BLOCKCHAIN BASED MEDICAL REPORTS MONITORING SYSTEM

Mohan Sai Kiran B. [b], Pawan R. Tanksali [b*], Monica Hegde[c], Pooja Rani Naik[c*] and Thippeswamy M. N. [a]

[a,b,c] *Department of CSE, NMIT, Yelahanka, Bangalore-560064;*

Email:{thippeswamy.mn@nmit.ac.in, kiranms20@gmail.com, pawantanksali@gmail.com, monicarhegde@gmail.com,ranip2780@gmail.com}

Abstract

Medicinal services frameworks have consistently been bolstered by fresher innovations to improve the client's connection with the whole well being framework. Despite the fact that numerous operational difficulties despite everything stay, specifically to those identified with a unified board of Electronic Health Records (EHR) that could empower different specialists to approach the total wellbeing history of their patient. Blockchain could bolster unified records, information security and improved protection, making it a powerful answer for the previously mentioned social insurance innovation challenges. The proposed idea achieves giving monopoly to the user over the data, giving them the power to share their most comprehensive version of health records, with every organisation in their medical network. After the verification of this data, a unique block is created, stored in the existing block chain and the data is encrypted to avoid misuse. Further the patient can only view the medical records and cannot tamper or modify with the data in the records. If there is any other authority diagnosing the patient, the patient could grant access to this authority. Thus, one can completely rule out the part of mediator for sending agreements and the Patients will have complete command over their medical information.

Keywords: Blockchain, Electronic Health Records (EHR), Data Security.

1. INTRODUCTION

These days the general healthcare frameworks are attempting to convey central general healthcare administrations, for example, inoculations, syndromic and ailment observation. Frequently the frameworks are consistently on the verge of breakdown which was inferable from the high costs, enormous scope measurements and rare assets. Be that as it may, the interest is consistently more noteworthy than the qualities that one gets from government managed savings and private plans. In this way, there emerges an approaching need to construct framework healthcare versatility in light of the ever-developing number of huge stressors and final proposals to general wellbeing and social solidness in the coming years. As far as medical or healthcare industries are concerned, the confidentiality and uprightness of medical information or health records must be secured not just from hackers but also from unauthorized individuals inside the network, such as hospital staff, social insurance companies, or cloud specialists.Various breaches can occur, such as spillage of information or alteration of data by both external and internal individuals, and it can be intentional and unexpected. Therefore Blockchain can be a smart option for medical and safety records by any way.

Blockchain is clearly a data structure introduced by Satoshi Nakamoto with Bitcoin in 2008 which provides unchangeable and irremovable transactions through the creation of a digital ledger. Blockchain is a peer-to-peer platform for exchanging and computing distributed data. Blockchain enables various transactions within the network to be carried out by unknown parties[1]. Blockchain is a type of data system capable of monitoring and storing information from the vast number of devices without any central cloud. Blockchain is a distributed ledger that is tamper-proof and holds the through collection of data records. There is no single path, and there is no master machine. Public key cryptography is used to conduct transactions between nodes in the technology. Then, the transactions are stored on a shared ledger. The ledger contained a chain of blocks that are related cryptographically to each other. Blocks of data that were once registered on the blockchain ledger can not be updated or erased.[2].

The InterPlanetary File System (IPFS) is a convention and distributed system for putting away and sharing information in a distributed file system. IPFS utilizes content-tending to characterize each document in a worldwide namespace that interfaces all processing gadgets with a particular goal in mind. IPFS empowers clients to get content, just as host content, in a way like BitTorrent. As opposed to a halfway found server, IPFS is planned around a decentralized client administrator framework which holds a part of the general information, giving a versatile record stockpiling and sharing system[3]. Any system client can get to a document by their account address, and other system peers can find and solicit the substance from any hub since it utilizes a Distributed Hash Table (DHT).

1.1 OBJECTIVES

The objectives of the undertaken research study presented in this dissertation are:

- Implementation of the blockchain network where each node comprises the medical reports of the patient. The blockchain network is to be implemented along with cryptographic hash.
- Transmission of the records to the patient using encryption. Encryption is involved which makes the network more secure and robust.

- Granting access to the doctor for accessing the reports of the patient. Access must be given to the doctor so that they can access the records and carry out medical diagnosis.
- Creation of a suitable user interface for doctors to monitor the reports. A user interface is to be provided which would be user friendly and various operations can be carried out without any hassle.
- Link creation and transmission for secure and timely access of the reports. A link is to be created and secure transmission is to be carried out and timely access must also be imposed.

1.2 NOVEL CAUSE

To Implement a program to monitor the patient's health records in the healthcare domain. The information and records of patients are stored as blocks in blockchain. The patient should monitor his / her data access. The problem statement is to create a blockchain based program. The doctor reviews the data and if additional records need to be added the doctor puts those records in the blockchain network . Post verification a block is created which is further added to the blockchain network and a cryptographic hash is also used which provides security and privacy.

We propose a solution using Blockchain for the implementation of our project. The patient data would be sent to a web application where the details of the patient like Name, Blood group, Address etc. would be taken and then sent to the doctor. The doctor after diagnosing the patient would upload the reports and corresponding prescription of the patient as a block. This block would have a unique Hash Address which would identify the patient without disclosing any personal information. The doctors if needed to access the patient's records need the patient's authorization. The patient would then authorize the hospital/doctor and further they can access the records of the patient. The key advantages include:

1. Understanding can be reached without the involvement of a mediator; along these lines, keeping away from a performance bottleneck and a solitary purpose of disappointment.
2. Patients have authority over their information.
3. Clinical history as a blockchain information is reliable, opportune, precise, and effortlessly dispersed.
4. Changes to the blockchain are obvious to all individuals from the patient system, and all information additions are unchanging. Likewise, any unapproved changes can be easily distinguished.

The paper further discusses the Literature Survey which provides information regarding Related work, Existing systems and Applications from different research papers which is elicited in Section 2. The detailed Design of the system which briefly explains about the architecture of the system is provided in Section 3. The glimpse of the implementation of our project has been discussed in Section 4. Detailed description and snapshots of various functionalities is presented in Section 5. The conclusion derived from this research is presented in Section 6.

2. LITERATURE SURVEY

General medicinal services records are as of now attempting to convey central well being administrations like inoculations, syndromic and illness observation, maternal and youngster well being. A few of those frameworks have circumscribed the breakdown because of high costs, huge scope measurements, and regularly rare assets. Medicinal service information is extremely important for any patient and they would not need their information to be seen by some other individual without their approval. The information which is leaked is incorporated and in this way a solitary assault could be perilous. As indicated by the examination in [4] medicinal service information keeps on being a rewarding objective for information penetration, it makes patients be presented to financial dangers as well as could be expected social disgrace and mental anguish.

The security and integrity of medicinal services information must be shielded from outer assailants, yet in addition from unapproved get to endeavors from inside the network. The assaults or spillage of information can be purposeful or inadvertent, and associations might be punished or held criminally at risk. The Internet of Things accelerates the hazard with new wearable gadgets and different wellsprings of getting wellbeing information. From the exploration in [2] the inescapability of keen gadgets has likewise brought about a change in outlook inside the healthcare industry. Such gadgets can be client possessed or introduced by the medicinal services supplier to gauge the prosperity of the patients and encourage observing of patients.

Electronic medical records (EMRs) are essential sensitive non-open information for assignment and treatment, that must be generally disseminated and pooled among peers like guide providers, protection firms, drug stores, analysts, patient's families. This represents a genuine test in keeping up a patient's case history exceptional. A patient, distressed with a huge ailment like malignant growth, or HIV, must support an all-inclusive history of the treatment methodology and post treatment restoration and recognition[5].

2.1 RELATED WORK

This work depends on giving security and protection through cryptography based access control to store information in a decentralized and distributed storage and utilizing encryption. Blockchain Technology is the propelled information innovation in the clinical division that requires secure information sharing among associated parties inside the system. The work factors have impacts on electronic case history Blockchain innovation appropriation. On-line structure was improved by taking from writing with execution point of view, trust, and hazard thoughts. On-line overview sent to patients and clinical workforce. The input respondents were 149. The examination results indicated that the principal significant issue of acceptance is completing execution desire which fuses the notoriety of innovative edges and relative endowments. Trust issues affect acknowledgement and generally positive effect on the Blockchain technology[6].

Numerous creators investigated blockchain innovation and found that they have a hypothetical methodology, we will in general use it somehow or another to upgrade quality and security in EHRs abuse. We will in general have discovered various references examining genuine executions of EHRs over blockchain since blockchain could be a similarly new innovative turn of events. Cyph MD oversaw by an Australian startup utilized Ethereum for advancement. We were unable to see more insights about to assume that it's inside the awfully beginning phase of development[9]. Ehtereum offers a standard ledger and allows secure key administration and check tasks of Gem OS area unit offer chains and EHRs. Ethereum is an approval-of-idea that uses blockchain as moderate to the health data. The encapsulation known as MedRec, brings clinical research and help partners to the "mine" inside the circle and, as an endowment for information mining, it produces access to aggregate healthcare data. The creators express that a property and guaranteeing shared system is structured basically by providing huge data, in order to engage analysts where patients and suppliers[7].

2.2 EXISTING SYSTEM

Blockchain innovation is being utilized to redesign the shared trade of fundamental research and valuable healthcare information, thus empowering key partners, for example, clinical scientists, specialists, drug specialists, and other medicinal services suppliers to increase secure, quicker, rearranged and dependable access to electronic clinical data. The business as of now has a comparative stage called the wellbeing data trade. In the current system of monitoring medical records, We have a Blockchain implementation or a simple cloud storage that is accessible by everyone. The cloud is centralized and any attack by a hacker would result in the loss of all the data stored in the cloud and the patient's data is at risk. Also the records of the patient are maintained in a storage and the patient has no rights or authorization over his records. Figure 1 depicts the centralized cloud based EHR system[8].

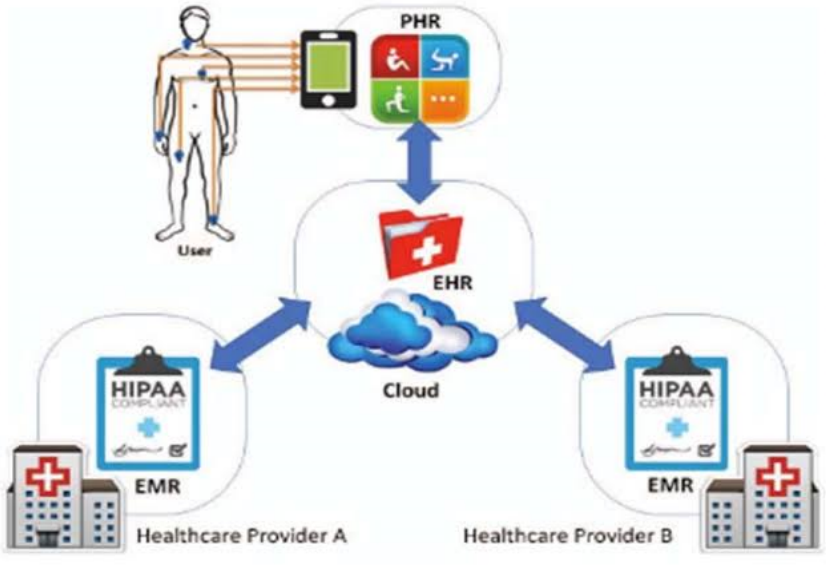


Figure 1: A conceptual centralized cloud based EHR system

2.3 APPLICATIONS

1. Blockchain in Electronic Health Records (EHR): A computerized EHR on a conveyed record of an authorized blockchain is kept straightforward, from the information age stage to the information recovery level, without human mediation.
2. Clinical Research: Blockchain gives a decentralized, ensured framework regarding clinical research for any information research that may happen. With this, information can be traded securely with study groups[9].
3. Identification of clinical extortion: Blockchain, which has the attribute of being lasting, helps in identifying misrepresentation by not empowering any replication or change in the exchange, and eventually takes into consideration a straightforward and stable exchange.
4. Neuroscience Research: Blockchain brings numerous future applications that consolidate mind growth, cerebrum reenactment and mind learning. Plainly, digitizing an entire human mind needs some medium to store it in, and it is here that inventiveness in the blockchain raises its head.
5. Pharmaceutical Industry and Research: Blockchain watches out for each progression of the pharmaceutical flexibility chain, utilizing its capacity of exact following, the birthplace of the medication, its segments and possession are normally recognized at each point to obstruct the manufacturing/taking of products[10].

3. SYSTEM DESIGN

3.1 ARCHITECTURE DIAGRAM

Figure 2 shows the software and hardware components, their respective interfaces and interaction among them. The user interface is used for the registration of patients and doctors. It depicts a brief outline of how the patient, doctor are connected to Blockchain and to the user interface. There are basically five parts namely blockchain, user interface, patient, hospital management and doctors in a hospital. Doctors and patients register themselves in user interface (admin). Their personal details will be added as a block in the blockchain network. Patients can consult doctors, grant access, view reports and register which is denoted by five outgoing arrows from the patient. Doctors can register, add reports to blockchain and send patient details to hospital management. Hospital management has to request access and patients have to grant access.

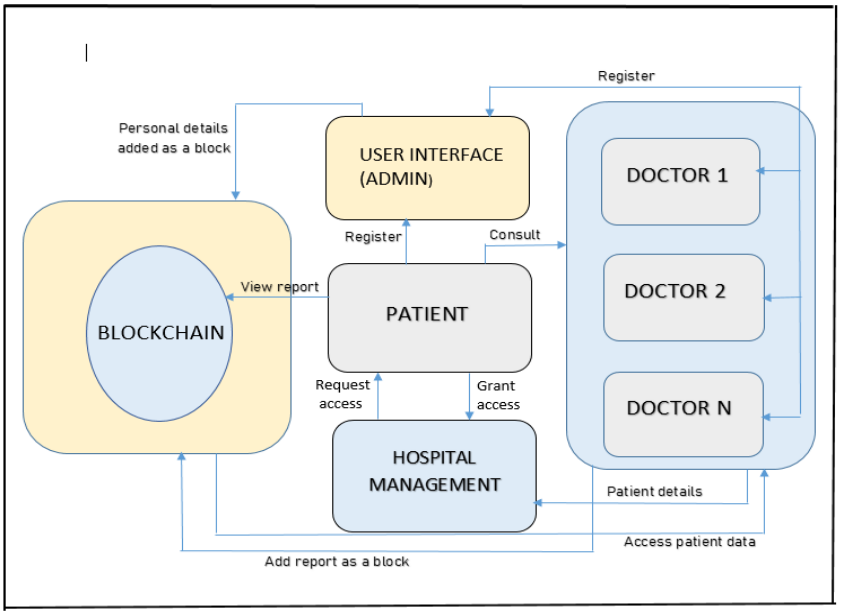


Figure 2: Architecture Diagram

3.2 SEQUENCE DIAGRAM

Figure 3 shows the role of patient and doctor (associated to User interface, Blockchain) concerned with their sequence of messages. Patients and doctors are represented as actors. As we can see, initially the patient and doctor register and login into the application created by admin which is represented by Register,Login. After the patient and doctor registers their details from AdminUI will be added as a block in the blockchain. Requests for appointment are sent by the patient to the doctor represented by request_Appointment, the

dotted line shows the reply of the doctor to the patient for accepting the appointment given as confirm_Appointment. Further, the doctor generates a report of the patient and adds it to the Blockchain which is represented by upload_patient_report. For viewing the report, he again needs to have the access to report permission from the patient. The requesting access is shown as access_report_request. The dotted line from patient to doctor represents the receipt of granting the request. Then the doctor can view reports from blockchain.Also patient details are shared to Hospital management by the doctor represented as an arrow which is labelled as patient details, which can access the report from Blockchain only when the patient grants permission. The hospital management accesses the patient's report and the interaction is represented by access_report_request. The patient in turn grants request which is represented as request_granted.

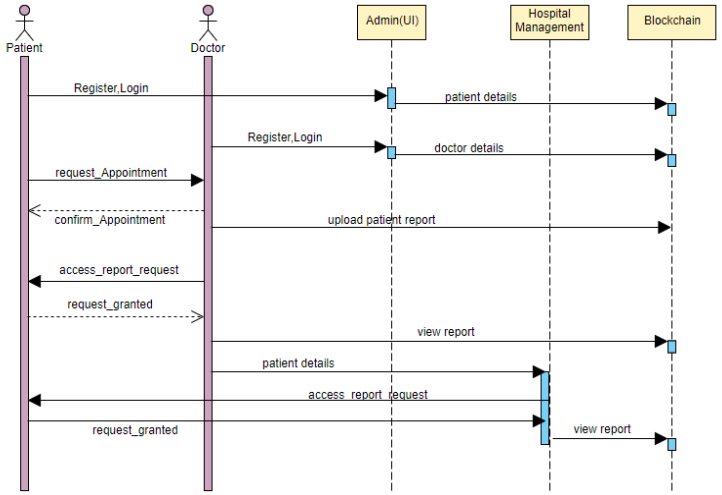


Figure 3: Sequence Diagram

3.3 CLASS DIAGRAM

The Figure 4 shows the entities, their attributes and relationship between the entities. Here as we can see (patient, admin) and (doctor, admin) show many to many relationships between them which is represented by double lines. This shows all the patients, doctors can separately register and login to the application. The functions of a patient i.e login() is used for a patient to login into the application, make_appointments() is used to request an appointment to a specific doctor, grant_access() is to grant permission to the doctor to view his/her report from Blockchain. Admin has the function verify_doctor() to verify the doctor to approve him joining the application. Doctor has accept_appointment to accept the appointment requested by patient, send_report() is used once the report is generated to send the report to Blockchain, send_pdetails() to send patient details to hospital management. Patients provide access grant permission to doctor and hospital management to view the report from Blockchain.

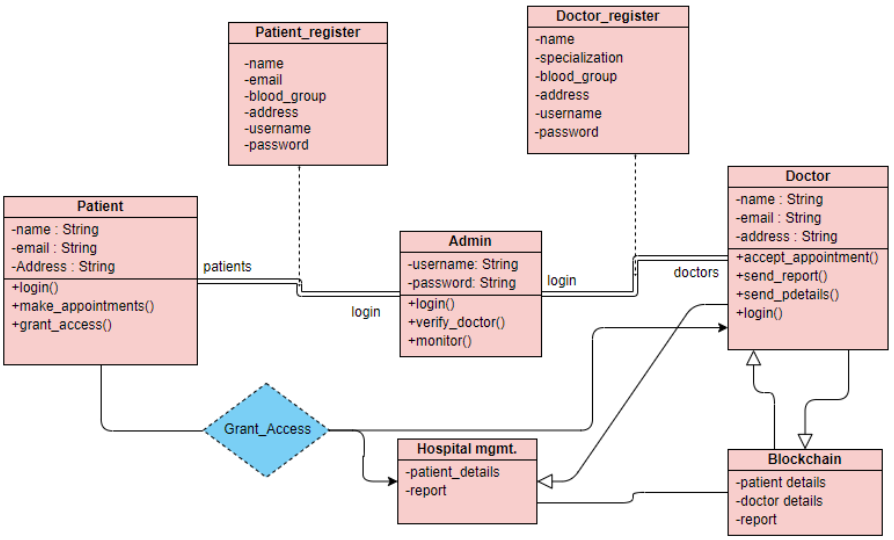


Figure 4: Class Diagram

3.4 DATA FLOW DIAGRAM

The Figure 5 shows the flow of data among various processes and systems. The entities are represented by the rectangular box (patient, doctor, Blockchain, Admin, Hospital management) and the processes by rectangular curved edge box. Here the processes are Register for patient and doctor to register into the application. Login process to login into the application. Request_access is used by doctor and hospital management requesting the patient to view his/her report in Blockchain. Grant_access process shows the patient grants the permission to view the report. Admin verifies doctor details and adds doctor details to Blockchain. Hence the flow of information is depicted.

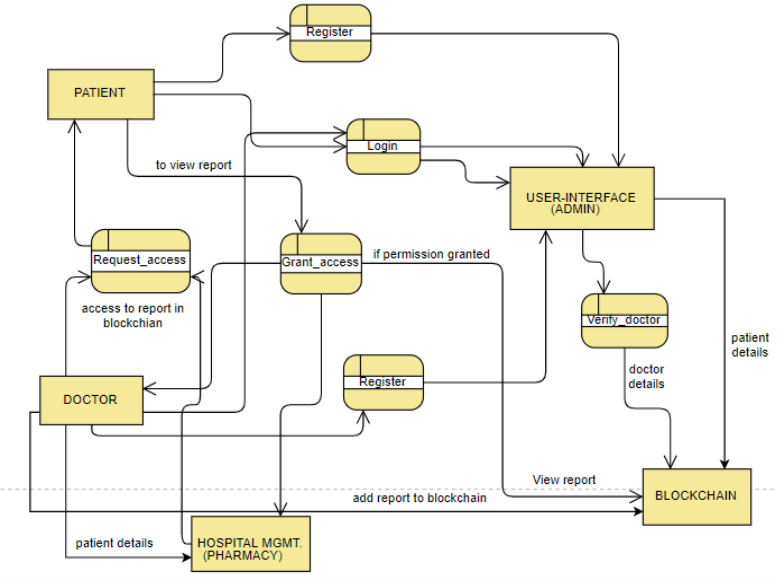


Figure 5: Data Flow Diagram

3.5 USE CASE DIAGRAM

The Figure 6 shows the interaction among users, mostly shows the dynamic behaviour i.e. how the system behaves when it is running. Here the actors are patient, doctor and Blockchain (external). The use cases are denoted by oval shape. The system shown in the figure is User Interface. It shows the patient and doctor register to the application, then the request for appointment is sent by patient to the doctor which is further approved by doctor. Doctor tests the patient and generates a report which he adds to the Blockchain. If a doctor has to view the report from Blockchain, he must request access from the patient.

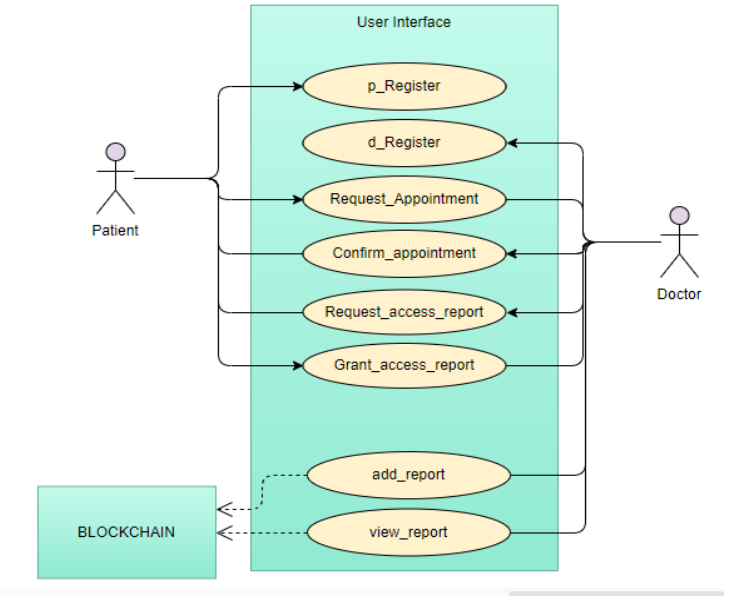


Figure 6: Use case Diagram

4. IMPLEMENTATION

Blockchain innovation is a compelling method to give security to the clinical records where it is otherwise called circulated record innovation, where it requires no outsider to sort out, keep up, oversee information in the records. The execution is done in the following way:

1. Installation of ganache, ethereum, metamask, react

Ethereum is a decentralized software platform which encompasses various functionalities such as smart contract and distributed applications with the benefit of service without any hurdles like downtime, error, fraud or third party interference. It is a simple computer code which allows the users to write the operations to be performed and identification of errors as well. It can be installed with a windows/mac version and geth is installed which serves as a multipurpose command line tool which gives a feeling of ethereum node in blockchain. Ganache is a tool for quick testing of blockchain on a local machine. Ganache CLI is a tool which is used to install and work with ganache which enables working with blockchain and is a part of Truffle suite[11]. Metamask is a browser extension that permits you to utilize browsers like Chrome and Firefox to run disseminated applications without running a full Ethereum hub. React is a Javascript library which is utilized for working with and planning front end applications for portable and sites. Create-React application is the official instrument that encourages you to make React ventures without managing complex setups.

2. Webpage

A login page is displayed to the user with options for login and password. Depending on their suitable roles whether the user is a doctor, patient, management staff or pharmacy staff logins to the portal with correct credentials. If the user is a new user, then the user proceeds to register himself/herself on to the website with all the mandatory details filled. Doctors have to fill all the details as well as upload the certificates which will be used by the admin for audit purposes. Similarly the patient registers himself/herself on to the portal with suitable details. Upon registering as a doctor it is the role of the admin to properly validate the doctor by verifying the certificates uploaded and giving consent to the doctor to give services to the patient. Admin has the important role to authenticate and give access to only trusted individuals. Doctors upon login after successful registration will go to the dashboard with the tabs giving information about the doctor, requesting access to the patient's report, approving appointment of patients, uploading reports as well as uploading prescriptions after consultation. Patients upon login will be able to see the account details, book appointments with doctors, view reports, grant access to doctors to access reports and grant access to pharmacists for prescription. Here the patient is given the monopoly of granting access to the access of reports and prescriptions and admin acts a mediator for authenticating and authorizing people.

3. Block creation

Patient and doctor details are added to the blockchain as distinguished blocks. When a user registers to the website an ethereum account is created. The user needs to import the ethereum account in the Metamask extension of the Chrome browser using the private key generated. For each and every registration and other operations a blockchain transaction is created costing a few ethers to the user. As blockchain ensures the security of the data, the medical reports and prescriptions of the patient are stored in the blockchain as different blocks with hash addresses. If a user wants to access the medical records of a user then the access to the blockchain and the file is given by the user.

5. RESULTS

1. A user either a doctor or a patient registers himself to the system through the signup page.
2. Once the doctor registers the request is sent to the administrator for the verification where the admin verifies the genuineness of the doctor scrutinizing the certificates uploaded by him.
3. Once a doctor is verified, he can login to the system through the common login page which takes him to a doctor dashboard which provides functionalities approving appointments, requesting access to the patient records and uploading the patient reports and prescriptions.
4. After uploading reports and prescriptions a hash for the file is created which will be stored in the blockchain.
5. When a patient registers to a system and logins, he is redirected to the patient dashboard which provides different options for booking appointments with a particular doctor, viewing his reports uploaded by the doctor which cannot be modified and granting access to his medical records.
6. If a patient gives access to his records then the requested user will be able to access the records.
7. Another role has been created for the hospital management and pharmacy which allows to search for a particular patient for his details and to request access to the prescriptions of the patient.

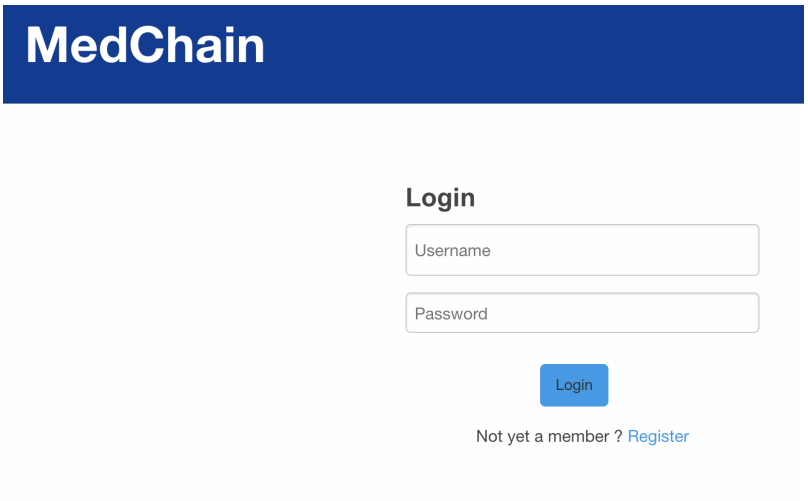


Figure 7: Shows the common login page for all the users where the users can enter their credentials and will be redirected respectively. If there's a new user then the Register button would navigate the user to the Sign up page.If the login credentials are wrong or if the doctor is not yet verified an appropriate alert is shown to the user.

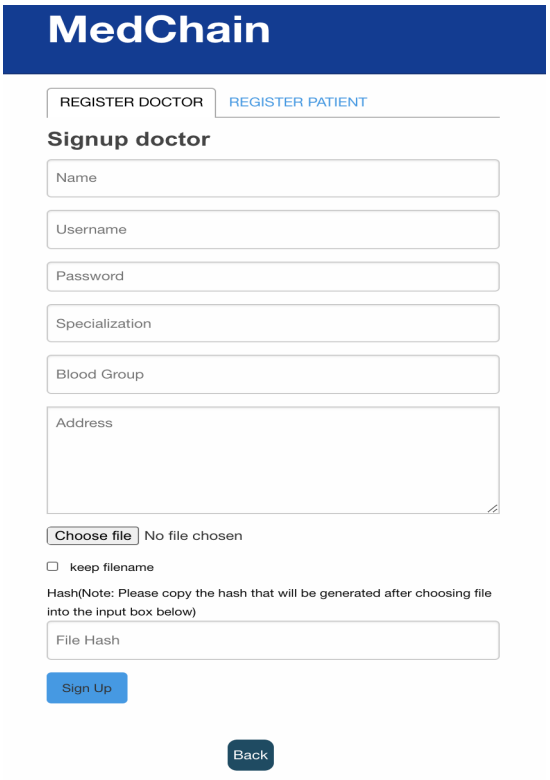


Figure 8: Demonstrates the registration of the doctor which will be sent to the administrator for the verification.

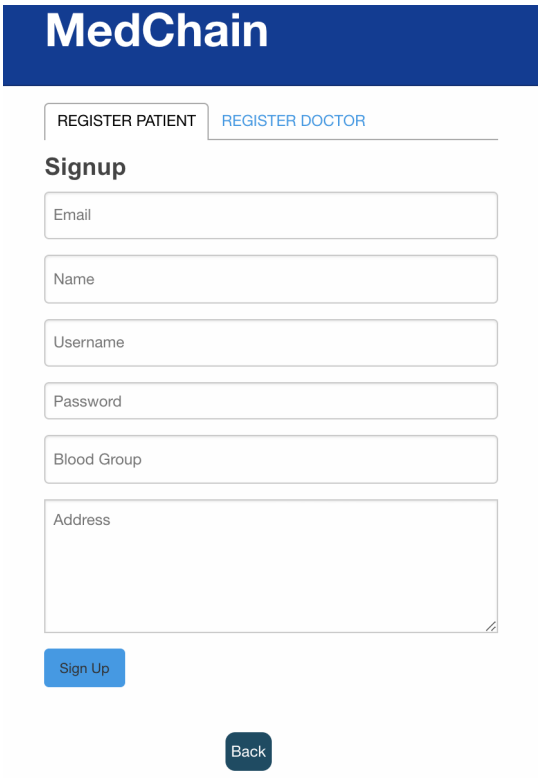


Figure 9: Showcases the registration of the patient which will be added as a new patient block in the blockchain.

MedChain

Logout

Doctor ID	Name	Username	Password	Specialization	Address	Blood Group	File Hash	Approval
113	Monica	monicarh	1234	pathology	Bangalore	A	Qmf1MQvnuXXuRNLhG1NWZQEDMQX1ixnWDJ99JWrAG6mL8b	YES NO
114	Bob	bob12	1234	Ortho	Bangalore	A	Qmf81qcUGpH3TBAG2rNaFX5Yoi4Zh9Nog2jT3WqbnAGD2V	YES NO

Figure 10: Shows the dashboard of the admin to verify the doctor where details of all the registered doctors in the network would be shown and the admin after verifying these details would either approve the doctor or not. When admin clicks on No, the doctor is not verified and cannot login onto the webpage.

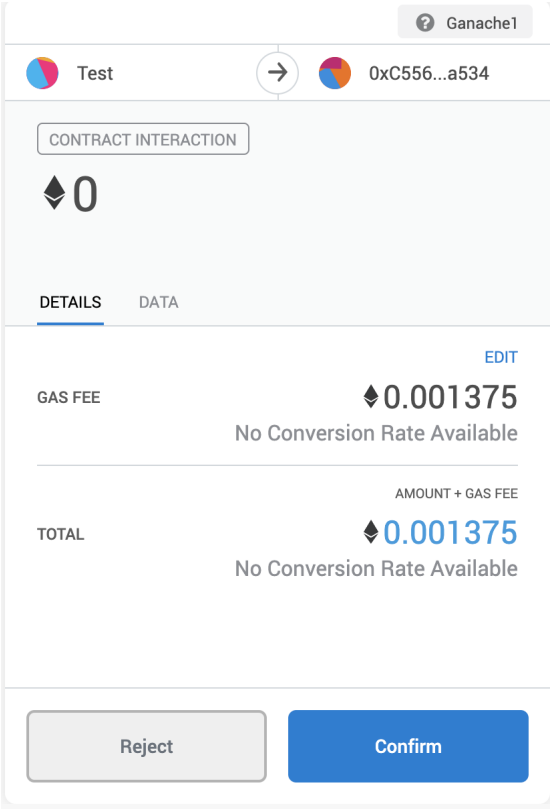


Figure 11: Blockchain operations are approved through pop-up notifications from Metamask and upon clicking confirm a blockchain transaction is generated where Gas is transferred as ether and this entire transaction is recorded in the Ethereum Blockchain. On clicking the reject button the transaction fails and the data is not transferred or stored in blockchain.

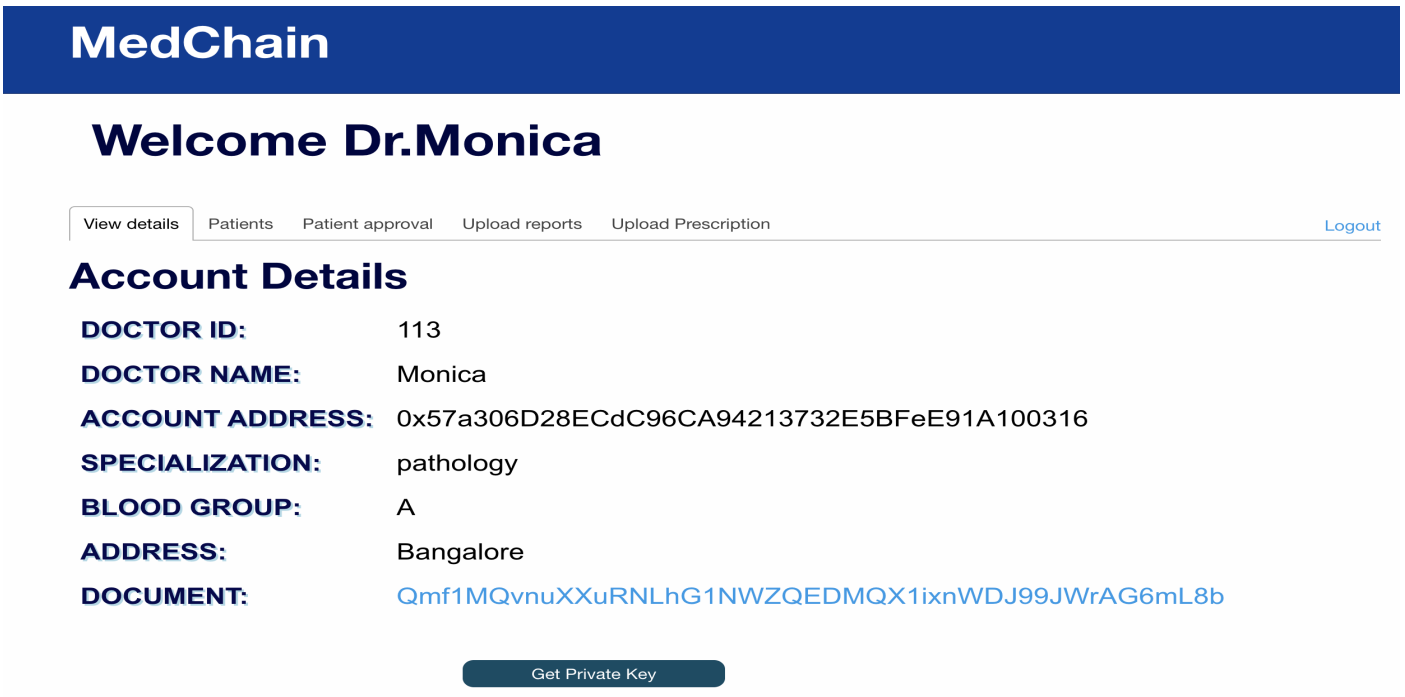


Figure 12: Shows the dashboard of the doctor which has separate tabs for viewing basic details and also a button to get the private key, gives the list of patients diagnosed by the doctor, the appointment approval requests and tabs to upload the patient's reports and prescriptions on to the blockchain network.

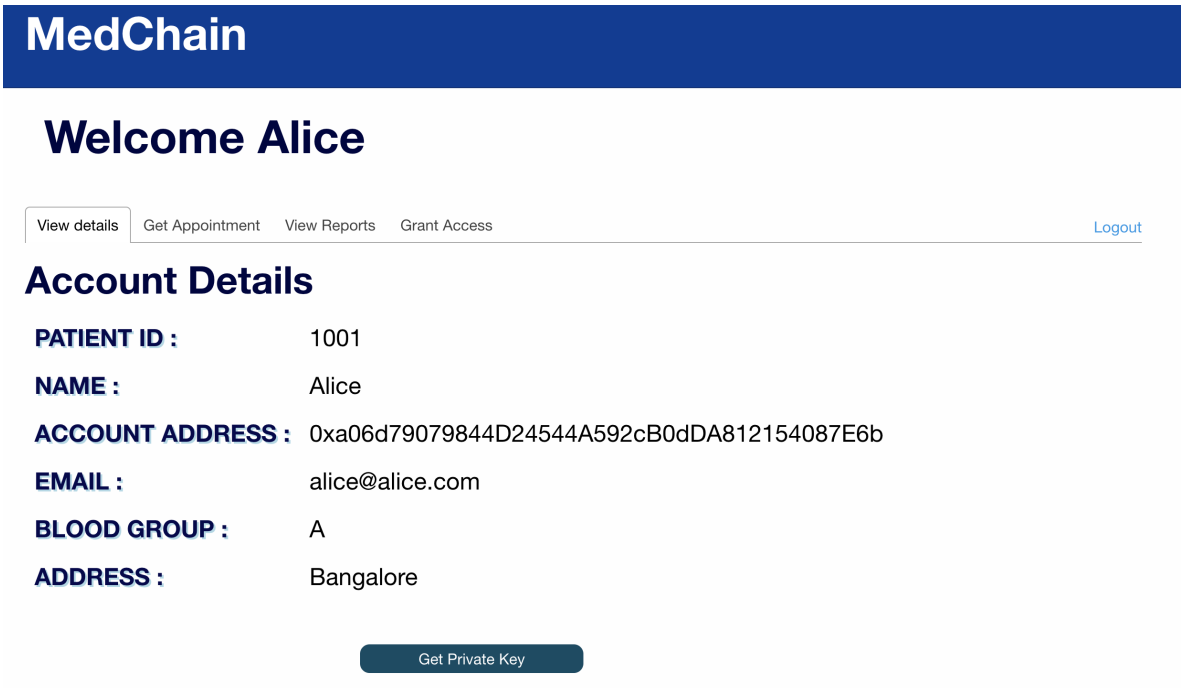
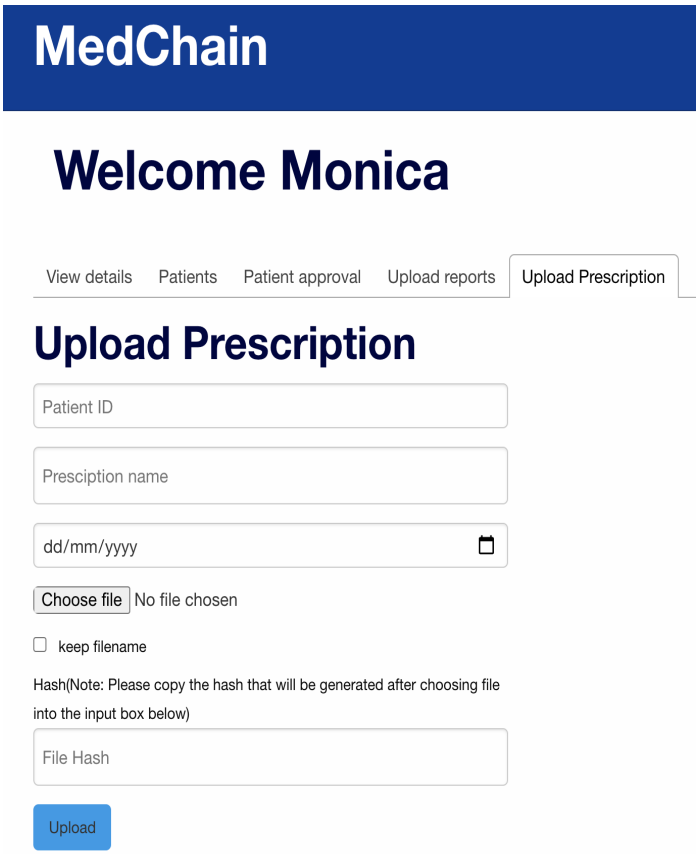


Figure 13: Provides the dashboard for the patient where he can get appointments with a desired doctor, view reports uploaded by the doctor and grant the access to his records. The basic details of the patient are shown along with a button to get the private key, The view reports tab helps to showcase all the uploaded reports based on the patient ID and Grant access tab helps to approve the file requests.



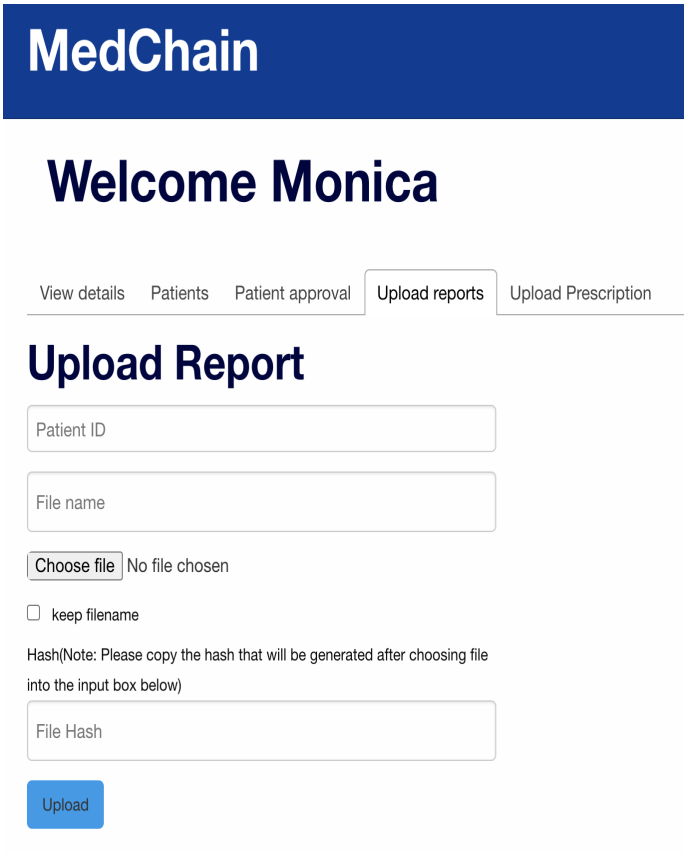


Figure 14 and 15 Shows the option to upload prescriptions and reports of the patient respectively based on the patient ID and also giving an encrypted Hash to safeguard the file using IPFS along with a file name for identification.

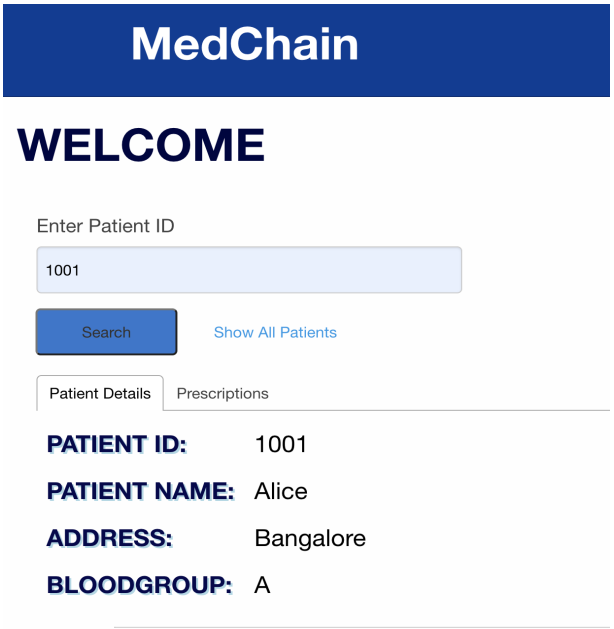


Figure 16: Demonstrates the option for hospital to access patient details by a input box and also an option to fetch all patient details.

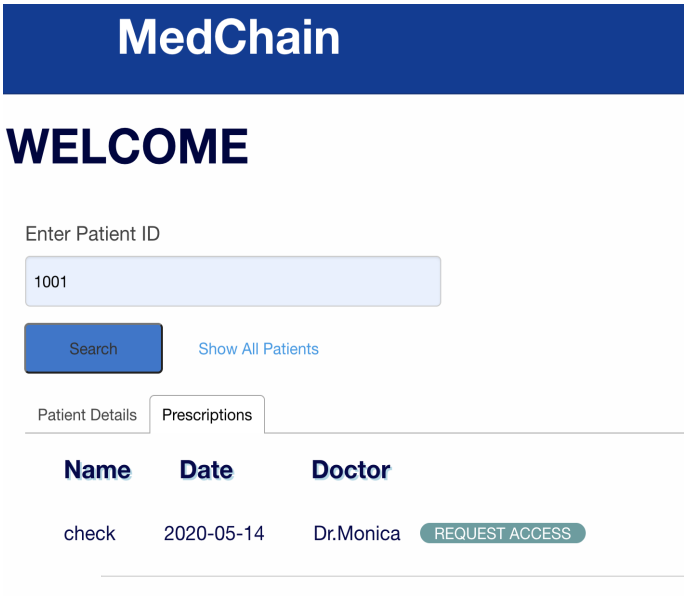


Figure 17: The image shows the prescription tab of a Patient where the management can Request access for the prescription of the patient.

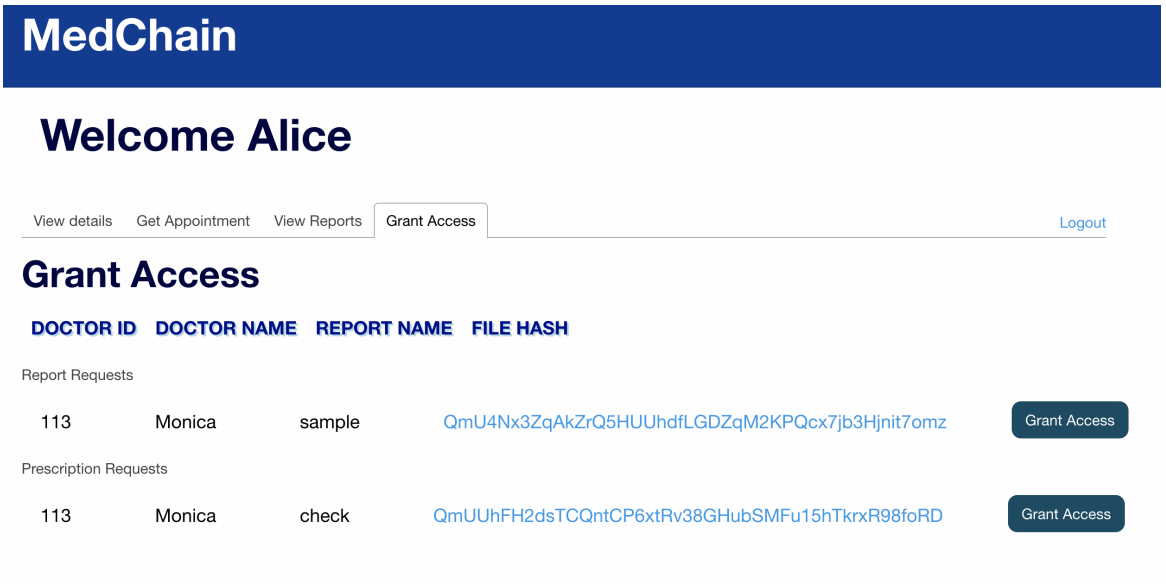


Figure 18: Showcases the part of the patient dashboard which allows him to grant access to his medical records based on the requests made by either the doctor or the management. The doctor would request for the reports and the management for the prescriptions of the patient. The patient would get an alert when he logins to the system if he has incoming file requests.

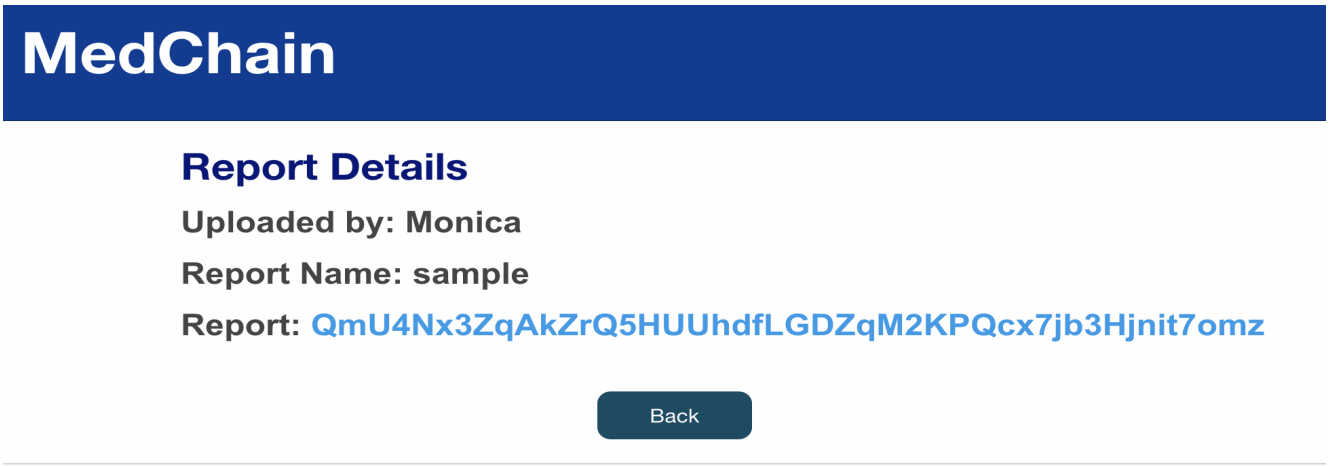


Figure 19: Shows the report details along with the hash of the file once the request is granted by the patient. The report details show the report name, uploaded by and also the main hash which on click would open a new tab of the report and could be downloaded from there. On clicking the back button the status of the files would again go back to initial state and if the doctor/management required to view the reports they need to request access from the patient.

6. CONCLUSION

Traditional healthcare systems have a lot of drawbacks being the main concern as data management. The records of patients are stored in different clinics and hospitals, there isn't a proper system to maintain the data and further perform analysis and analytics on it which could also be useful to track various diseases and also invent new drugs. The data is confined to the hospital, and hence the patient is not able to track his medical history. Blockchain based healthcare systems provide extreme security to data and also makes access to data easier. The system hence gives the control of medical records to the patient itself. Hence allowing the patient to monitor and control his medical history. Thus, the system designed allows a medium for the doctors and patients to connect and the Blockchain allows the sharing, accessing and storing of the medical records of patients which minimizes the privacy related concerns of patients. The system prevents any kind of theft by giving access to the records of patients stored in Blockchain to doctors or any entity only on patient's consent. Since Blockchain is one of the most emerging technologies known for its security and accessibility, it must be utilized in fields of healthcare to generate a patient-centered system.

7. REFERENCES

[1]. Mettler, M. (2016, September). Blockchain technology in healthcare: The revolution starts here. In *2016 IEEE 18th international conference on e-health networking, applications and services (Healthcom)* (pp. 1-3). IEEE

[2]. Lori Cameron, " Keeping your Medical Records Safe In cloud: Researchers Analyze Blockchain as solution"

[3]. B. Narendra Kumar Rao, B. Bhaskar Kumar Rao and Vellingiri J, "Blockchain Based Implementation of Electronic Medical Health Record", IJITEE Journal, vol.8, issue.8, June 2019

[4].Patel, V. (2019). A framework for secure and decentralized sharing of medical imaging data via blockchain consensus. *Health informatics journal*, *25*(4), 1398-1411.

[5]. Laplante, P. A., Kassab, M., Laplante, N. L., & Voas, J. M. (2017). Building caring healthcare systems in the Internet of Things. *IEEE systems journal*, *12*(3), 3030-3037.

[6]. Griggs, K. N., Ossipova, O., Kohlios, C. P., Baccarini, A. N., Howson, E. A., & Hayajneh, T. (2018). Healthcare blockchain system using smart contracts for secure automated remote patient monitoring. *Journal of medical systems*, *42*(7), 130.

[7]. Chen, Y., Ding, S., Xu, Z., Zheng, H., & Yang, S. (2019). Blockchain-based medical records secure storage and medical service framework. *Journal of medical systems*, *43*(1), 5.

[8].Kassab, M., DeFranco, J., Malas, T., Neto, V. V. G., & Destefanis, G. (2019, May). Blockchain: a panacea for electronic health records?. In *2019 IEEE/ACM 1st International Workshop on Software Engineering for Healthcare (SEH)* (pp. 21-24). IEEE.

[9]. Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2018). Open and Big Data (OBD). In *International Conference on, IEEE* (pp. 25-30).

[10].Radanović, I., & Likić, R. (2018). Opportunities for use of blockchain technology in medicine. *Applied health economics and health policy*, *16*(5), 583-590.

[11]. Ritesh Modi Solidity Programming Essentials: A beginner's guide to build smart contracts for Ethereum and blockchain.