

Health Record Management through Blockchain Technology

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Abstract—The world is moving towards progress, to achieve the desired progress, the world should have a healthy population and health records are the projections of an individual's health over time. The centralised approach of maintaining the health records lead to data breaches. According to 2017 Ponemon Cost of Data Breach Study, the cost of the data breach for healthcare organizations estimated to be \$380 per record. According to 2016 Breach Barometer Report, 27,314,647 patient records were affected. So we moved towards institution-driven approach of record maintenance, which didn't make much difference with the previously existing one. Since the patient have no control over the data, the chances of data being misused is high. So we need a patient-centered approach which is completely decentralised, which can identify data thefts, prevent data manipulation, and patient has the right in access control. Blockchain Technology serves as a best solution to address all the problems and fulfill the needs. Blockchain being a decentralised and distributed ledger it can also impact on billing, record sharing, medical research, identify thefts and financial data crimes in days to come. Implementation of smart contracts in health care can simplify things even better. Where invoking, record creation and validation will be done on Blockchain.

This paper highlights on the patient-driven model of record maintenance using Blockchain technology where smart contracts can be incorporated in future days

making it more potential in data exchange. Finding its huge scope, hoping that more researches will be carried out and practically implemented.

Index Terms—Decentralized, Blockchain, Immutability, Cryptographic hash, Smart contract

I. INTRODUCTION

Better health is important to human happiness and the welfare of society. It plays a vital role in the economic progress of the nation. Ill health, casualty, emergencies occur every day and the diseases are expected to be diagnosed and treated. A health record is a collection of clinical data related to the patient's mental and physical health, gathered from different sources. Health record consists of a patient's medical history, examination, diagnosis, treatment, results of lab investigation, scanning reports, alerts like allergic to etc. These health records can be managed both manually and digitally.

The traditional method which is followed in most of the hospitals for maintaining records is the manual method which includes papers and books[13]. This method has serious limitations such as a need for large storage areas and retrieval of records is difficult. In the present era computerization[2] of clinical records has become popular as the storage and retrieval of the records is easy. However, the chances of manipulation

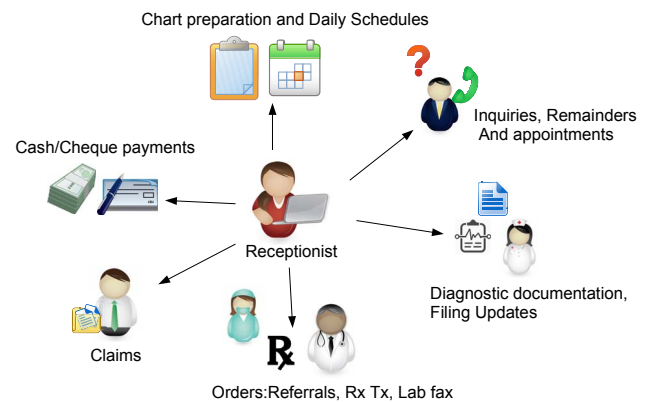


Fig. 1. Existing centralized healthcare model

without identification has become a serious concern. Another major perturb is the maintenance of patient records confidentially as the patient can hold the doctor and the hospital irresponsible for breaking the confidentiality of his medical records[6].

Also, paper-based records are often incomplete, giving rise to unwanted repeat testing and medication. There is wastage of time since this system needs more manual power for transferring records by mail or faxes as these are dispersed and are not centralized[8]. Even accessing of medical records by doctors is limited.

Health records can be easily and quickly shared between medical institutions by integrating digital technologies in the healthcare system[17]. In this respect there are intense queries about the storage of patient's data, providing authorization to access the data, security & immutability of the data[21]. These problems can be solved by developing a decentralized digital health infrastructure that is by integrating Blockchain technology into the healthcare system[12]. Blockchain technology has the capability to rebuild the modern economy by maintaining and updating records[5].

The rest of the paper is organized as follows:section IIA

provides detailed description of Blockchain technology, section IIB gives a brief review on existing Blockchain challenges and proposed solutions followed by section III where we have highlighted the medical record management in decentralized manner. Section IV provides some concluding remarks.

II. BACKGROUND

A. Blockchain Technology

A blockchain is a decentralized, distributed, immutable, shared & tamperproof data structure to store a continuously growing list of the transaction[22][9].

Let us consider Blockchain as a register containing transaction records into timestamp blocks. Each block has its own identity called cryptographic hash[10]. Each block is provided with the hash value of the block that came before it. Because of which a link is established between the blocks, thus creating a chain of blocks. We get a clear picture of how a Blockchain works only when we explore how a Blockchain network runs. It is a peer-peer network where each node holds the record of each transaction that's been carried out in the network. To carry out transactions each node has its own wallet. The interaction between the user and the network is via a pair of private & public keys (Cryptographic keys)[14]. A private key is used to sign their own transaction whereas the public key is visible to all the nodes in the network[20]. Someone who wants to carry out transaction should send a message by signing the transaction with their private key, when this is combined with the public key it forms a digital signature[15]. This transaction is broadcasted onto the Blockchain network where it is verified by the miners. Miners are the nodes in the Blockchain with high processing power[18]. Miners make the transaction unaltered & irreversible using a consensus algorithm called Proof of work. There is a competition among miners to generate a valid block and the one who generates a valid block is rewarded[16].

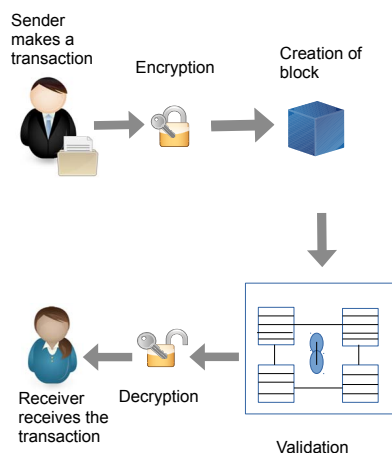


Fig. 2. Working of Blockchain Technology

A block of the transaction is approved only when it is verified by all the miners in the network and if more than 50% of the miners validate the transaction then this block is considered as a valid block and is added to the longest Blockchain[19].

B. Literature Survey

In this section, we highlight the various attempts made to safeguard health records, its challenges, and the possible solutions.

a) Towards using Blockchain technology for eHealth data access management: In the paper entitled "Towards using Blockchain technology for e-Health data access management" the authors have highlighted the benefits of Blockchain and the specific problems associated with it for the secure deployment of the health record and it also provides a scalable solution in order to obtain the best performance. They have also proposed an architecture to address-Health application challenges where Doctors and hospitals are considered as nodes which are connected to the eHealth Blockchain with the smart contract even an off-chain database is also maintained[1]. Patient's can interact with the Blockchain and medical sensors through the data gateway. This paper also proves that with the use of correct tools, models, protocols and the Blockchain technology may fully functional systems are yet to be implemented to revolutionize the future applications.

b) Decentralized e-Health Architecture for boosting healthcare Analytics: In the paper titled "Decentralized e-Health Architecture for boosting Healthcare Analytics" authors have summarized the problem integrated with the analysis and security of medical data. They have also tried to provide a solution that improves the quality of medical services. They have proposed a Blockchain solution for state-scale in healthcare which is based on the Exonum framework, which consists of nodes connected through peer-to-peer connections where all nodes are authenticated by using the public key[3]. They have also told that Blockchain will be used to deal with large volumes of clinical data and also to maintain the confidentiality of medical data. One more advantage is Blockchain can be used to create a data-based market where the patients will get a data monitoring tool through which they can participate in medical analytics and if they provide their data to the medical institution, research institutions they can even get rewards.

c) Blockchain technology: Is this the solution to EMR interoperability and security issues in developing countries: The paper "Is this the solution to EMR interoperability and security issues in developing countries" tells that the use of Blockchain in EMR safeguards continuous availability and access to real-time data. Taking the case study of EMR in Kenya, the authors have discussed the existing method of maintaining the health record and they have highlighted the importance of Blockchain technology as it increases the interoperability and security of the system. Blockchain helps the patient to have full access to the data and control on how data is shared. Further Blockchain depends on cryptographic

techniques to interact in a network without preexisting trust between the parties[6]. When the patient's information is passed between stakeholders, the patients' privacy is preserved because of the encryption of information.

d) Introducing Blockchain for Healthcare: In the paper titled "Introducing Blockchain for Healthcare," the authors have focussed on different Blockchain structures, existing challenges of Blockchain and the possible solutions. Even though Blockchain is used to create smart contracts between healthcare providers[7] and to provide access to certain data or patient records there arises a problem that who is accessing the data and the person who is accessing is authorized to do so or not. One more security issue is Sybil attack which can be solved by forcing each of the miner nodes to involve themselves in solving a mathematical problem before a new block is added to Blockchain by the attackers[7]. Another issue is the inference of private data because of these issues the author have suggested the scientists come up with new architecture design for Blockchain which does not rely on a current cryptographic algorithm.

III. MEDICAL DATA MANAGEMENT ON BLOCKCHAIN

The modern healthcare system is using digital methods for maintaining patients health records.

Presently healthcare organizations use a centralized method for saving patient's information, diagnostic reports, and doctor's prescription. Since it is a centralized system there are chances of data getting leaked or exploited for various reasons as patients don't have control over their data and also exchanging of the recorded data is time-consuming & a complex process. With the aim of dealing with these problems, we are proposing an idea of switching a centralized system to a decentralized system using Blockchain technology. For integrating Blockchain in healthcare, firstly we need to understand the scope of data and where and how it is being generated. Healthcare organizations generate sensitive and critical medical data at every stage of medical treatment like a consultation,

diagnosis, and surgery. The medical data comprises of doctor's prescriptions, X-rays, MRI scans, ultrasound reports, angiography, radiography, endoscopy and also few sensitive health information like HIV diagnosis, cancer diagnosis or psychological conditions.

Before storing data to the Blockchain we need to add some value to enhance the quality of the data. Patient's medical records should be accurate, understandable and structured because unstructured data leads to inconsistencies, delays in the treatment process. The risks associated with the centralization of data can be eliminated by storing the digital health records across multiple nodes within the network called Blockchain.

On the Blockchain network, patient's health records can be saved using their public keys and transactions containing patient's health records are saved with their unique IDs and patient's public key. Healthcare organizations can access the patient's non-identifiable data through smart contracts only when the unique IDs match. If required patients can share the public key with the health organizations but without the private key data would always remain non-identifiable[12]. To ensure the users will to share/retrieve the data, smart contracts are necessary.

Smart contracts are self-executing contracts with the terms of the agreement between two parties being directly written in the form of code without the involvement of third party. It is a protocol that digitally facilitates, enforces and verifies the negotiation or performance of the contract.

In our work, the proposed concept is developed as a contract by the name healthcare which consists of 2 nodes that is equivalent to two people and can be assumed as hospitaladmin / labadmin. A structure is created and named as a record which comprises of patient's address, patient's unique ID, test name, date, hospitalname, price, isvalue, signature count.

i) Invoking the transaction:

We have used a constructor which is public in nature and is automatically called when the Dapp is deployed.

Transaction on the Blockchain network should be invoked only by hospitaladmin and he is the one who chooses labadmin and assigns him with a particular address.

ii) New Record Creation:

The existing records of the patient are stored in an array called Records and we have deployed a function called newRecord to add new data to the existing record by assigning values to the corresponding parameters.

iii) Validation:

For validating the record we have created a function called signrecord in which we check whether the new record is already present in the existing record array or not by using signaturecount if it is '0' the hospitaladmin will sign the transaction and if the record already exists the signature count value will be '1' there will no signing of the transaction. When the value of the signature count turns out to be '2' record signed is emitted.

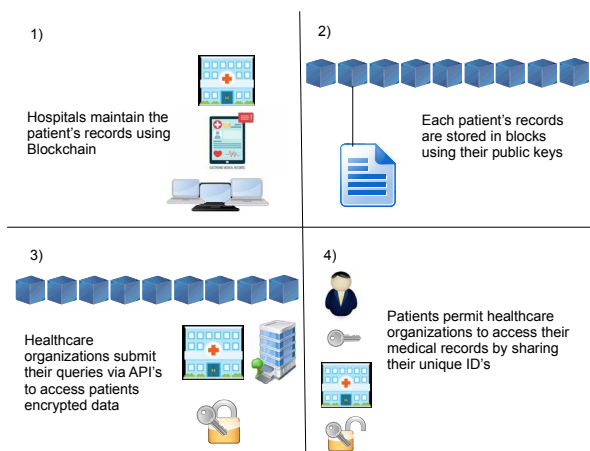


Fig. 3. Process of managing healthrecords

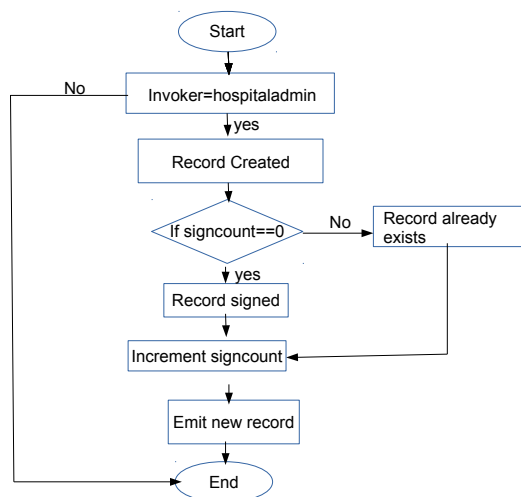


Fig. 4. Flow chart of the smart contract

IV. CONCLUSION AND FUTURE WORK

As an age old saying goes "Health is Wealth" in the present scenario we can now consider in addition to health, health records are also wealth. So it is more important to keep our health records safe. The world has started moving towards patient-driven interoperability where patients provide the on-demand access to their health records. In this model, the patient is considered as the sole owner to his health records who would decide on sharing what data and with whom. This drift from an institute-driven to patient-driven comes with a bundle of challenges which are effectively addressed by Blockchain by decentralizing the whole mechanism in contrast to the traditional way of data management. 200 health executives were interviewed by IBM's Institute for Business Value Blockchain, of which 16 percent of people are ready to deploy commercial Blockchain. As discussed above, Blockchain does not just help in decentralizing the data, it also gives the real-time data access, keeps the data confidential, handles high volumes of data efficiently, and also authenticate and authorize the data.

Our approach also deploys smart contracts, which is a code, which executes on its own when both the parties agree on the set of protocols. Here we consider Hospital admin as one end user and the patient as another party. There are three steps of executing the smart contract namely, Invoking, Record creation, and Validation. Our paper suggests Blockchain technology as one of the possible solutions for the efficient maintenance of health records. Blockchain technology's usecase is not restricted to health record management, it can also be implemented in various domains such as utility payments, banking, e-voting, transport, supplychain management and etc. Further research can help implementation of Blockchain in all domains making the lives easier.

ACKNOWLEDGMENT

The authors would like to thank Dr P Shyamaraju, Chancellor, REVA University for all the facilities provided to carry out the research activities. Also, the authors would like to thank Dr Mohammed Riyaz Ahmed, Chintarlapallireddy Yaswanth Simha, Teja K, M B Sravani of ECE, REVA University for their continuous support and encouragement.

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