Implementation of Electronic Health Record and Health Insurance Management System using Blockchain Technology

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***Abstract*—Electronic health records (EHR) play an important role in digital health transition. EHRs contain medical information such as demographics, laboratory test results, radiological images, vaccination status, insurance policy, and claims. EHR is essential for doctors and healthcare organizations to analyze a patient's profile and provide appropriate therapy. Despite this, current electronic health record (EHR) systems lag with difficulties such as Interoperability and security. Better and faster care may be provided with an integrated and secure health record for each patient that can be transmitted easily in real-time across countries. People having health insurance policies are often confronted by insurance jargon and the insurer's cumbersome requirements while filing a claim for treatment. There are times when the claims processing takes longer than expected. The insurer, Third-Party Administrators (TPAs), and network provider hospitals examine, approve, and initiate the sum claimed. The use of blockchain in the process allows for more efficient information sharing at a lower cost and with more security. Only authorized individuals have access to the shared ledger on a blockchain, making it more confidential and secure. All parties engaged in a health insurance policy, including the insurer, the insured, the TPA, and the network provider hospital, may be members of the blockchain network and have access to the same set of policy data. In our proposed work we implemented a Blockchain-based EHR and Health insurance management system using Ethereum and deployed smart contracts using solidity and created a web application with web3js and React Framework.**

Keywords*—Electronic health records; insurance policy and claim processing; smart contracts; Ethereum; homomorphic encryption; edge computing

I. Introduction

Blockchain transforms the healthcare sector by storing and sharing patients' electronic health records, insurance policies, and claims to provide more secure, transparent, and traceable data [1]. The technology integrates diverse data management systems resulting in an electronic health record system that is connected and interoperable. The doctor treats the patient and enters the patient's report into their existing health information system, which includes tests, prescriptions, and significant notes. The data fields connected with the patient's public ID are then redirected to the blockchain using APIs. In the blockchain, each transaction is authenticated and given a unique identity (public key). APIs can be used by doctors and health organizations to make a query and retrieve encrypted patient data using the patient's public key. Patients can give the doctor or the healthcare facility permission to decrypt their data by supplying the private key (which functions as a password). The data remains encrypted for those who do not have access to the private key [4]. Blockchain is a distributed network of computers that is governed by a time-stamped collection of immutable data records that are not held by a single person, company, or government entity. Because the blockchain network is decentralized, data may be exchanged and updated, but it cannot be copied, modified, or erased, making it public and accountable [2]. As a result, the best platform for storing and distributing electronic medical records is blockchain. An Electronic Health Record (EHR) is an electronic representation of a patient's medical history [6]. Blockchain is the next big thing in healthcare and it will revolutionize how it is supplied and administered. The fundamental issue is information asymmetry, which means that not everyone has the same easy access to the data [5]. Blockchain and smart contracts safeguard data, increase interoperability, and allow numerous entities to access the medical information that makes up the EHR by providing a secure distributed network, a shared ledger, and the ability to add independent blocks of medical transactions [3]. Blockchain has four main benefits in an EHR system.

- Longitudinal patient records: Data is assembled progressively, ensuring that no data is lost or tampered with.
- Master patient indices: A single master patient file contains all of the different blocks of information, reducing the chances of medical errors or mismatches.
- Claims adjudication: Instead of relying on a central authority, automated smart contracts can assist handle claims more quickly and efficiently.
- Interoperability: Only approved authorized providers have access to the data and the capacity to edit it, allowing for greater data reconciliation and care quality improvement.

The advantages of electronic health records extend far beyond cost savings. An EHR system provides quick access to accurate and up-to-date patient information. This lowers long-term healthcare costs and improves efficiency, especially if a patient is transferred between departments during treatment [11]. Blockchain technology ensures that every participant has their own copy of the digital ledger, which is updated in real-time as transactions occur. Hacking is nearly impossible due

to the lack of a centralized server. Because a recorded transaction cannot be reversed in theory, the ledger is an immutable source of truth, regardless of how many copies are kept by participants [10]. It is possible to confirm data, records, and participant identities while keeping their identities disguised. Our digital environment is rapidly changing in the pursuit of excellence. Without a doubt, technology has a significant impact on our daily lives and other elements of our lives, with the potential to dramatically improve them. One of the industries that potentially benefits from the adoption of blockchain is insurance [17]. Many blockchain insurance firms are working to improve the end-user experience as well as the businesses that handle people's insurance. Because most underwriting and claims work requires collaboration among numerous parties, blockchain will assist the insurance sector [18]. While blockchain adoption is still in its infancy, the applications covered here are a good place to start for insurers interested in taking advantage of its potential. When it comes to technology, it has the potential to affect the lives of millions of people all over the world. Because life insurance procedures differ from country to country, finding a consistent manner to manage all claims and processes is vital [22].

II. Literature Survey

More than 4,000 years ago, the Sumerians penned medical data on a clay tablet. The Egyptian papyrus was next, followed by the thick folders. The first medical electronic information system was established by Lockheed in 1960. The Decentralized Hospital Computer Program (DHCP) and the Computerized Patient Record System (CPRS) were implemented by the Department of Veterans Affairs in the 1970s. President Bush first mentioned the term "Electronic Health Record" in 2004. The usage of the EHR system allowed increased payments to physicians and hospitals under President Obama's American Recovery and Reinvestment Act of 2009, which was part of the Health Information Technology for Economic and Clinical Health Act (HITECH) [10]. In Estonia, 99 percent of health records have been digitized. E-Health Records are even accessible to first responders and paramedics [7]. It's useful for non-responsive individuals when further information about their medical history and probable sensitivities is needed quickly. Currently, systems in many countries are scattered and do not communicate with one another. By integrating scattered systems across countries and regions, a blockchain-based electronic health record can enable real interoperability [14]. Instead of being saved in a single database, healthcare data can be stored immutably in a decentralized fashion using blockchain. As a result, a hacker would not be able to access the data through a single point of entry. This is how blockchain improves the security of health-related data. Homomorphic encryption can be used since blockchains do not provide anonymity [12], [16]. However, complete anonymity in healthcare is neither essential nor desirable. Instead, alternatives should be found that allow patients to choose who to reveal their name to, whether to remain pseudonymous and what data to provide. They can, however, be improved to improve patient care and accessibility to information. An electronic health record (EHR) is a collection of patient-related data that is maintained electronically [15]. The growth of screening tests, medical imaging, and diagnostics has resulted in an avalanche of information on patient health. EHR (electronic health record) systems are a fantastic approach to boosting patient care. As more patient data becomes digital and an increasing number of consumers seek mobile access to health records, the function of EHR is improving and digitizing in healthcare [13]. In general, electronic health records (EHR) features and frameworks have long been seen as a surefire means to improve medical care delivery systems. The current life insurance claims system is inefficient, as it might take a long time to process a claim. It means that the claimant will have to deal with a lot of red tapes before their claims are handled [24]. All of these issues can be mitigated with blockchain life insurance. To ensure that claims are processed more quickly and efficiently, a good blockchain-based life insurance model can work in combination with the hospital, insurance company, death certificates, and burial licenses.

III. Challenges in Existing Electronic Health Records and Health Insurance

According to research, 50-60% of physicians experience burnout, which results in lower patient satisfaction, decreased patient safety, and more malpractice claims [23]. A large amount of time is necessary to incorporate data into EHR systems. As a result, physicians are unable to devote sufficient time to improving patient communication. As a result, the quality of patient treatment declines, and physicians grow increasingly frustrated and dissatisfied. Furthermore, EHRs are believed to be a cost burden on both providers and practitioners in some cases. Interoperability refers to an EHR's capacity to communicate data and information to other devices so that it can be used by a large number of individuals. The systems must communicate well with one another to obtain a complete picture of a patient's medical history as in Fig. 1. Data communication in an EHR is frequently delayed due to a lack of interoperability between segments of the same EHR or between the EHR and another system. The information held in an EHR and shared on a blockchain's distributed ledger would be updated and secured, ready to be used by anybody with authorization [8]. A blockchain-based EHR solution will improve data quality and interoperability thus reducing the time it takes to obtain a patient's information [9]. Furthermore, using blockchain for electronic health records will help to reduce costs, especially in terms of software development and health record system maintenance.

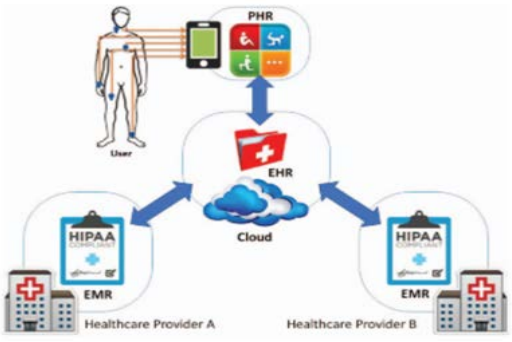

Fig. 1. EHR Framework.

When information is maintained within an EHR and shared on a distributed blockchain ledger, it may be updated, safeguarded, and made ready for use by anybody authorized to access it [12]. A blockchain-based EHR system reduces the amount of time it takes to get information on a patient. It will also improve data quality and provide seamless and safe interchange. As a result, blockchain for EHRs (electronic health records) may result in lower costs [19]. Insurance clients, who are frequently perplexed by plans, have grown skeptical of insurers and have developed a rising suspicion of them. The issue of trust is a huge one for insurance companies. The majority of the time, insurance companies do not have access to all of a patient's information, resulting in higher processing costs or incorrect plan assignments. Documents are occasionally incorrectly filled or not submitted, and sometimes lost, due to the distributed paperwork and filings among the numerous parties in the insurance network [24]. Customers are dissatisfied when insurance firms fail to process claims within specified deadlines [25]. Insurers are under increasing pressure to decrease administrative expenses, and blockchain technology have the potential to assist by upgrading fragmented legacy IT systems, improving efficiency, and increasing competitiveness [26]. Increased automation is required in the insurance industry, which blockchain technologies can help with. New systems, processes, security protocols, and business models are necessary to meet rising customer demands for tailored services, increased privacy, innovative products, added value, and competitive pricing from their insurers.

IV. Blockchain Implementation in Electronic Health Records and Health Insurance Systems

The IoT healthcare sensors such as temperature, humidity, airflow, pressure, SpO2, heart rate, and pulse sensors are used to collect the patient's real-time data and store it in edge computing devices [12]. The data stored in the edge device is then retrieved and the transaction is processed in the blockchain as shown in Fig. 2 and Fig. 3. This might lead to healthcare providers and academics having access to enormous amounts of anonymized patient data for research reasons. Every blockchain node has a copy of the data that is constantly updated. As a result, any tampering or manipulation of health information will be discovered right away. Every transaction is also signed with a cryptographic stamp, allowing each piece of data to be traced back to its source. This means that a doctor can monitor a patient's recovery from surgery or sickness in real-time recognizing potential problems or concerns with eating, exercise, and vital indicators like heart rate without having to see them in person. It allows a doctor to monitor a patient's recovery after surgery or illness in real-time.

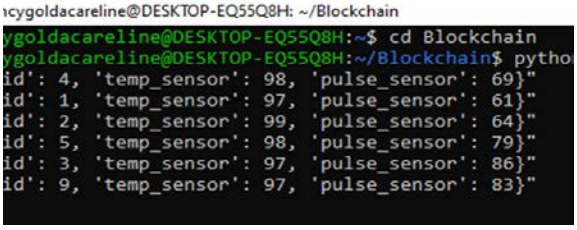

Fig. 2. Sensor Data is Stored in the Blockchain.

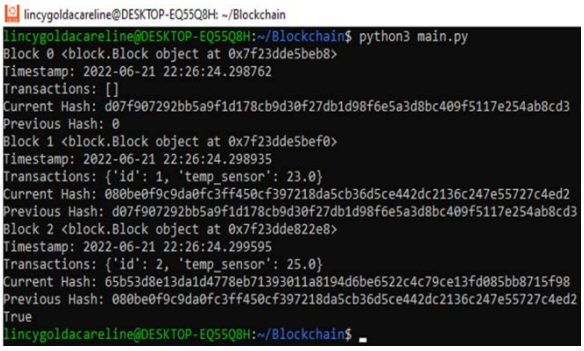

Fig. 3. Transaction is processed and Hash is generated for the Appended Sensor Data in the Blockchain.

Customers may encounter time-consuming paper forms when applying for insurance or reporting a claim. They may need to talk with the insurance companies and hospital employees to get medical insurance claims reimbursed [17]. Claims processing, data verification and reconciliation, and documentation procedures are shown in Fig. 4 and Fig. 5. Blockchain can help make selling and servicing insurance better, faster, and cheaper by improving fraud detection [19], claims administration, health insurance, and reinsurance. As a result, customers may see lower costs and have a better experience. The Blockchain has the potential to assist in the resolution of present property and casualty insurance issues. The strategy is to digitally manage physical assets. Smart contracts allow claims to be processed automatically. All modifications can also be tracked for authenticity, making them auditable. Smart contracts are crucial because they provide the functionality of converting paper contracts into programmable code [20]. The smart contracts, in turn, can be automatically performed by ingesting all of the data and acting on it as needed [21].

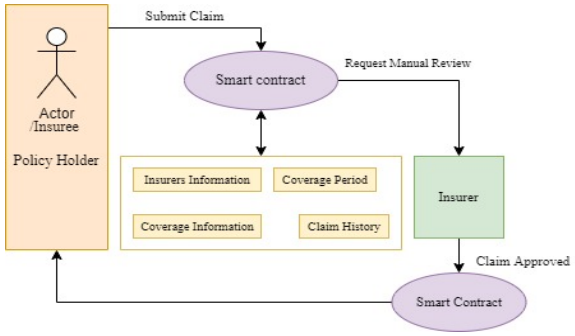

Fig. 4. Proposed Insurance Claim Processing.

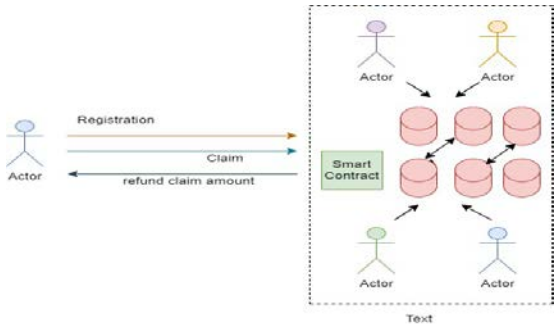

Fig. 5. Health Insurance Framework.

Deploying blockchain on healthcare networks will improve patient diagnostics and medical expenditures by expediting and improving patient diagnosis. The patient is the owner of his or her medical information and has the right to give it as needed without relying on any other parties. Because hospitals and clinicians would have immediate and complete access to a patient's data, the need for additional testing and long or incorrect diagnoses would be greatly reduced. Smart contracts will automatically initiate transactions, making claim processing and denial even easier and faster. This would greatly boost the level of trust in insurance companies. Sharing data across the network's many providers on a distributed ledger ensures that data will be retrieved quickly at any time, while also reducing the danger of improper documentation and data/documentation loss to nearly zero. This would help insurance firms save money on processing costs. The widespread adoption of blockchain by insurance companies throughout the world brings up a slew of prospects for distributed ledger technology validation services.

Blockchain is quickly gaining attraction as a technology that has the potential to alter the insurance sector. For accuracy and credibility, insurers rely largely on information and data acquired by various devices. Insurers should make sure that blockchain is linked with IoT as the best way to assure that the data captured is accurate. The interplay of blockchain, IoT, and big data in this way has the potential to transform the insurance sector. The idea is to automate the entire process, including premiums, claims, and other issues. With the ability to streamline the insurance sector while simultaneously increasing transparency and confidence.

V. Results and Discussion

In our proposed work we implemented a Blockchain-based electronic health record and Health insurance management system using Ethereum Framework, smart contracts are deployed using a solidity debugger and the transaction are processed through truffle-based Ganache Test network. Created a web application with React framework as shown in Fig. 6.

Patients' and recipients' electronic health records such as demographics, laboratory test results, vaccination status, insurance policy and claims are stored in the React framework as in Fig. 7 and Fig. 8. Delegations are created and the electronic health records can be updated using the React framework as shown in Fig. 9 and Fig. 10.

The electronic health records are stored in the blockchain using Django REST Framework. The promise of blockchain technology is enormous, and integrating it with EHR will ensure that we all benefit from a better, more equitable, and healthier future.

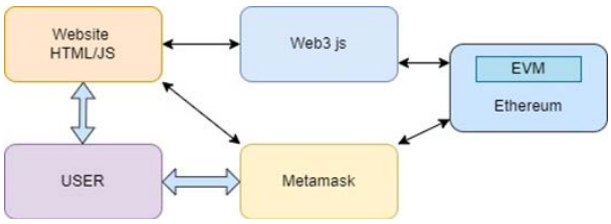

Fig. 6. Block Diagram of Proposed Work.

Fig. 7. Patients Signup Webpage using React Framework.

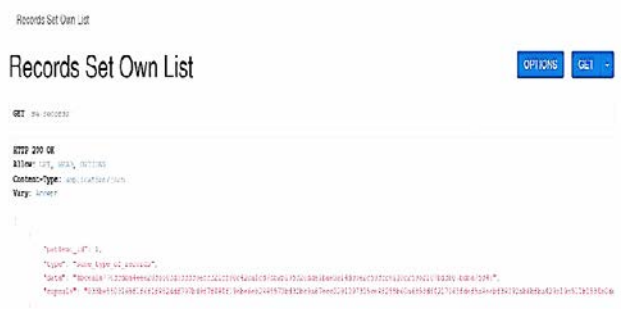

Fig. 8. Recipients Signup Webpage using React Framework.

Fig. 9. Delegations are created in React Framework.

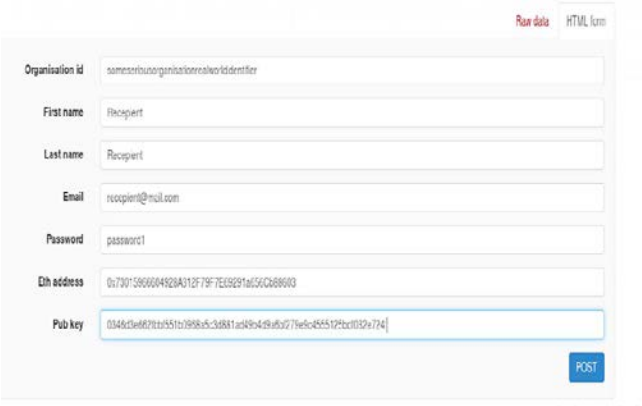

Fig. 10. Patients Heath Records are Uploaded in React Framework.

VI. Advantages and Limitations of Proposed System

There are major advantages that blockchain can offer to the traditional health record system. Patients have more control over their data because they can provide just the relevant authorities access to the data. Health data may be collected, saved, secured, and shared using blockchain for EHRs, which also allows for real-time utilization. It might lead to the selection of anonymized patient records for use in research by healthcare practitioners and researchers. When a blockchain is used to maintain electronic medical records, it offers a long-awaited standardized solution for the management of digital health data. To access patient data, hospitals and care providers will no longer need separate software or databases. EHRs give clinicians access to a patient's medical history. Patients no longer need to fill out the same paperwork at each visit to the doctor. The convenience of e-prescriptions provided straight to pharmacies is increased. The usage of a dashboard also makes it easier for patients to communicate with their doctors and streamlines their care. Patients and doctors can communicate directly because they use the same platform. Different specialists, hospitals, laboratories, and even pharmacists will be able to share the same information. Treatment providers will have a better understanding of how to improve patients' care if data is less scattered. Automated claim management aids in the seamless processing of reimbursements. It also reduces the administrative expenditures of hospitals or offices. Efficiency and expenses are improved by automating administrative processes and automatic clinical documentation.

The advantages of electronic health records are vast, but they also have a few limitations, most of which are related to the implementation and learning of EHR systems. The cost of implementing an EHR system is not insignificant. The majority of these costs are directly tied to the implementation of hardware and software. When new systems are implemented, the workflow is inevitably disturbed, resulting in a temporary loss of productivity. In the end, these losses will be only temporary, and revenues will rise. Because of increased productivity and faster claim reimbursements. The entire medical history of a patient is readily available, which is beneficial for diagnostic purposes but possibly dangerous for keeping sensitive information private.

VII. Conclusion and Future Work

The potential of blockchain technology has already been recognized by the majority of forward-thinking healthcare industries. More importantly, blockchain will improve patient care by standardizing how parties manage and access electronic medical records. It can aid in the detection of health trends and the improvement of treatment. Blockchain technology has enormous and thought-provoking possibilities and the deployment of EHR on the blockchain has the potential to alter the healthcare industry. Using blockchain to standardize the management and access to electronic medical records, on the other hand, would elevate patient care to new heights. Patients will receive more accurate diagnoses and have complete ownership over their digital health information. And, if electronic health metadata has been collected and reconciled securely, it can be used to identify health patterns, improve treatment, and eradicate diseases. Insurance is no exception, and blockchain has a lot of potentials. The most prevalent use cases are fraud detection and prevention, claims management. The 'quickest win' for blockchain in the insurance sector is cost savings. The enhanced security of blockchain, as well as its capacity to establish trust between entities, are two reasons why it may be able to tackle the interoperability challenge more effectively than current solutions. Existing EHRs in hospitals and physician offices would most likely be used to create a blockchain-based interoperable and comprehensive health record.

Combining Electronic Health Records (EHR) with Artificial Intelligence and Voice Recognition is beneficial to EHR systems because it allows clinicians to enter information and patient data. Artificial Intelligence has a history of transforming the healthcare industry by supporting clinicians in analyzing prior trends in a patient's condition and establishing a diagnosis. The predictive analytics application has a significant impact on the healthcare industry. Predictive analytics technology is being employed in a wide range of applications, from cancer treatments to emergency staffing optimization, and it will soon be embraced even more widely. With features like real-time data monitoring, telemedicine, and more, 5G has a lot of potential in the healthcare sector. Healthcare personnel will be able to access data via a tablet or smartphone through mobile computing and cloud-based infrastructure to securely store and retrieve data. As a result, devices like smartwatches will be used in the healthcare industry to automatically upload and track patient data as well as enable remote patient monitoring.

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