Implementation of Secure Medical Consultation Platform using Blockchain

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***Abstract*— After the pandemic era, the need for platform which allow doctor and patient remotely have increased because of ease of use and safety. But managing and securing patient's data securely is becoming difficult because of increasing data breaches. This project work develops a decentralised web application which allows doctors and patient to share the confidential information like prescription, bill, medical history using blockchain.The web application also allows patient to book appointment with the a specialist doctor very easily. The payment is also done using the cryptocurrency and it is transferred from patient's wallet to doctor's wallet once appointment is booked. After the appointment is booked, the patient and doctor will join a custom meet link and doctor can provide required help to the patient. After the meeting ends, the doctor will upload the documents in secured decentralised database which can only be accessed by the patient with correct wallet address. By offering blockchain secured appointments, this project aims to make medical consultations more accessible and secure.**

***Index Terms*—Telemedicine; Blockchain; Electronic Medical Records; Video Conferencing**

I. INTRODUCTION

The healthcare field has experienced a remarkable meta-morphosis in recent years, primarily propelled by the swift advancements in technology. These breakthroughs have paved the way for inventive methods of dispensing medical services, particularly through remote means. Among these ground breaking innovations, the emergence of telemedicine [4] stands as a noteworthy milestone, reshaping how patients access health- care services by granting them the convenience of consulting with medical professionals without leaving their residences. While the convenience and accessibility offered by telemedicine are undeniable, they have also given rise to urgent challenges, most notably revolving around the security and integrity of sensitive medical data. With the increasing reliance on digital platforms and the transmission of confidential pa- tient information, ensuring the privacy and safeguarding of this data has become an utmost concern. To tackle these crucial concerns, the proposed solution integrates blockchain technology into remote medical consultancy. This potent fusion of telemedicine and blockchain technology holds the potential to significantly enhance the dependability and security of remote medical consultations, protecting the integrity of medical data in an era where data breaches and fraud persist as looming threats.

A. History

The remote doctor consultancy started back in the late 1900s when people first came up with the idea of telemedicine. Back then, it was mostly about trying to send medical images and information over long distances to help diagnose patients. This was like the first step toward having remote consultations and overcoming location barriers in healthcare. As technology marched on, telemedicine really started to evolve. Once video chatting and secure data transfer got better, it opened a whole new world of possibilities. Doctors could now have real face-to-face appointments with patients remotely and securely share important medical files and this let them do way more than just consultations - they could provide comprehensive care and monitoring from afar. Around the same time in 2008 blockchain exploded on the scene with Bitcoin. This introduced the concept of a distributed ledger that could securely record transactions in a transparent way [13]. So, combining telemedicine and blockchain tech could really take remote medical consultations to the next level when it comes to reliability and security.

B. Motivation

The reasons behind developing blockchain-secured remote medical consultancy apps are quite diverse. First, there's been a global surge in the demand for remote healthcare services, particularly due to the COVID-19 pandemic. This has made it crystal clear that we need telemedicine platforms that are not just convenient but also rock-solid in terms of security.

Secondly, when it comes to healthcare, patient data privacy is non-negotiable. Laws like the Health Insurance Portabil- ity and Accountability Act (HIPAA) in the United States demand to keep patient information confidential and secure. Blockchain offers a compelling solution for this because it has some nifty features – like being practically tamper-proof and not relying on a single authority to validate transactions [12].

Another major reason is healthcare fraud and data breaches. Blockchain tech has the potential to be the guardian here by adding multiple layers of security and transparency[2]. It could be the missing piece in the puzzle

for making healthcare safer and more reliable in an increasingly digital world.

C. Objectives

The main objective of this project is to develop a secure and efficient decentralised web application which allows patient to remotely consult with doctors using video conferencing. The application uses blockchain to ensure secure storage of confidential documents like prescription , bills and medical history.This application will allow seemless connection between doctors and patients.

D. Scope And Application

This web application can make sharing of medical history between the doctors and patients easy and secure. Also, it can help in tracking the prescription and doctor associated with it. Another benefit is that it can reduce the barriers to healthcare in remote areas. This helps in making healthcare accessible to everyone. The web application reduces the chances of data breach and ensures that the data of patients is secured. The scope of web application is currently limited to diseases which can be diagnosed easily without need of special equipment or physical examination. Also, video conferencing requires a threshold internet bandwidth. However, this application can be integrated with IOT devices which can monitor patient's vitals and remotely send it to doctor for diagnosis [11].

II. TERMINOLOGY

A. ReactJS

React.js is an open-source solution for developing frontend interfaces that helps developers to make web applications efficiently.

B. Smart Contract

A smart contract is a self-executing contract with the terms of the agreement between two or more parties directly written into code. It operates on a blockchain, such as Solana, and automatically enforces, verifies, or facilitates the negotiation and performance of a contract.

C. Transaction

In web3, a transaction represents a digital interaction on a blockchain, involving the exchange of data or value between participants, often secured by cryptographic signatures and recorded on a public ledger.

D. Video Conferencing

The technology that allows users who are at different locations around the world to remotely connect and communicate using realtime audio as well as video.

III. LITERATURE REVIEW

This section contains the prior research that has been done on Blockchain and File sharing.

A. Related Work

In the early 2010s, researchers began to explore the potential applications of blockchain technology in healthcare. The features of blockchain, like decentralization, security were recognized as valuable assets for improving healthcare. During the same time, the rapid growth of telemedicine platforms happened and these platforms provided remote healthcare con- sultations through video conferencing and secure messaging systems. But data security and privacy breaches were serious issue. So, in the mid-2010s, the integration of blockchain in telemedicine started. Researchers began to explore how blockchain could enhance data security and health records storage. One significant idea was that of patient-controlled health records stored on a blockchain. Patients were having full control over who could access their health data.

In order to improve the efficiency of blockchain with telemedicine, many researchers have done work. The research paper [1] proposed a system to host electronic health records on blockchain. This system provided a secure and time limited access to the EHR. This increased the security of data and documents. The system also uses zero knowledge protocol. Also, using the proposed system can securely store electronic health records (EHRs) and helps in avoiding error. The research work [3] investigated the use of blockchain to improve security of IOT based healthcare systems which can increase the privacy of user data collected from multiple sensors. Multiple researchers have provided frameworks to use blockchain for managing prescription and tracking medication histories. Researchers have investigated the use of blockchain for secure payments in telemedicine. Smart contracts can help to automate billing and payments, ensuring that the doctors receive justified and timely compensation. Some researches have proposed decentralized telemedicine networks[5]. These networks create peer-to-peer connections between patients and doctors. Some work has also been done in the area of enhancing privacy in telemedicine. Techniques like zero-knowledge proofs and secure multiparty computation are investigated to maintain confidentiality during movement of document from patient to doctor[6].

B. Challenges and Limitations

Most public blockchains like Ethereum have scalability issues, as they can become slow during peak usage, leading to high transaction time and higher fees. This issue can hinder the access of medical data and transactions affecting user experience. Also, different blockchains may not be compatible with one another and integration of current blockchain technology with healthcare applications can be complex. Another major challenge is interoperability. It is crucial to ensure that medical data is accessible and usable across different platforms, which is vital for the success of remote medical consultancy. An- other major challenge is the environmental hazard caused by minting of coins. Some blockchains, particularly those which use a proof-of-work consensus, uses a significant amount of energy[7]. This has raised environmental concerns. Thus, it is not sustainable in the long term. These applications use significant internet bandwidth so only users having a threshold internet bandwidth can make use of this technology. The blockchain technology can enhance healthcare, but it's only beneficial to those patients who have the access to devices and internet connection[10].

IV. PROPOSED ARCHITECTURE

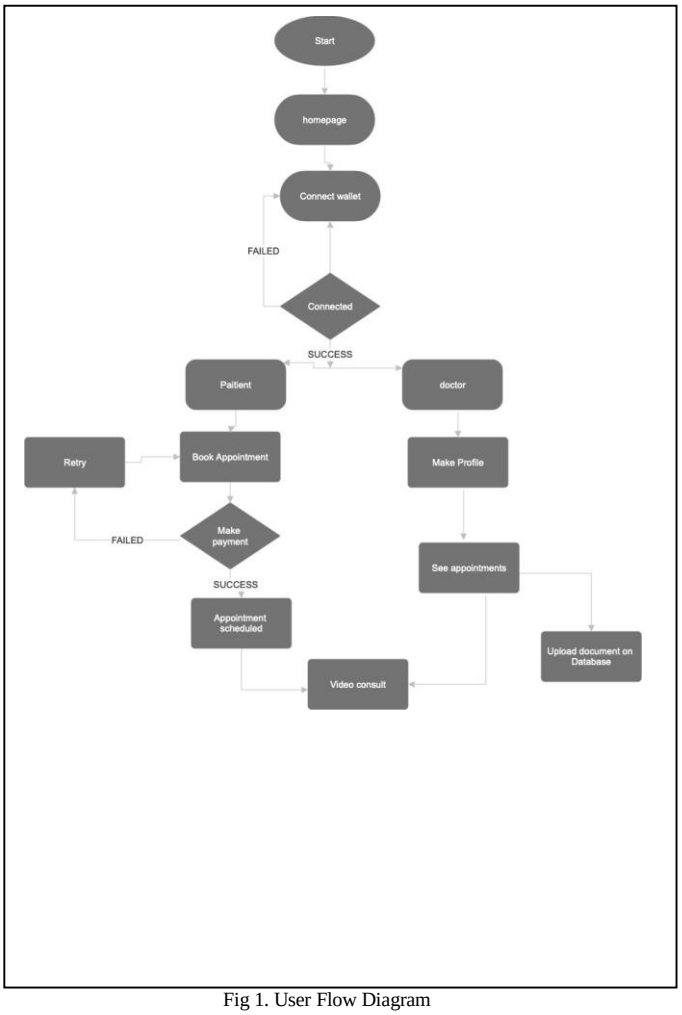

Fig 1. User Flow Diagram

Fig.1 shows the use flow diagram. This flow diagram show how user interacts with the application and what happens next after a certain action. It shows flow for both patient and doctor.

On the homepage, the user will get a option to connect a wallet. If the wallet is not connected successfully, user will not be able to book appointment or create account. After successful wallet connection, user can register as a doctor or register as a patient. If registered as a patient, user can book appointment and will have to pay the fees upfront. If payment is successful, the appointment is scheduled and video meeting room is created. If registered as a doctor, user can see upcoming appointment, manage profile and after video consultancy is done, user can upload documents like bill, prescription and other documents. History will also be available to show the details of past communications of file sharing activities.

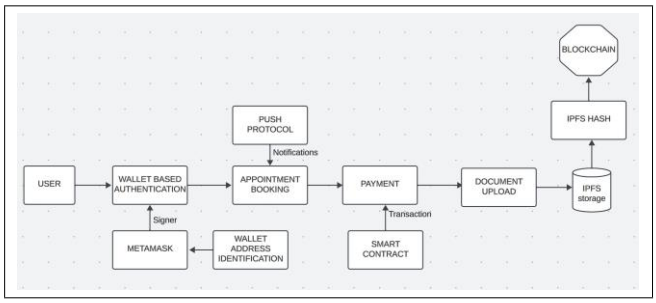

Fig. 2: Architecture Diagram

As shown in Fig. 2, the architecture allows for a seamless and secure user experience, facilitating appointment booking, transaction management, notifications, payment processing through smart contracts, and document storage. At the core of this architecture is the user and their wallet. The user's wallet address serves as a unique identifier and an authentication method. By using popular wallets like MetaMask or equivalent services, users can securely sign transactions and authenticate their identity. The system allows users to book appointments, manage transactions, receive notifications, and process pay- ments through smart contracts, ensuring transparency and trust in financial interactions. Additionally, it incorporates IPFS for document storage, guaranteeing the availability and security of medical records. In sum, this architecture creates a user-centric ecosystem, enhancing user identity verification, simplifying appointment scheduling, securing payments, and offering reliable document management, thus setting the stage for the future of digital healthcare services.

V. MODULES

A. Wallet Authenticated Access

Doctors and patient can create accounts using their cryptocurrency wallet. The authentication is done on the basis of wallet address. If address matches to actual user,then only a person is granted access.

B. Doctor Profile

Doctors have to make their profile and upload certificates and details like speciality, hourly rate, experience.This will be visible to patients.

C. Appointment Scheduling

The patients can schedule appointment with a doctor of their choice. The patients have to pay the consultancy charge upfront.

D. Video Consultation

After the appointment is scheduled, a video room link will be generated which doctor and patient can join to connect.

E. Secure Document Upload

The doctors can upload the prescription, bills and other documents, once the meeting is done and these documents are stored securely on a decentralised database.

F. Appointment History

The patients can see their previous appointments and documents associated with it. Each appointment will be shown with the wallet address of the doctor

G. Notifications

The patients and doctor will get updates about upcoming tasks in form of notification

H. Payments

The payment is done in form of cryptocurrency and it is done while booking the appointment. The respective amount is deducted from patient's wallet and transferred to doctor's wallet.

VI. IMPLEMENTATION

The proposed application combines front-end developed using React, blockchain integration with MetaMask, and smart contract developed in Solidity for secure medical consultations.

A. Frontend

The frontend implementation of the application is done using React, to provide a seamless and secure user experience. Using React, project have an intuitive user interface that allows patients to easily schedule appointments and interact with doctors. Axios client is used to communicate with the smart contract and wallet connection. This communication is used for payment and appointment scheduling processes. Through a well-structured redux store, the application's state is managed efficiently. React hooks like useState are used for state management in a single component. Using react helps us in rapid application development, thus reducing the development time. React provides large set of libraries of pre-built modules which can be easily integrated in the application

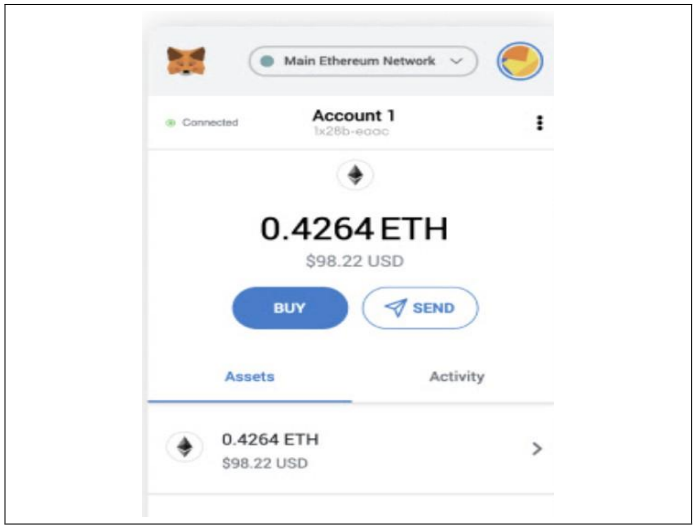

Fig. 3: MetaMask interface

B. Integration with MetaMask

Integrating Metamask into proposed application is important to ensure secure and user-friendly access to the platform. To integrate MetaMask, users have Metamask installed in their web browsers or mobile devices. It's essential for handling.

C. Backend

The backend of the application is built on a Solidity and Polybase database. This provides data security, scalability, and seamless interactions. In this architecture, Solidity, a smart contract programming language, plays a pivotal role in managing access, appointment scheduling, and payment. The backend integrates Solidity smart contracts to maintain doctor information, and appointment records securely on the blockchain. Polybase, a distributed database for decentralised application, acts as the data layer ensuring high availability of medical data. It assists in storing and retrieving encrypted information. These are the major collection in the Database:

Appointment has following attributes:

- Patient wallet address
- Doctor wallet address
- Meeting Link
- Date

Patient has following attributes:

- Patient wallet address
- Name

Doctor has following attributes:

- Doctor Wallet Address
- Name
- Speciality
- Email
- Certificate
- Cost per Hour

Additionally, the application uses push protocol to send real- time notification to doctors and patient. It is one of the most used notification system for decentralised application. For handling video conferencing, this application uses Huddle SDK, which provides pre-built solution for communication.

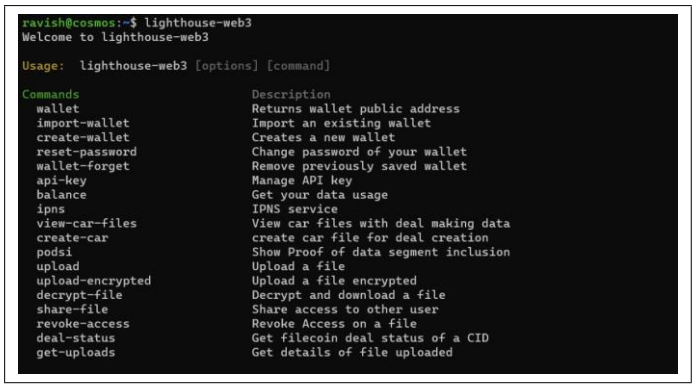

Fig. 4: Lighthouse IPFS CLI interface

The application uses decentralized file storage solution, like Inter Planetary File System (IPFS), to securely store medical records and other documents. Fig.4 shows the lighthouse IPFS storage CLI interface. IPFS is designed to be decentralized, which means that there is no central server or

authority con- trolling the data. Instead, files are distributed across a network of nodes that host and share the content. This improves data redundancy and availability. This application is using Lighthouse for IFPS storage. Lighthouse is a perpetual file storage protocol that allows you to pay once for the files and store them long-term. It is built on IPFS and File coin, with smart contracts to be deployed on multiple chains like FVM, Optimism, Polygon, Solana, etc.

VII. RESULTS

In this section, the interfaces are shown for each implemented module of the proposed application.

A. Doctor Registration Interface

Doctors can upload certificates and details like specialty, hourly rate using Fig.5 interface. The first field necessitates the entry of the doctor's full name, enabling easy identification. In the second field, doctors specify their medical specialty, a crucial detail that aids patients in selecting the right doctor according to their needs. The third field contains the CPH (Cost Per Hour), denoting the hourly consultation fee charged by the doctor. Doctors also need to upload the certificate of qualification also.

Fig. 5: Doctor registration interface

B. Appointment Scheduling Interface

The patients can schedule appointment with a doctor of their choice. Fig.6 shows the interface. The booking process is straightforward. Patients can click on the "Book Appointment" button to select suitable dates and times for their appointments, ensuring flexibility and convenience in booking. The platform is integrated with a wallet system, so while booking an ap- appointment, patients will be prompted to pay the doctor's cost per hour the user's unique identifier within the platform, allowing access to their account and enabling interaction with other users and platform features. Also, the generated token serves as the secure authentication token, granting users access to their account and verifying their identity during subsequent login attempts, further increasing the platform's security measures.

Fig. 6: Appointment booking interface

C. Payment confirmation with Wallet

The payment is done in form of cryptocurrency, and it is done while booking the appointment. The patient can confirm or cancel the payment. Fig. 7 shows the interface. It provides patients with transaction details, including the receiving wallet address (belonging to the doctor), the sending wallet address (their own), the associated gas fee, and the total payment amount due to the healthcare provider.

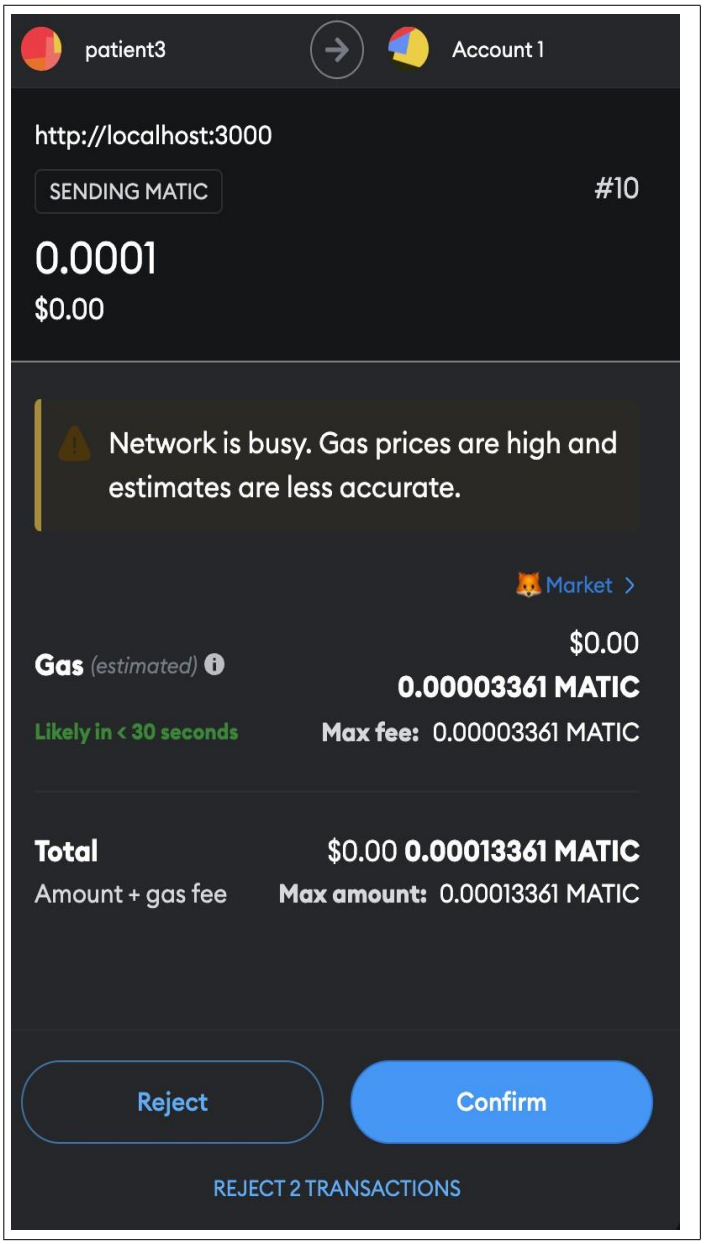

Fig. 7: Payment Interface

D. Document Upload Interface

The doctors can upload the prescription, bills, and other documents. Fig. 8 shows the interface. Patients can access their medical history in the "history" tab, providing them information about their past consultations and associated documents. This empowers patients to track their prescriptions and the doctors responsible for them.

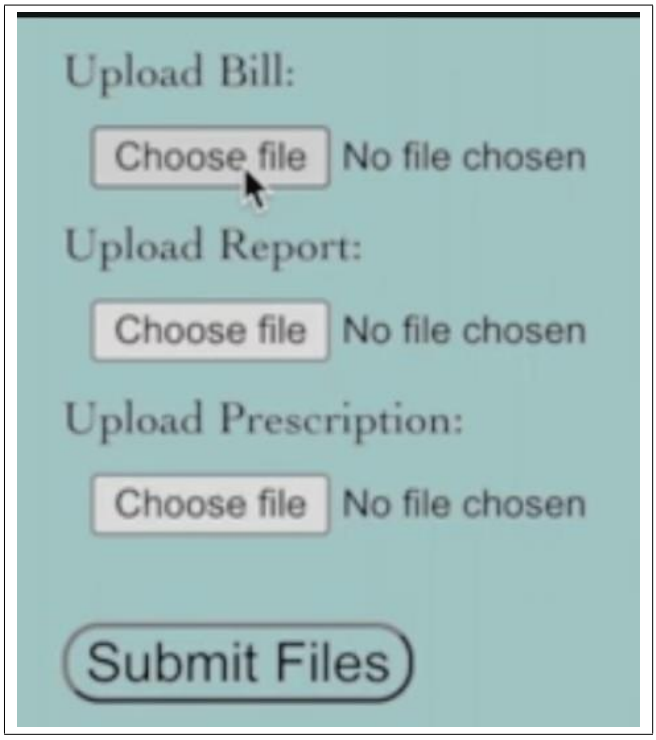

Fig. 8: Document upload interface

VIII. CONCLUSION AND FUTURE WORK

The proposed web application helps patients and doctors to connect remotely with features such as secured document upload, video conferencing and easy to use interface. The application maintains the confidentiality of documents with the help of secured decentralized database [8]. Thus, this solution makes the healthcare consultations more accessible and secure. However current solution is not suitable for diseases which involve physical examination [9]. The stored medical history will also help patients to provide correct information to doctors and increase the accuracy of diagnosis. This application can be helpful for those who cannot visit the doctor physical due to location or due to health-related issue.

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