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BLOCKCHAIN-BASED HEALTHCARE RECORD MANAGEMENT SYSTEM

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Abstract: **Blockchain is an engrossing research field area to introduce in the healthcare sector due to its security, privacy, confidentiality and decentralization.**
In Blockchain-based systems, data and authority can be distributed, and transparent and reliable transaction ledgers created. Privacy-enabling approaches for Blockchain have been introduced, such as private blockchains, and methods for enabling parties to act pseudonymously. We explore a set of proposed uses of Blockchain within cyber security and consider their requirements for privacy. We compare these requirements with the privacy provision of Blockchain and explore the trade-off between security and privacy, reflecting on the effect of using privacy-enabling approaches on the security advantages that Blockchain can offer. In this research, we present a framework that will help to reduce the inconsistencies that we have to risk in our everyday lives. The aim of this framework is to implement blockchain on storing healthcare records in a pre-assigned database.

Keywords: **Blockchain, Health records, Smart Contracts, Database.**

I. INTRODUCTION

Blockchain stores all the information in recording ledgers that are distributed in a decentralized manner across all computing devices that are part of the blockchain infrastructure. The infrastructure is peer-to-peer based, and functions by having both users of the network (that are participating in transactions) and the blockchain miners (which facilitates the transactions in a distributed ledger). The ledger is stored in a decentralized network of nodes that are created through cryptographic processes computed by all miners within the network. In addition, the blockchain ledger offers highly reliable storage capabilities as it is created using consensus mechanisms, digital signatures, and hash chains. Due to these advanced features, blockchain provides numerous services including traceability, integrity, security, authenticity and immutability, while storing all information in a public decentralized manner in a privacy-preserving manner.

The centralized database management systems have numerous disadvantages; since all the data is stored at one location, it reduces the speed of search performance and access. The whole system might slow down as multiple users try to access it. This may reduce the efficiency of the system. There is a lot of data access traffic for the centralized database as well as it may create a bottleneck situation. Therefore, if there are no database recovery measures in place and a system failure occurs, then all the data in the database will be destroyed.

In the rapidly-growing industries of cloud computing and technology, a huge amount of personal health-related data is being generated and accumulated. These personal datasets contain valuable information and they are the asset of the individual users and hence should be owned and controlled by themselves. Currently most of such datasets are stored and controlled by different service providers and this centralized data storage brings challenges of data security, hinders the data sharing. The reliable capabilities that blockchain has to offer is the reason that has motivated us to do this project. The decentralized database in blockchain technology emphasizes on data sharing. The consensus in blockchain technology makes sure that data is legitimate and secured. Reliability of data is also very crucial in machine learning and the convergence of these two technologies can give efficient results with the security and integrity of blockchain technology.

II. BLOCKCHAIN

Like the name indicates, a blockchain is a chain of blocks that contains information. A blockchain is a distributed ledger that is completely open to anyone. They have a very interesting property, that is, once some data has been recorded inside the blockchain, it becomes very difficult to change it. Each block contains some data, the hash of the block and the hash of the previous block. The data that is stored inside the block depends on the type of the blockchain. For example, the bitcoin blockchain stores the details about a transaction such as the sender, receiver and the amount of coins. A block also has a hash which can be compared to a fingerprint, it identifies a block and all of its contents and it is always unique just as a fingerprint. Once a block is created, its hash is being calculated and changing something inside the block would cause the hash to change and in other words hashes are very useful when we want to detect changes to a block.

The third element inside each block is the hash of the previous block and this effectively creates a chain of blocks

and it's this technique that makes the blockchain so secure which is one of the main principles of blockchain. There is one more way that blockchain secure themselves, that is by being distributed. Instead of using a central entity to manage the chain, blockchains use a peer-to-peer network and everyone is allowed to join. When someone joins this network, he gets a full copy of the blockchain. The node can use this to verify that everything is still in order. When someone creates a new block, that block is sent to everyone on the network. Each node then verifies the block to make sure that it hasn't been tampered with and if everything looks fine each node adds this block to their own blockchain. All the nodes in this network create consensus, they agree about which blocks are valid and which are not. Blocks that are tempered with will be rejected by other nodes in the network.

Blockchains are constantly evolving and one of the most recent developments is the creation of smart contracts. Smart contracts are just like contracts in the real world, the only difference is that they are completely digital. These contracts are simple computer programs that are stored on the blockchain. Because smart contracts are stored on a blockchain, they inherit some interesting properties. Smart contracts are immutable and distributed. Being immutable means that once a smart contract is created it can never be changed again. So, no one can go behind our back and temper with the contract. And being distributed means that the output of our contract is being validated by everyone on the network. So, a single person cannot force the contract to release the output because other people in the network will spot this attempt and mark it as invalid. There are a handful of blockchains who support smart contracts but the biggest one is Ethereum. Ethereum was specifically created and designed to support smart contracts. Blockchain treats all users equally with a high degree of inclusiveness and respects their privacy cryptographically.

III. RELATED WORKS

[1]."Blockchain-based Personal Health Data Sharing System Using Cloud Storage" by X Zheng, Raghava Rao Mukkamala, Ravi Vatrapu, JoaqunOrdieres-Mere´, 2018 IEEE 20th International Conference on e-Health Networking, Applications and Services (Healthcom).

In this paper, we saw that the authors proposed a personal health data sharing system which was based on blockchain, cloud storage and machine learning techniques. The system enables users to own, control and share their personal health data easily and securely, and get benefits during this process. In this work, first, the authors classified personal health data into different categories according to data characters (dynamic and static data), and the data acquisition methods (continuous and instant data) in the context of health-related data from wearables like smart watches etc, and mobile devices. They proposed to use different solutions to share the large size continuous dynamic data using hash pointers to the storage location. Secondly, the proposed system overcame the size limitation of the continuous-dynamic health data by integrating blockchain and cloud storage. The authors also proposed that larger size of health-related data can be stored in encrypted format on the cloud and only the transactional data and metadata can be saved and shared on the blockchain. Third, a data quality validation module was included to the proposed system to control the data quality from both hardware and software aspects supported by machine learning techniques.

[2]. "Implementation of Distributed File Storage and Access Framework using IPFS and Blockchain" by Randhir Kumar and Rakesh Tripathi, 2019 IEEE Fifth International Conference on Image Information Processing (ICIIP)

In this paper, we came across that the authors have designed the IPFS (InterPlanetary File System) based storage model for blockchain to mitigate the drawback of storage and transaction access of a block in a blockchain network. The paper stated that the result of their IPFS (InterPlanetary File System) storage model provides efficient storage space owing to the content-addressed hash of the transactions. Moreover, the content-addressed scheme is applied to access the transactions of blocks using the hash value provided by the IPFS distributed storage. In the proposed model, the authors are storing the hash of the transaction rather than storing the complete transaction or original transaction to ensure the efficient storage scheme for the blockchain network. The paper also stated that the proposed structure of the storage model can be utilized with the other types of transaction files such as video and audio on blockchain. The existing storage model like bitcoin, Ethereum, Hyperledger suffers from the storage of bulky data in the distributed ledger of blockchain networks. Thus, the proposed model can also be applied on existing storage models to reduce the size of each block. To implement the framework, anaconda python, python flask, and IPFS is used.

[3]. "Distributed Off-chain Storage of Patient Diagnostic Reports in Healthcare System using IPFS and Blockchain" by Randhir Kumar, NingrinlaMarchang and Rakesh Tripathi, 2020 IEEE 12th International Conference on Communication Systems & Networks (COMSNETS)

In this paper, the authors have presented the design and implementation of consortium blockchain and IPFS (Interplanetary File System) based off-chain storage model for maintaining patient reports. It was seen that only hashes of reports are stored in the blockchain for scalability and thereby reducing the size of the network. The proposed model is completely decentralized in nature unlike the presently available centralized storage mechanism for data sharing among healthcare providers. Moreover, the model

does not rely on a third-party (as done in cloud-based systems) and provides fair service to authorized peers.

[4]. "Towards Secure and Smart Healthcare in Smart Cities Using Blockchain" by JinglinQiu, Xueping Liang, Sachin Shetty, and Daniel Bowden, 2018 IEEE

In this paper, it is discussed how the integration of information and technology with healthcare can bring significant impacts on the improvement of the health and medical services around the world. The integration of healthcare and smart cities involves the merging of information and technology with the aim of promoting the treatment and healthy living. The technologies include artificial intelligence, machine learning, sensor network and engineering systems. The authors mentioned how the sensor network technology has been of great benefit in the promotion of health in the smart city. The smart cities utilize the sensor technology to monitor elements that are essential to have considerable impacts on human health including temperature, humidity, and pollution. Additionally, Information and Communication Technologies (ICT) has eased the procedural methods of recording data during patients' admission and their payment services in the hospitals.

[5]. "Converging Blockchain and Machine Learning for Healthcare" by Sonali Vyas, Mahima Gupta and Rakesh Yadav, 2019 IEEE

In this paper, the author proposed that every user in the Blockchain network will get an authorized certificate from Certificate Authority. It will provide identity to the user who will be making a transaction in the network. The identity will be a digital certificate. The digital certificate will be used by the user to sign the transaction and submit it to the blockchain. This will authenticate the blockchain that the user performing or requesting any transaction is a legitimate user and also ensures that the user has rights to access the ledger for the transaction they are performing. For instance, Patient will get a certificate from the authority. The Patient can access his/her own details but will not be eligible to access the details of other patients. Patients will not be eligible to view details regarding other activities. The authors proposed that every authenticated user will have a copy of the shared ledger. This will resolve data acquisition problems and the machine learning models can be directly fed with data which will be highly reliable and results can be retrieved. The model(s) can be trained with real data which will increase the efficiency and accuracy of models. The Patient can get lifestyle advice. The model can be trained on the basis of suggestions given to other patients (by doctors) having the same problems or symptoms. If a patient does any basic enquiry regarding his/her health, the trained model with the help of Natural Language Processing can identify the disease as well as give treatment suggestions. On the basis of Patients symptoms, the trained model can give clinical suggestions to doctors.

IV. METHODOLOGY

The prime objective of the project is to keep maintaining transparency and proper verification of the information submitted by a hospital about a particular patient. The approval of the medical details relies upon the agreement from supporting hospitals linked to a specific hospital. We intend to take the benefits of blockchain technology in fulfilling these requirements. Thus, we choose to deploy Ethereum in a health details management platform where the correctness of the information is ensured with the help of smart contracts.

Our proposed architecture states that the patient visits a primary hospital and undergoes certain tests and medical readings for a particular disease. The medical readings and medical bills are generated based on the tests undertaken and these readings and bills are shared with the secondary hospitals. All the secondary hospitals along with the patient has to agree to the information and only then it is stored in the blockchain which is further stored in a database. This database is used so that in future an app can be created using which this information can be accessed not only by the patients but also a different hospital who wants access to the patient's information.

The activity involved in block creation; the patient first takes the treatment and then accordingly certain medical bills are generated in the hospital for which the patient provides his/her approval. Then all the nodes involved in the blockchain network create a consensus. If the nodes/validators agree then the transaction is stored in the blockchain or else the transaction is discarded. The validated transaction is further stored in the database.

PROTOTYPE FOR EXPERIMENTAL EVALUATION

Ethereum setup: Created a private Ethereum network; a five-node network is created with a boot node and then proceeds to connect all the nodes to build and test the network.

Smart Contract: A Smart contract is built, with the required functions and data that will cater to our work. In the contract a function is created to: set the list of supporting hospitals, to get the health details, get the bill details. Mapping is also used for determining which secondary hospital has voted/agreed to send the correct details to the database using data_migration_allow function.

The Smart contract is then deployed to the network and run as a program; we can then interact with the smart contract using web3.py.

Web3.json package is imported, and from web3 we import Web3.

Using "web3 = Web3(Web3.HTTPProvider('http://127.0.0.1:8546'))" we connect it to our blockchain network. Then using the abi and bytecode we connect it with our smart contract.Web3.py is

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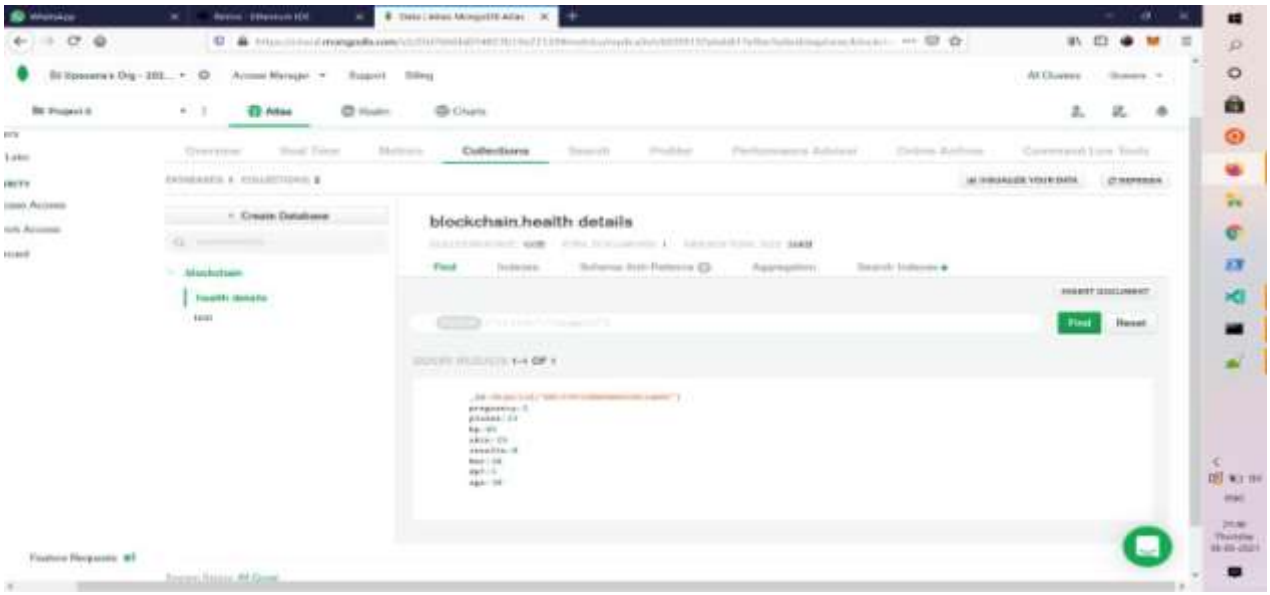
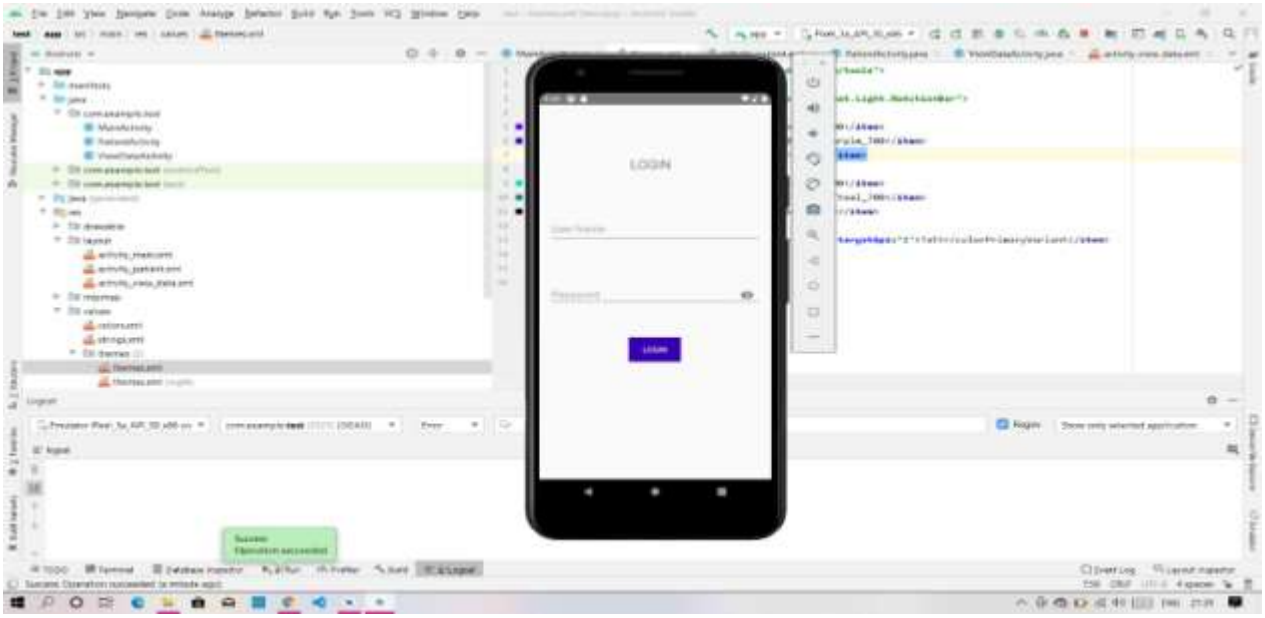
used to control the set and get functions from the smart contract.

MongoDB: MongoDB is used for storing the data after it is approved by the list of secondary hospital.



Android App: To view patient health details stored in the database. Here, the registered user can log in and can view the data stored in the database.



Machine Learning (ML): This model is used for accurately predicting whether a patient has diabetes or not. The data that is stored in the database is taken from the Pima dataset. Machine Learning is used to test and train the model, the model is then used to predict the output of a record from the database

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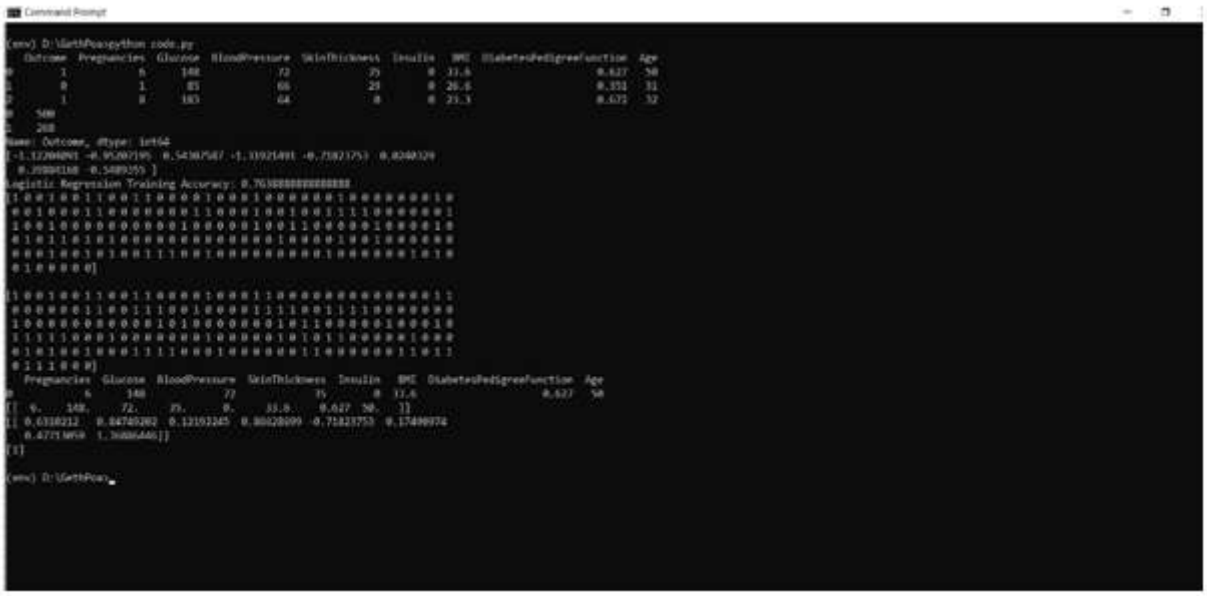
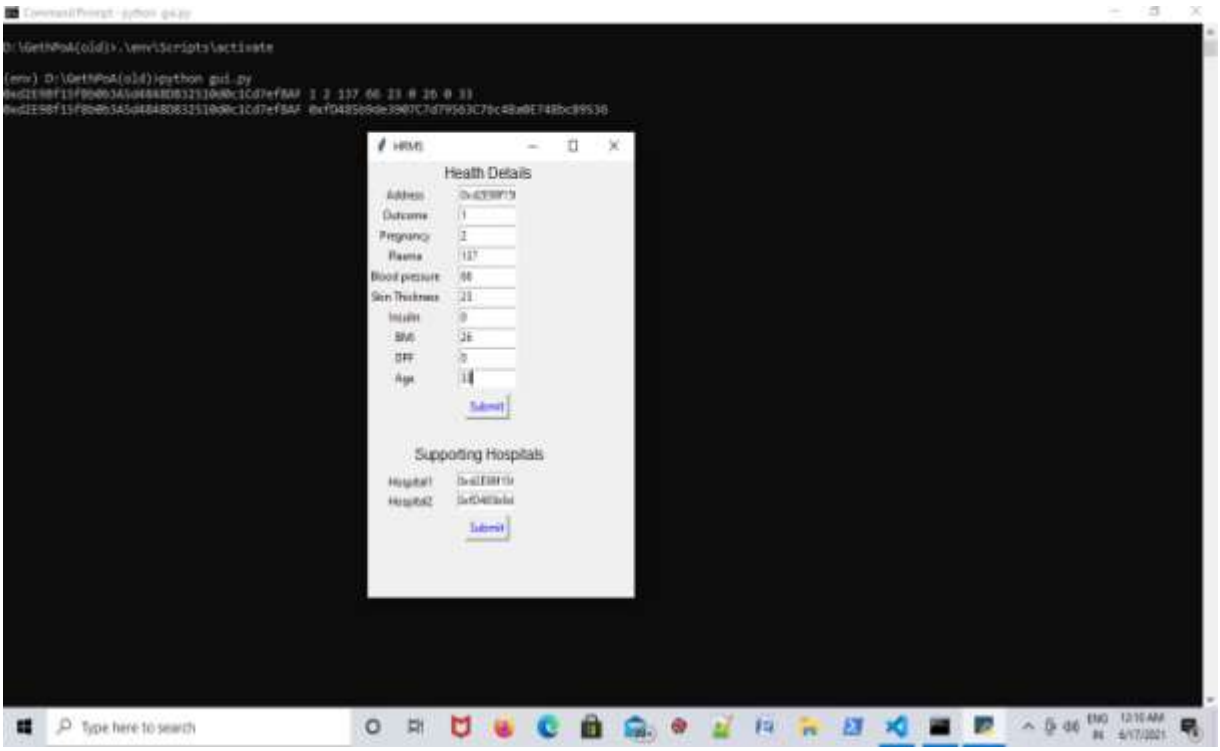


V. EXPERIMENTAL RESULTS AND OBSERVATIONS

Input data: Health data details and payment module or bill details.

Tkinter: Sample GUI using tkinter is used to enter the health and bill details. Tkinter interface is used to store the data into the blockchain for a fast and easy access.

Transaction and Execution Cost: It denotes the transaction and execution cost during the deployment of the smart contract.



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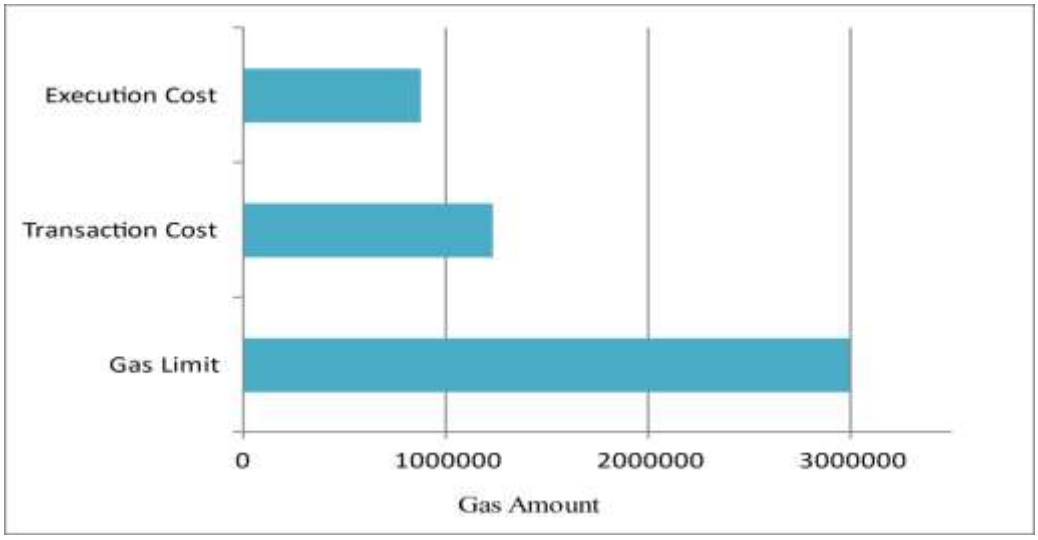

Fig 15: Gas consumption during the smart contract deployment

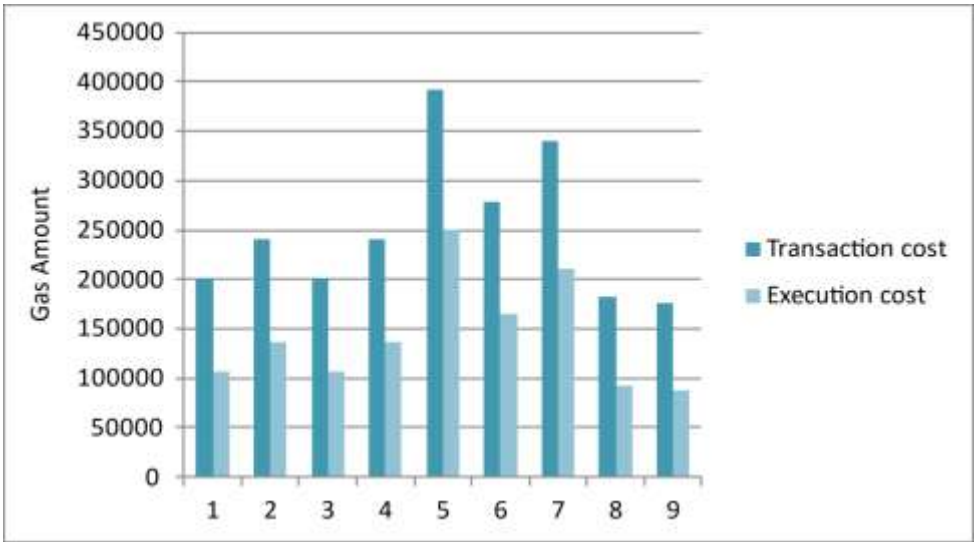

Fig 16: Gas consumption of the individual modules (Labels: 1 - set bill details, 2 - get bill details, 3 - set health details, 4 - get health details, 5 - set supporting hospitals, 6 - get supporting hospitals, 7 - approve pending entries, 8 - get data migration allow, 9 - get vote count)

Latency: It denotes the execution time of individual functions in the python program.

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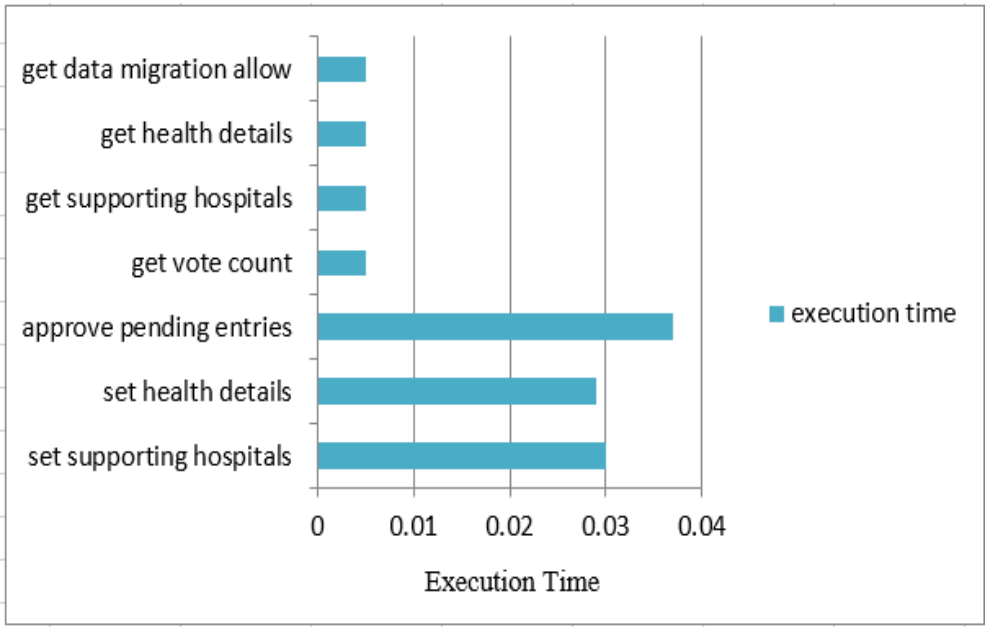

Fig 17: Latency/Execution time

VI. CONCLUSION

Blockchain Technology gives a great number of opportunities if utilized properly and is seen beyond bitcoin. With blockchain, the dominance of central authority could be eliminated. The strongest potential of blockchain technology in the healthcare arena is its heavily researched applications, namely: security, integrity, decentralized nature, availability, and authentication principles due to the general ledger and block related infrastructure. Blockchain through the use of its confidential, secure and decentralized ledger can offer security by storing information among many computers instead of a single source and can meet several healthcare requirements. In this paper we discussed how blockchain technology can be useful for the healthcare sector and how it can be used for electronic health records. This framework creates such a system that is easier for the users to use and understand and the Role-based access also benefits the system as the medical records are only available to the trusted and related individuals. For the future, we plan to implement machine learning in the existing framework.The Application areas like legal documents and contracts, transportation, healthcare industry, human bot interactions study would be done on considerations and based on requirement principles for the framework. In the rapid development of technology, Machines can have a tremendous growth with the implementation of Blockchain in reducing the issue of structure that could be resolved.

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