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MANAGING LIFETIME MEDICAL HISTORY DATA USING BLOCKCHAIN TECHNOLOGY WITH FAST RETRIEVAL

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Abstract

A person's medical background goes back to birth in lifetime medical history data. Modern hospital in the world has a system for keeping records. With the development of electronic health records and the field of health information technology, the data are now being preserved. They may include allergies, diseases, surgeries, vaccines, and the results of physical examinations and tests. The automated connection between hospitals is lacking from handwritten reports held in storage rooms; the connection is because, in medical emergencies, patients frequently lack time to travel to the hospital to get the records they need. The value of having an effective lifetime records storage system in an electronic form has been demonstrated by research done in a community hospital. One of the world's most secure data storage methods is blockchain, a young technology. Because it is decentralized, medical institutions can access the same data quickly. In addition to enhancing security, using blockchain technology in such a system has various advantages for healthcare systems, such as a decentralized architecture that enables interoperability, security, authentication, and integration. In this study, the decentralized application will be created and tested from the viewpoints of patients and doctors. A web application with a lifetime history of medical records was developed, which is decentralized and allows for quick retrieval using QR codes. The research has successfully learned and applied the technology related to blockchain, the creation of decentralized applications, the design of smart contracts using the NodeJS and Solidity programming languages, and the construction of web 3 applications. The objectives for this research have been successfully met.

Keywords: Blockchain technology, Fast retrieval, Lifetime medical history, NodeJS, Process Innovation, Product Innovation.

1. Introduction

A person's medical background goes back to birth in lifetime medical history data. The data may include allergies, diseases, surgeries, vaccines, and results of physical exams and testing [1]. These records have been made more accessible because of the development of electronic health records and the field of health information technology. However, deaths, harm, and medical errors induced by electronic health records have increased significantly since their emergence [2].

Although every hospital in the world has a documentation system, from automated to handwritten reports stored in storage rooms, the connection between hospitals is missing because, in medical emergencies, the patients don't always have time to get the information from the hospital to where the patient is [3]. It means that the current process of retrieving medical history reports is costly, slow, and could cause death. Not only is the retrieval the problem, but the quality of the retrieved information written by doctors and nurses would cost lives and help incompetent health officers to get away with any preventable adverse events [4].

Having an efficient lifetime records storage system as an electronic version of it has proven its importance after some conducted studies in a community hospital in Vermont, the USA, showed a 60% decrease in near-miss medication events, 20% increase in completion of daily fall assignments helping, 25% drop in the number of patient chart needing to be processed by signatures and an increase of revenue by more than US$ 100k in the study period [5]. However, having such a perfect solution is not there yet. The law protects sensitive information such as lifetime medical history for the safety and privacy of patients.

Blockchain is an upcoming technology that is one of the most secure data storage technologies in the world [6]. It is decentralized, allowing medical institutions fast access to the same data. By inherent design, the data on a blockchain cannot be modified. At the same time, working with smart contracts will benefit both parties, which are health institutions and patients. Having advanced technology like that does not mean it's all good [7].

In addition to enhancing security, using blockchain technology in such a system has other advantages for healthcare systems, such as a decentralized architecture that promotes interoperability, security, authentication, and integrity [8, 9]. It is supported by a decentralized architecture that is more secure, immune to single points of failure, and free of communication bottlenecks. It is based on a hashed linked list data structure that provides tamper-proof and immutable data storage, ensuring the integrity of health data [10]. Therefore, proposing blockchain technology is feasible and would significantly impact existing and new systems.

Accessing the blockchain could take time, and in health care, exceptionally sometimes fast data retrieval could save lives; therefore, implementing a fast retrieval using a QR code adds value to a valuable technology like blockchain [11, 12]. The existence of such great technology is suited ideally for the healthcare system; however, it is not used. For someone to get an accurate medical history could be impossible due to the lack of one secure decentralized system between institutions.

The QR code technology has been integrated with blockchain to decrease the number of fake diplomas for an interest, both for work and continuing education, to a higher level. The certificate will be printed with a QR code. It verifies numeric

QR codes via scanning on a smartphone or QR Reader. In designing the application, equipment used QR Generator that uses PHP language, and a QR Reader application installed on the smartphone or even is included in IOS devices. The program will be developed using the QR Code generated using the QR Reader on the mobile phone application [8].

2. Methodology

The principal research methodology used for this project will be prototyping to identify possible flaws and errors and ensure that all functionalities are covered. At the beginning of the project requirements, the gathering will commence using fact-finding techniques. This data will be used to start the design and build a prototype. Then as discussed, user feedback will be considered, and the process will repeat itself until a final satisfactory product is out.

After gathering all the required information from the previous step, gathering system requirements will be conducted by studying and researching existing systems with the same core concept as the author's project, which is a lifetime medical history management system. It will be used to plan and design the prototype and how the application will be implemented and used by the users.

This step builds a prototype based on the information gathered and the designs created in previous actions. The prototype developed is presented to users and tested and evaluated to get their feedback and identify any faults or errors in the system. The user's feedback will be recorded and considered for the next step.

In this step, the user feedback from the last step will be used to modify and refine the prototype. This phase is the final step of the methodology, where all the information and approvals are ready. The final application is built according to the findings of the previous phases. The application is made, exhaustively tested, and then released into production. Lastly, maintenance is scheduled regularly to prevent any crashes.

Gathering information from individuals using the methods outlined in the proposal would include three (3) fact-finding strategies: question and answer surveys as primary research to elicit pertinent user insights and suggestions regarding what they would want to see in a program like this. Also, how patients are comfortable with having their information stored and shared between health institutions like that, then we have interviews with patients and medical professionals to gather the information needed to build a comfortable flow for them. Also, to understand the medical technicalities and what the doctors want to see in an application like this.

Questionaries are a beneficial research tool where a set of questions are created to gather valuable data and information from the respondents. This technique is used in most of the research conducted because it is usually very efficient and effective as it offers fast, efficient, and inexpensive means of gathering large amounts of information from a volume of people.

The two (2) questionnaires—one given to the patients and the other to the doctors, as was previously mentioned—were used to gather data, as shown in Figs. 1 and 2.

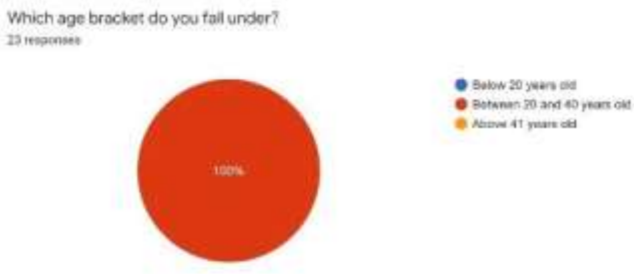

Fig. 1. Responses Q1.

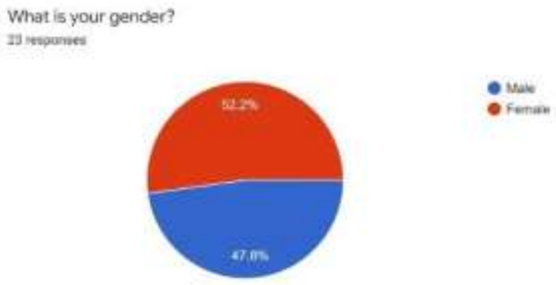

Fig. 2. Responses Q2.

The framework implementation will be a decentralized application (DApp) that supports a private blockchain network with a back end distributed file system (DFS). Ethereum has been used to implement the healthcare blockchain smart contract system. It is an open-source network and one of the largest public blockchain networks with an active community and a large public DApp repository. Currently, the platform uses a proof-of-work (PoW) consensus algorithm called Ethash. The system will use smart contracts from Ethereum to generate competent representations of existing medical records, which will be stored in individual nodes. The contracts will contain ownership metadata, permissions, and data integrity descriptions. These include issuing a basic medical prescription for treating complex diseases and their procedure, like treatment procedures for surgery patients.

The system is designed via various diagrams, as shown in Fig. 3. Two (2) questionnaires were distributed amongst two groups of people, and they gathered useful information and insights for the author in the development process of the proposed system. Secondary research was done for a similar approach to the proposed method, and excellent understanding was collected from it. Then the UML diagrams were used to explain the design of the proposed system in detail. The class diagram is used to elaborate on the object-oriented nature of the proposed plan; the use case table is used to elaborate on the uses of the system and much more. A simple UI/UX design has been created, but further improvements will be made.

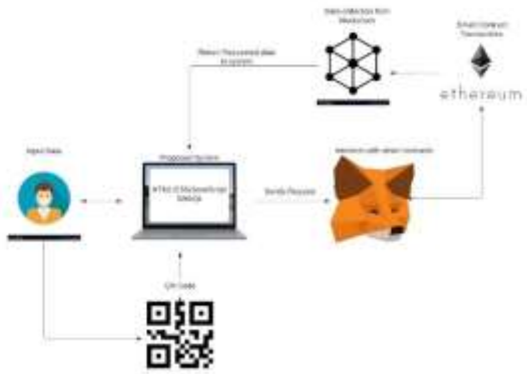

Fig. 3. Rich picture diagram.

2.1. Deployment of smart contracts

Deploying smart contracts onto the blockchain is the next step in developing this decentralized application. For this step, a framework called truffle is used. Truffle deploys the smart contracts on the ganache test blockchain. After the smart contracts are thoroughly tested and developed, they are compiled into EVM (Ethereum Virtual Machine) bytecode and ABI. EVM bytecode is an executable code on EV, and contract ABI is an interface to interact with EVM bytecode, as shown in Fig. 4.

2.2. Client-side development

A decentralized application's architecture is unlike any other web application, as the server side is considered the blockchain. So, to communicate with the blockchain via a user-friendly interface. On this part, a client-side has been developed for two (2) users: doctors and patients.

They are stored on the IPFS platform, and the hash leading to those documents is securely stored in the patient's profile on the blockchain. The patients' interface is used to access their visits to the doctors and the ability to create a QR code to the document where it can be accessed anywhere anytime by just scanning the QR code. Here, Fig. 5 shows how the DApp architecture works.

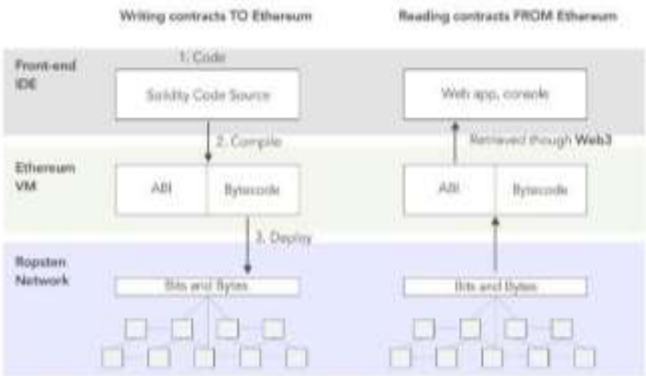

Fig. 4. Ethereum contract ABI & bytecode diagram.

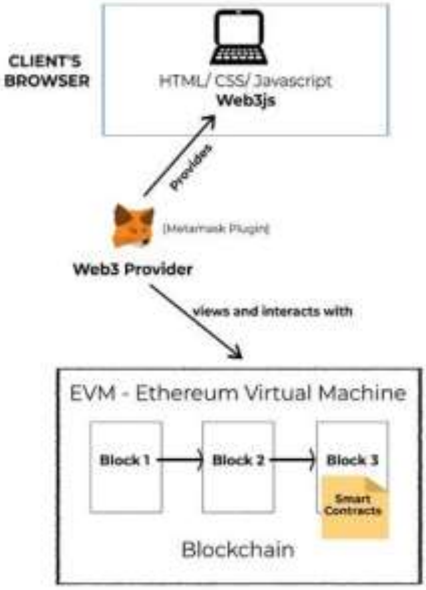

Fig. 5. DApp architecture.

2.3. Truffle Framework

Truffle is a development environment where developers could quickly develop smart contracts and test them using built-in test functions within the framework. Truffle also allows developers to compile and deploy contracts into the blockchain. The framework is designed for developers who want to create JavaScript decentralized applications based on smart contracts.

Truffle provides boilerplates that help the developers focus on the functionalities of the decentralized application. Other than setting up the redundant code for the project, they usually contain contracts, libraries, and front-end views as examples to help developers.

The box uses NodeJS and ExpressJS to provide API endpoint to the Ethereum blockchain and the ganache blockchain in the development phase. Truffle and ganache-cli should be installed using the npm command to activate the express box.

2.4. User interface

In this stage, the user interface has been developed to give the user a good experience - the application's main page, as shown in Fig. 6.

Figure 6 shows that this page is navigation for users who want to access the application. It automatically connects to a meta mask if you are logged into the account on the browser. New and existing doctors can enter the doctors' section. Current patients access their part to see their profile and documents, while new patients press on the new patients' section to create an account, as shown in Figs. 7 - 10.

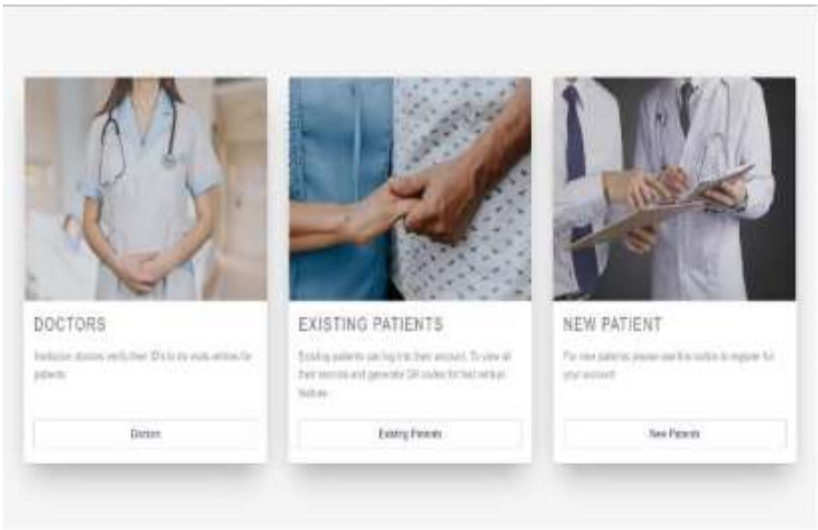

Fig. 6. DApp architecture.

Fig. 7. Doctors ID verification UI.

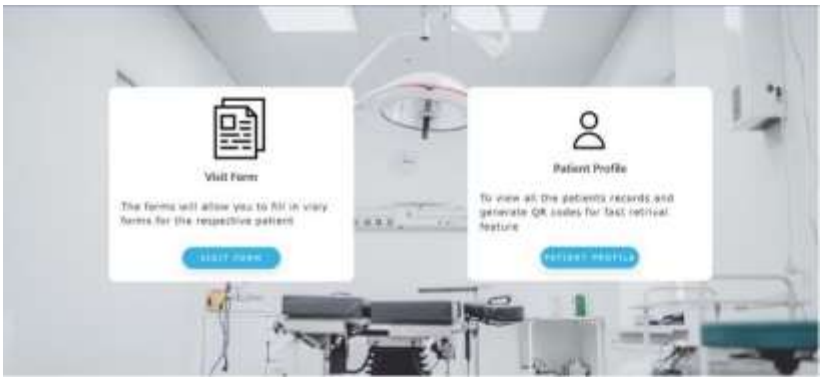

Fig. 8. Doctors patient home page UI.

Fig. 9. Doctor patient profile page UI.

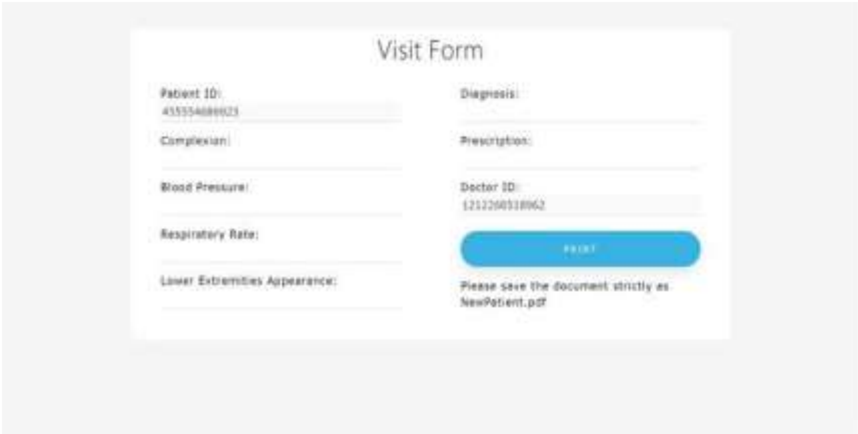

Fig. 10. Doctors visit from for patients UI.

The nature of medical data applications must be secure to protect patients' information. Therefore, the author has adopted the blockchain model, where the doctor's data and patients are stored in the blockchain, the medical history documents are uploaded onto IPFS, and the hash codes used to access the forms are stored in the patient's profile in the blockchain. The DApp was designed to adapt the process of writing and creating medical records and having the ability to retrieve them by authorized members only. The GUI was designed to have a user-friendly design which will make the process of creating medical records easy and especially recovering them more accessible and faster.

3. Result and Discussion

The decentralized application will be tested from the patient's and doctor's perspectives, as shown in Table 1.

The testing process and verify the consistency of the data between the decentralized application user interface and the data stored on the blockchain, as shown in Figs. 11 and 12.

Table 1. Test model Specifications and test conditions.

Function test No.	Description
1	Register New Patient
2	Patient Login
3	Patients view general information documents using a hyperlink
4	Patients generate and scan QR codes for general information
5	The doctor creates a new account and generates an ID
6	Doctor verifies ID
7	The doctor confirms the patient's ID
8	Doctor access to patient medical records
9	Doctor view patient records using hyperlinks and QR code
10	Doctor fill visit form for patient and upload to blockchain

Fig. 11. D New patient information on the console.

Fig. 12. New doctor-generated.

A lifetime medical records history decentralized web application with fast retrieval using QR code technology. The development of this system was challenging. The author has learned about blockchain, decentralized applications development, innovative contract development using solidity programming languages and NodeJS, and web3 application development. The project objectives for this project have been successfully met.

For future improvement of the developed system, the author believes that the QR code approach to retrieve data from the blockchain and IPFS platform should be used more by developers. The author would recommend having a complete hospital management system designed around blockchain technology for the developed system. The fast retrieval feature has proven its efficacy with a high percentage and should be integrated into blockchain decentralized applications.

4. Conclusions

This study suggests using blockchain to store medical records since doctors and other healthcare providers see patient records as sensitive information and typically take security measures to protect them. The suggested application uploads the patient's medical history documents to IPFS, and the hash codes needed to access them are kept in the patient's blockchain profile. The DApp was created to change how medical records are written and created, as well as how only authorised users can access them. The GUI was made to be user-friendly, which will make creating medical records simple and particularly recovering them more accessible and quicker. A variety of tools have been used, including the creation of Web3 applications and smart contracts written in the NodeJS and Solidity programming languages to operate on Ethereum.

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