEGRITY

To ensure data integrity, patient wallets store hashes that act as health data file references. These references are created when saving data from an external system. The integrity of data as strong as the hash used is SHA256. A reference is also stored on Blockchain to ensure data files cannot be tampered with.

PROTOTYPE IMPLEMENTATION, TESTING AND EVALUATION

Since all the necessary data has been collected so far, we are ready to move on to the development process. and we will go through each process until we meet the requirements as outlined in the chapter four main purposes of using Agile software development methodology that we can go back to at the first stage whenever needed. language and a set of web technologies. The programming language used is javascript while the system is designed for web browsers, and since the user interface is written using reusable REACT components, it can be shipped in any other environment and works perfectly. The programming language used to develop this project is Solidity, which helps us develop Blockchain applications for the Ethereum ecosystem. Vyper is also another programming language used to develop applications capable of running on Ethereum Virtual Machine (EVM). Other web technologies are also used for development, which are JAVASCRIPT ES6, JSX JSON, IPFS and

Nodejs with other libraries This is the point of interaction between the distributed application and the platform consists of a public registry and a distributed file system. Data from a patient visit that form Health data files are stored distributed among the nodes on the network. First things first, the components are required for every electronic health record plan. 1. Collection of symptoms 2.

Diagnostics and laboratory tests 3. Pictures (if needed) 4. Place an order

Local Blockchain Network

Working with the local blockchain network is even better trend to develop an application to be deployed on the Ethereum Blockchain or the Ethereum Virtual Machine(EVM). This portion of the paper covers the most valuable and crucial part of the study where we can see how the bloc chain system works from end to end and it will be very interesting. There are certain steps to get started and they are described as follows.

Step 1. Install Node + NPM on our machine

Step 2 install GIT

Step 2. Install the Truffle suite

Step 3. Install Truffle Ganache Step 4. Install Metamask browser extension

After installing the following applications and setting up everything we are ready to go ahead. The application we are developing contains both front end and backend, so the description is divided into two.

Front-end: Developed using React

Back-end: Developed using Solidity and JavaScript.

First we will download and setup a Truffle box with React embedded in it.

but the structure for a basic Blockchain application. After setting up the project we will copy all the solidity code in the contracts directory so that the application is ready for deployment.

DEPLOYMENT

Deploying the DApp is quite easy if its tested first. Keep in mind that deploying DApp is migrating it to the EVM. And everything write operation on the EVM coasts Gas fee so we need to compile our project before migrating it to the next.

When developing the **appropriate** environment on the application, **user authentication is included** but we **don't** have to worry about **that** because **the** Ethereum wallet is used for **User** authentication Authentication is the most important thing on blockchain applications and **is** done with **the** public key **cryptographic** algorithms. **Public key** cryptography, or asymmetric cryptography, is an encryption scheme that uses two **The keys are** mathematically related, but not **the same,** a public key and a private key. **Not the same as symmetry the main** algorithms rely on **a** key **for encryption** and **decryption,** each key **performing** a **a** function. The public key is used **for encryption** and the private key is used **for decryption. The** private key **cannot be calculated** based on the public key. Because of this, public keys can be freely shared, allowing users an easy and convenient method for encrypting content and verifying digital signatures, and private keys can be kept secret, ensuring only the owners of the private keys can decrypt content and create digital signatures. On any Etherium based wallets the public key is used as the identity of the user and the private key is used for authentication of a certain user. On the Ethereum network public keys are 32 characters long and private keys are 42 characters long sample public and private keys are shown on Fig

RESULTS

A simple random sample of 80 people were taken from purposely selected structured hospital that include physicians , paramedicals and patients of Apollo , Sunshine amd Nakshatra hospitals , Visakhapatnam , Andhra Pradesh . Out of 80 physicans and paramedics were 30 which staes that was drawn as most of the people face storage of their medical records and that keep their progress in a better way that can be easily accessable . A decentralised data storing application is required

A dApp was created based on etherium block chain with name Evexia that helps in registering patient and doctor accounts through metamask browser extension providing account and private key . The records are stored along with prescriptions and diagnostic tests and reports

TEST RESULTS

In blockchain once a system is deployed on the EVM Ethereum virtual machine it holds an address so updating the smart contract is unachievable even deleting the smart contract can't be done so the system shall be tested recursively using different tools so that it is Bug free.

For testing purposes different module is created. The type of testing used in this module was unit testing and JavaScript has special plugin libraries.

Installing the mocha unit testing library and chai assertion library each individual method is unit tested and the test result turns out positive.

DAPP DEPLOYMENT AND USAGE

Run the react development server by running the npm web app command start run start run at port 3000 and if the browser has installed the Ethereum wallet extension (Metamask) We will ask for a password to connect the wallet (Figure). After inserting the password we will get another Metamask popup and we will be prompted if we want to connect to DApp is deployed. (Figure 15) After pressing the login button, we will be redirected to the home page of the DApp. After that, doctor selecting from the top links adds information to the blockchain about the patient. The insert symptoms are as follows.

In a similar way, the doctor inserts other data into the blockchain. The only data that blockchain is not able to process are medical images. One might wonder why we can't put images on the blockchain. The reason why we can't place large files on the blockchain, each block in the EVM copies itself to each node in the network so that everyone on the network has their own copy of all the transactions in the network. network it makes the network secure and immutable and no one can delete or modify all data inside the blockchain. So to set each block from block one or origin can block to the last block on the network because the text will not pull large data from the archive of our system. But if we put the image on the blockchain, the blockchain will run out of storage space right away. Even synchronizing with the blockchain would be a very difficult task to do. So the system is set up with some wisdom, use IPFS. IPFS inter Planetary File System is very similar to blockchain but it is meant to put files in it and return silent so whenever we want to retrieve our file we give the hash to IPFS and it returns case.
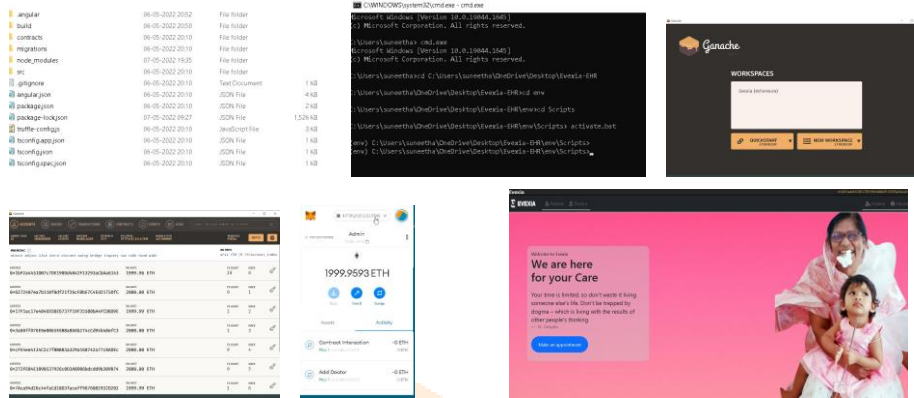
Appointements

#	Patient	Date	Time	Status
1	Adhya Reddy 0x1Bf4D9c87Ed7445101ceC1513253FD5e87862FCB	2022-05-08	15:30:00	Active

CONCLUSION

Much effort was made in this study to ensure that the EHR system could address key security issues such as transparency and confidentiality of patient medical records. The use of a distributed ledger has made the system viable and even reliable. Several associations have developed standards and technologies to ensure that data is exchanged seamlessly. Doctors assert that this data is important for making key decisions about a patient's health status. Most doctors and developers have not been able to implement this standard in their systems. From the interviews conducted most developers expressed a difficulty in integration because of the different systems deployed in the health facilities and also different infrastructure. On the other side doctors were fearful of losing data hence the deadlock. Since the blockchain is scalable by default and the distribution of data among nodes makes it, built-in immutable and easy to implement. The solution connects to existing compatible E Health record systems. During the development of the system, several factors had to be taken into account in order to answer the research question. To create an interoperable ecosystem, the study considers the use of distributed file systems. But again another problem has arisen regarding the integrity of the data, which is because someone could introduce false information into the platform or modify existing records. To circumvent this problem, a distributed file system using a distributed hash table was incorporated. In addition to record integrity, the issue of health record location has led to the use of an immutable distributed public ledger (Blockchain) that allows stakeholders to obtain the location of health data. using the credentials provided. By using this platform, healthcare organizations and other stakeholders create an ecosystem of interoperable systems. If approved, the platform would allow healthcare organizations with electronic health systems or developing new systems to have a common

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