Ethereum Blockchain, AI, and Cloud Storage for Medical Reports

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Abstract- This study explores the application of blockchain technology in developing a secure medical record sharing system for managing health data stored in the cloud. The aim of this paper is to collect, secure, and enable sharing of medical records using the Ethereum blockchain, ensuring confidentiality and integrity while enabling efficient exchange of medical information among healthcare professionals through patient-specific medical profiles. The paper discusses the unique features of e-health and reviews the integration of Artificial Intelligence (AI), cloud computing and blockchain technologies to enhance security in digital health. The synergistic relationship between these technologies is examined, highlighting their combined potential for smarter and more secure applications. The project utilized MetaMask, a digital wallet, to purchase and connect to the Ethereum blockchain for securing the health report links and cloud storage to store the reports themselves. Moreover, Recurrent Neural Network (RNN) and Long-Short Term Memory (LSTM) models were used to predict Ethereum blockchain transaction prices which provide insight to the user on potential impacts of the system and market trends. The results show that the implementation of the technologies is effective in healthcare data management where there is enhancement in decision making and security issues.

Keywords: IoT, AI, Machine Learning, Cloud Computing

1 Introduction

The healthcare industry is ever evolving and growing rapidly, with a relevant increase in the amount of data being generated [1]. Patient medical information such as nuclear magnetic resonance image, prescriptions and pathological results are private data and contain all the information of a certain patient. Quality patient care can be attained by making use of this type of data. However, managing and securing this data is essential for the health organizations as it helps protect patients' privacy. The development of technologies the electronic medical records (EMRs)[2], cloud computing and blockchain has shown enough promise enable patients' data security and privacy. However, further research and development are needed to fully integrate these technologies into the healthcare system and ensure their effectiveness in protecting patient information. It is crucial for healthcare organizations to prioritize the implementation of robust cybersecurity measures to safeguard patient data and prevent potential breaches.

Blockchain technology has gained significant attention in recent times for its potential applications in different industries such as the healthcare. It was originally developed for cryptocurrencies[3]. Data management in the healthcare industry has benefited from blockchain technology in increased security, data integrity and privacy. It is impossible to tamper or manipulate data that has been stored in a decentralized network of nodes[4]. This allows sensitive medical information such as patient records to be protected. One of the blockchain technologies which is Ethereum, allows patients to have control of their data and therefore more control over their healthcare decisions. Artificial intelligence (AI) is also transforming healthcare data management. From its definition[5], AI can be used analyze patient's data and identify trends and patterns that may be missed by human analysis which in turn gives accurate diagnoses and better treatment decisions. Through predictive models, AI can help to anticipate patient needs and deliver personalized care. Another technology that is revolutionizing the healthcare industry is cloud computing. It provides a storage platform which is secure and scalable[6] for storing large amounts of healthcare data that is easily accessible. Cloud storage reduces the risk of data loss and provides security measures to protect against unauthorized access or data breaches.

The aforementioned three technologies are poised to transform the future of healthcare data management. Patient outcomes can be improved, operations can be streamlined and costs can be reduced by leveraging these technologies. With Ethereum blockchain, medical records stored in the cloud can be shared securely with multiple providers which in turn reduce the need to duplicate tests or procedures. AI technology can then be implemented in the automation of the saving processes of the data. Creation of patient reports can be done online thanks to cloud computing. Despite the numerous benefits provided by these developing technologies, there are also unique obstacles that must be addressed. One key impediment is the smooth transmission of data across platforms. To facilitate successful communication between systems, existing data formats and protocols must be modified. Furthermore, as healthcare information becomes more available through digital means, worries about data privacy and security have grown. To address these issues, healthcare providers must prioritize the implementation of strong security measures to prevent data breaches and potential cyber-attacks. With that said, the fundamental goal of our project is to create a system that allows doctors to write reports online, deliver them to patients, and follow their progress effectively. We are also going to implement a machine learning model to predict the prices of the Ethereum which can in turn help the patient decide when to transact.

2 Previous studies

As stated in the proposal that the aim of the project is to use JavaScript to build a frontend view of the project, a cloud service provider to host the content of the site and Meta Mask to be able to login to a user's wallet to be able to store and fetch the medical records. In order to get an in depth understanding on the project, a literature study on the topic was carried out. The following papers were reviewed:

In [7] proposed a decentralized application model that uses Ethereum private blockchain, InterPlanetary File System (IPFS) and associated web technologies to help healthcare providers, policymakers, and research organizations in Nepal. In their study, the authors used both quantitative and qualitative methods in gathering data from the citizens and medical doctor in Kathmandu, Nepal. A questionnaire of survey was given to 60 adults living in the city to learn how they archive their medical health records, their tendency in switching doctors and how medical history is presented. Interviews were also carried out from 8 medical doctors who gave an insight on their experience when dealing with patients without their medical history. The findings that were made were that there was asymmetry between doctors and patients regarding medical records. Patients can hardly remember their previous medical conditions and doctors did not have enough knowledge of patient's medical history. Therefore, the researchers proposed an application model which had a security layer, role-based access control and Ethereum private blockchain. The proposed application model aimed to create an accessible and informative medical record database for both doctors and patients while ensuring the security and privacy of patient data. The paper concludes that the proposed framework can provide effective healthcare services to patients by creating tamperproof and trustworthy patient data for health. The authors suggest that their research will play a meaningful role for future researchers in the field of healthcare and Blockchain technology.

[8] proposed a system that combines blockchain and artificial intelligence to improve the accessibility and affordability of healthcare services. It utilizes a web application with image classification algorithms to detect diseases and charges a small fee in the form of a specially created cryptocurrency. This global digital currency operates on the blockchain and eliminates intermediaries, making healthcare diagnoses more cost-effective. The system optimizes clinical life cycle management and enhances clinical trial workflows, leading to faster insights and decision-making for patient care. The system aims to address both the speed and economic aspects of healthcare, providing efficient and affordable solutions through the integration of blockchain and AI technologies.

In another research, Mancer et al. [9] aimed to manage health data by collecting, storing and sharing electronic medical records using blockchain. The system that was proposed was designed to be decentralized, meaning that the data cannot be erased making it secured and non-tamper. Blockchain technology was used for the system in providing patients with proof and certainty that their medical records cannot be modified. The entity that was presented in this study was Secure Shared Medical Record (SSMR), which interact to provide control and data protection in the exchange of health information. The system provides doctors with medical information from other doctors, such as medical history, laboratory results, imaging, and treatment in progress. The paper concluded that blockchain technology has the potential to revolutionize several sectors, including healthcare. The proposed Secure Shared Medical Record (SSMR) system provides a secure and efficient way for doctors to access patient medical records from other healthcare professionals.

In another paper, [10] a blockchain-enabled emergency detection system for mobile healthcare was presented. It utilizes encrypted physiological information and smart contracts to detect emergencies without compromising patient privacy. The system improves security, trustworthiness, and communication resilience through blockchain technology. The authors provide a proof of concept and experimental evaluation, showing promising results. Their research offers a valuable contribution to the field of mobile healthcare by leveraging blockchain for secure and efficient emergency detection. Moreover, [11] highlighted the use of AI in healthcare, particularly in radiology, and its successful applications during the Covid-19 pandemic. It proposes the combination of blockchain and federated learning as a solution to maintain data integrity and privacy while improving AI models. The paper provides an overview of related work, presents the proposed framework, and concludes with future directions. It offers valuable insights into leveraging AI, blockchain, and federated learning for real-time healthcare needs.

The research conducted by [12] introduced a cloud-based implementation of blockchain security in the context of the Internet of Things (IoT). The study proposed a three-tier architectural framework that utilized pseudonym-based encryption, with a private blockchain deployed at the edge. The framework ensured that IoT devices had to authenticate through a gateway device before transmitting data to the cloud. Additionally, a public blockchain was implemented in the cloud, enabling a community of users to securely access the Electronic Health Record (EHR) system. [13] proposed a decentralized system using blockchain technology to store patient records, addressing the challenge of fragmented medical data. The system architecture involves a DAPP interface for patients and healthcare providers, granting access to comprehensive medical records. The use of blockchain ensures data security and accessibility. The system leverages Ethereum and IPFS for data storage and sharing, with a user-friendly DAPP interface. AI and ML techniques enhance the system's capabilities. Furthermore, the proposed architecture enables the availability of up-to-date and accurate medical data for training machine learning and deep learning models, enhancing their performance and prediction accuracy. The paper presents a promising approach for leveraging blockchain and machine learning in the healthcare industry

3 Methodology

Currently, patients' records are locked in multiple centralized systems which are maintained by different healthcare institutions. This means that the comprehensive medical data history of the patient has been locked away, making it difficult for doctors to make informed decisions. Using a decentralized system to store the patient record solves this issue. Figure. 1 shows the architecture of our proposed system.

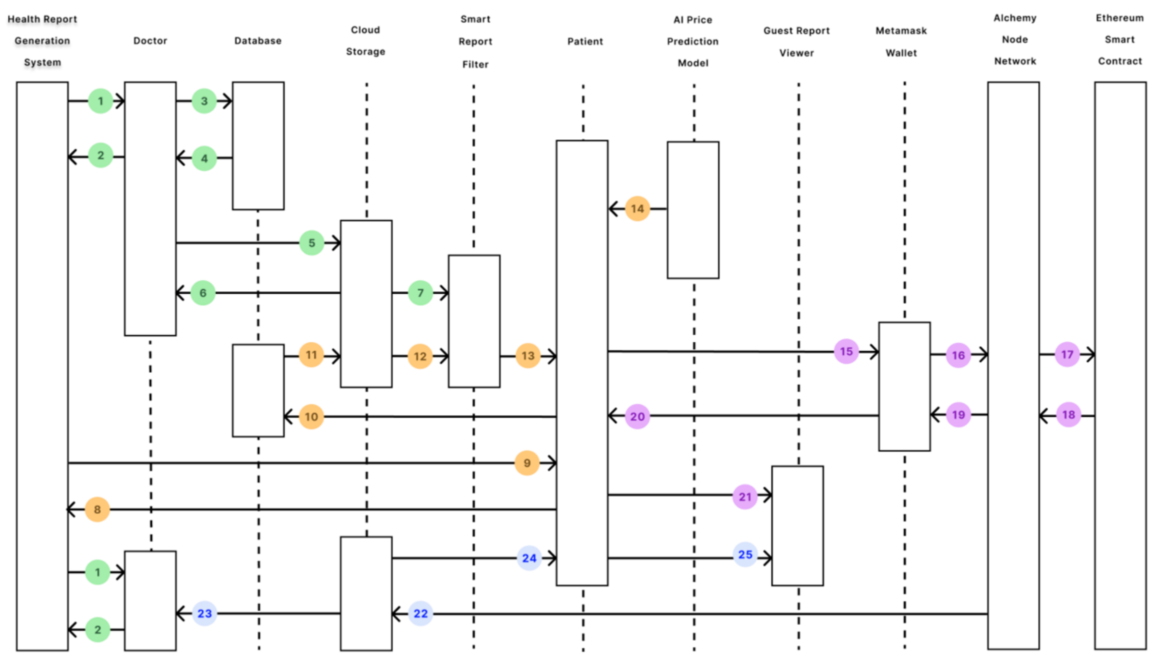

Figure 1. General Architecture of The Proposed System

The following list describes the arrows in the general architecture of our proposed system:

1. The doctor logs in.
2. The system authenticates the doctor.
3. The doctor dashboard fetches required data from the database.
4. Data is returned to the dashboard.
5. The doctor creates a new report and requests to store it onto the cloud.
6. The cloud storage stores the new report onto the cloud.
7. The smart filter ensures the report will go to the correct patient.
8. The patient logs in.
9. The system authenticates the patient.
10. The patient dashboard requests data from the database.
11. A request is sent to the cloud storage for the reports.
12. The smart report filter, filters the report for that patient.
13. Request is satisfied. The patient can see new reports from their doctors.

14. The AI Prediction Model sends predicted transaction prices.
15. The patient connects to the Metamask wallet.
16. A request is sent to an intermediary node network manager.
17. The addReport function runs on the Ethereum Contract.
18. A success message is returned.
19. The intermediary node network manager forwards the message.
20. The message reaches the user's dashboard.
21. A report link is generated for the guest report viewer.
22. Metadata is fetched from the Node Chain
23. Reports on the chain can be seen by the doctor who created the report
24. Reports on the chain can be seen by the patient who added the report to the blockchain.
25. Reports shared to a 3rd viewer can be seen on the guest viewer using a report link

The authors first built the User Interface (UI), which includes the login page for the doctor and the patient. We then have a page for the doctor to create a report for a certain patient. A dashboard is also available for the patient to review a report sent by their doctor, to approve it before adding it to the blockchain. Finally, a view is available for a guest who has been granted permission to view a report.

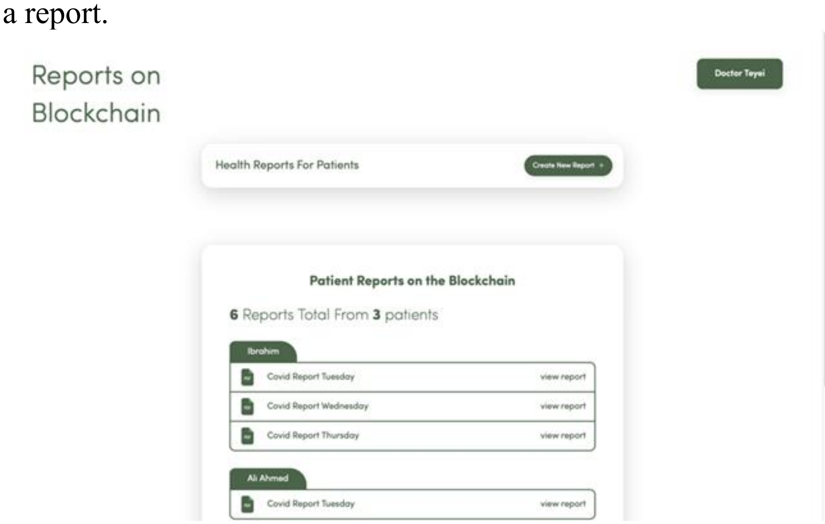

Figure 2. The Dashboard for The Doctor.

The next steps are to build out the logic when a doctor is creating a report, building the report templates themselves and being able to realize what kind of data those reports include by creating forms that the doctor can use to enter relevant data about the patient's health. In this project we focused on 2 types of diseases, High Blood Pressure and Covid-19.

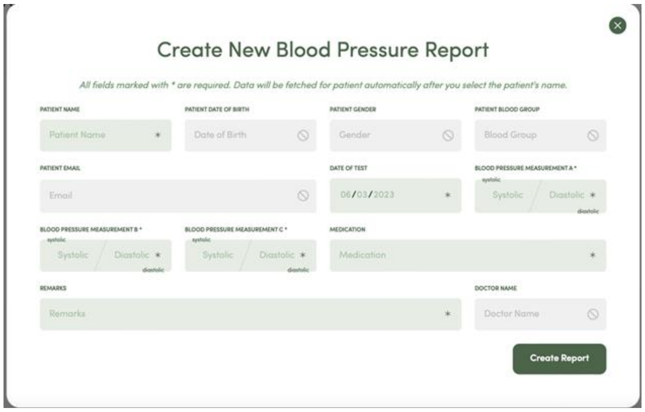

Figure 3. High Blood Pressure Report Form.

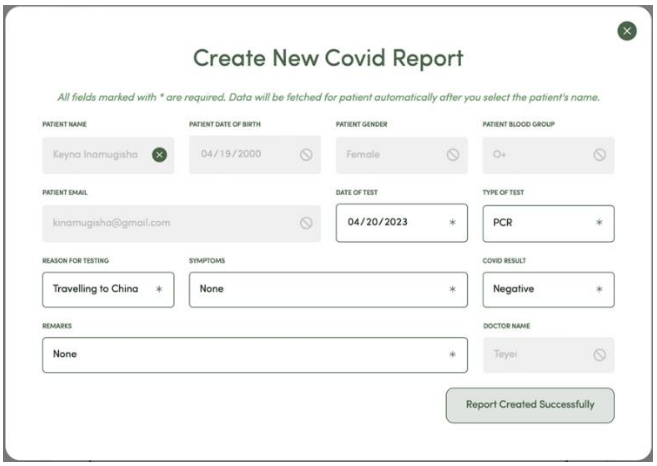

Figure 4. Covid 19 Report Form

We fetch data using AJAX for the doctor about the patient details using their name and then write that data into the report form fields to make data entry quicker for the doctor. This also ensures that zero errors are made when entering personal details about the patient. Once the doctor creates the report. It is bound as a PDF file and then upload securely onto the cloud storage. The data must live somewhere. Within the MYSQL database, we have a reports table to be able to handle the movement of report metadata while it's in the doctor's view until he/she forwards it to the patient. The system includes smart filters that are there to filter reports from the doctor to the correct patient once it has been forwarded. Once the report has been created and forwarded, the patient can log in to their dashboard to review it. Here he/she will find the reports that have been forwarded by their doctors as well as a price prediction widget that will let them know the current transaction price, as well as the best time to upload their reports for the ceapest price.

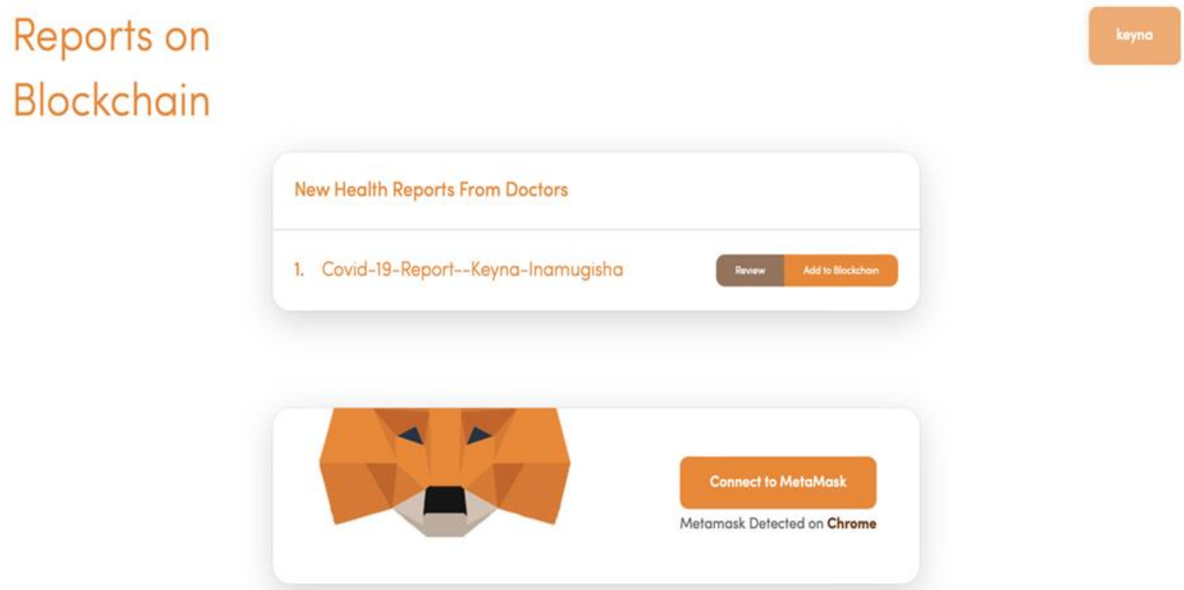

Figure 5. Patient Dashboard Page.

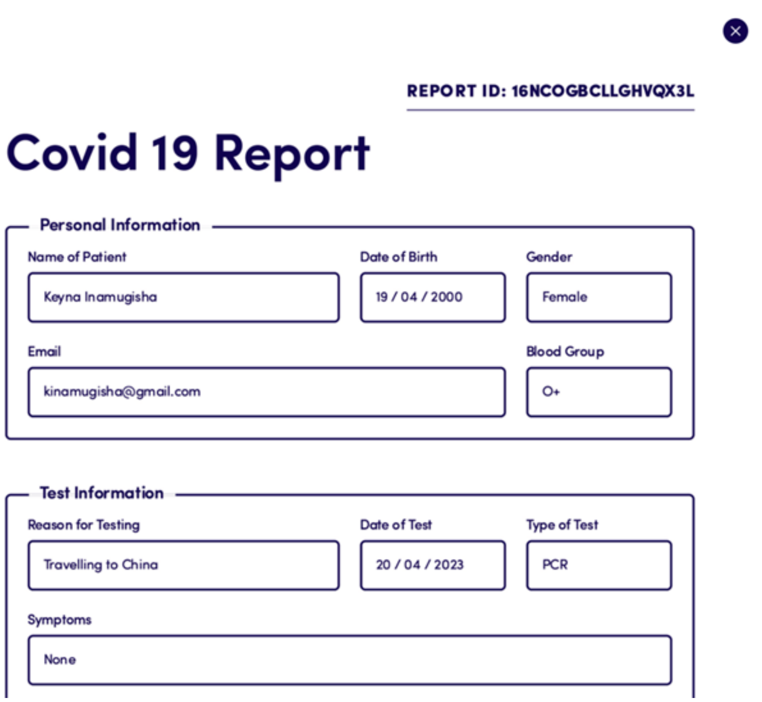

Figure 6. Reviewing Generated Health Report.

The price prediction feature was built using an RNN layered with LSTM nodes to build a time series forecasting model that is able to predict future transaction prices for Ethereum. The data includes transaction prices from dates ranging from *2020 to 2023*. The model was trained over 10 Epochs resulting is a very low loss value and a high accuracy value that was calculated by comparing the predicted values with the real values over a duration of seven days.

```
============================
________________________________________________________________________________________________
Layer (type)                 Input Shape               Output shape              Param #
================================================================================================
dense_Dense1 (Dense)         [[null,4]]                [null,64]                 320
________________________________________________________________________________________________
reshape_Reshape1 (Reshape)   [[null,64]]               [null,16,4]               0
________________________________________________________________________________________________
rnn_RNN1 (RNN)               [[null,16,4]]             [null,16]                 20352
________________________________________________________________________________________________
dense_Dense2 (Dense)         [[null,16]]               [null,1]                  17
================================================================================================
Total params: 20689
Trainable params: 20689
Non-trainable params: 0
________________________________________________________________________________________________
```

Figure 7. Model summary of the RNN-LSTM model

```
const model = tf.sequential();

model.add(tf.layers.dense(
  {units: input_layer_neurons, inputShape: [input_layer_shape]}
  ));
model.add(tf.layers.reshape({targetShape: rnn_input_shape}));

let lstm_cells = [];
for (let index = 0; index < n_layers; index++) {
     lstm_cells.push(tf.layers.lstmCell(
      {units: rnn_output_neurons}));
}

model.add(tf.layers.rnn({
  cell: lstm_cells,
  inputShape: rnn_input_shape,
  returnSequences: false
}));

model.add(tf.layers.dense(
  {units: output_layer_neurons, inputShape: [output_layer_shape]
}));
```

Figure 8. Code of the RNN-LSTM model

```
Epoch #1 of #5 -- loss: 0.03320883960
Epoch #2 of #5 -- loss: 0.00506563298
Epoch #3 of #5 -- loss: 0.00179170608
Epoch #4 of #5 -- loss: 0.00021462121
Epoch #5 of #5 -- loss: 0.00007380049
slidingWindow: [ [ 0.0015, 0.0018, 0.0019 ] ]
ethereumPricePrediction: [ 0.0016082829097285867 ]
2023-05-13 : 0.001608283
```

Figure 9. Training the RNN-LSTM model

Transaction Price Predictions

Day	ETH Price	Price in Dollars
Friday 2023-05-12	0.0019	$3.42
Saturday 2023-05-13	0.0018	$3.24
Sunday 2023-05-14	0.0013	$2.34
Monday 2023-05-15	0.0015	$2.70
Tuesday 2023-05-16	0.0018	$3.24
Wednesday 2023-05-17	0.0013	$2.34
Thursday 2023-05-18	0.0014	$2.52

Figure 10.. Predicted Ethereum Transaction Prices for The Next 7 Days Using RNN – LSTM Model.

Since the model is of a time series forecasting, we use the Mean Absolute Percentage Error equation to calculate how accurate the results are. The values were predicted Ethereum transaction prices, versus the actual transaction prices recorded days later, over a period of 7 days. The dates were from the 13th May 2023 to the 19th May 2023.

$$\boldsymbol{M = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|}$$

$$M = \frac{1}{7}\left(\left(\frac{-8.3937 \times 10^{-5}}{0.0009}\right) + \left(\frac{-6.0153 \times 10^{-5}}{0.0008}\right) + \left(\frac{-7.8666 \times 10^{-5}}{0.0012}\right) + \left(\frac{-1.5088 \times 10^{-4}}{0.001}\right) + \left(\frac{-1.20896 \times 10^{-4}}{0.0009}\right) + \left(\frac{0.14486 \times 10^{-4}}{0.001}\right) + \left(\frac{0.1455 \times 10^{-4}}{0.0009}\right)\right)$$

$$M = \frac{1}{7}(0.0932 + 0.075 + 0.0655 + 0.15088 + 0.13429 + 0.14486 + 0.1455)$$

$$M = 0.1156$$

The equation yielded a MAPE value of 11.56%

The price prediction widget gives the user an overview on when to escape high transaction fees. It gives them the freedom to choose when to upload their reports, as once the report metadata is uploaded, it is immutable. Any new changes would require them to add a new block, resulting in more transaction fees.

When the patient is ready, they can then choose to add the report to the blockchain. When a user clicks the add report to blockchain button. The system checks if they have connected to a web3 wallet like MetaMask. A popup will then appear to connect them to their wallet. Once a successful connection has been established, he will be given options to set permissions on who will be able to view the report after it is added to the blockchain. If permissions are added for people using their email addresses, an email is sent to them with a link so that they can view that report. A viewer's page is there to load a record from the blockchain and authenticate said user so that they can view that particular report. On confirmation, MetaMask will display the price in Ethereum for adding a new transaction to the Ethereum Network.

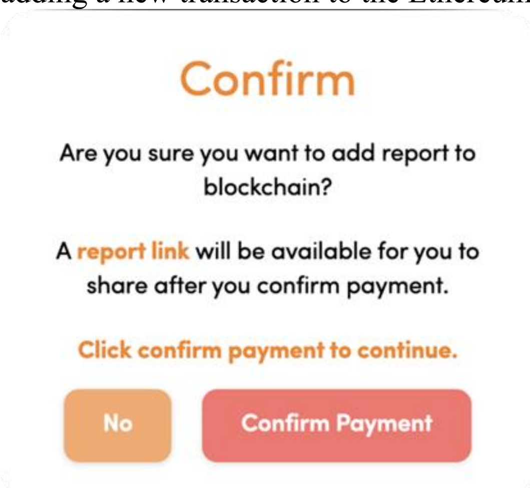

Figure 11. Confirmation Popup Before Adding Report To The Blockchain.

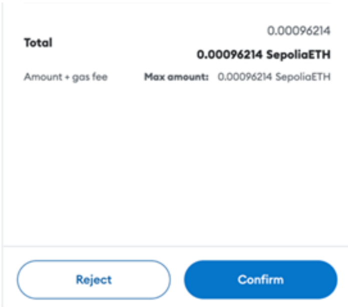

Figure 12. Confirmation Of Payment in MetaMask Wallet to Sign Contract Transaction.

When a new transaction is added to the Ethereum Network, it goes through an Alchemy Network Node that communicates our code with the contract on the chain. We wrote our contract in solidity, a JavaScript like language that runs on the Ethereum Virtual Machine. The contract consists of several functions to manage communication with our webapp. The most important ones are the addReport( ) and getReports( ) functions. They enable us to add new data onto the chain and to read data off it.

```
function addReport(
    string memory _reportID,
    string memory _reportName,
    string[] memory _reportPermissions,
    string memory _reportLink,
    string memory _reportOwnerName,
    string memory _doctorsEmail,
    string memory _ownersEmail,
    string memory _reportUploadDate
    ) public {

    Reports[_reportID]["reportName"] = _reportName;
    Reports[_reportID]["reportLink"] = _reportLink;
    Reports[_reportID]["reportOwnerName"] = _reportOwnerName;
    Reports[_reportID]["reportUploadDate"] = _reportUploadDate;
    Reports[_reportID]["doctorsEmail"] = _doctorsEmail;
    Reports[_reportID]["ownersEmail"] = _ownersEmail;

    ReportOwners[msg.sender].push(_reportID);
    GroupedIdentifiers[_doctorsEmail].push(_reportID);

    for(uint i = 0; i < _reportPermissions.length; i++){
        ReportPermissions[_reportID].push(_reportPermissions[i]);
    }

    emit LogReportProgress(_reportID,"report added");

}
```
Figure 13. Contract Function to Add Report Details to The Blockchain.

```
function getReport( string memory _reportID )
public view returns(string memory, string memory, string memory){
    return (
        Reports[_reportID]["reportName"],
        Reports[_reportID]["reportLink"],
        Reports[_reportID]["reportOwnerName"]
    );
}
```

Figure 14. Get Report Function to Fetch Report Details from The Blockchain.

When the user accepts to add a new transaction, the metadata from the database is written onto the contract using the addReport function and removed from the system. Adding report metadata to the Ethereum smart contract has a prerequisite which is to specify the link to the file, the owner's name, the permissions list of viewers, the Ethereum address of the owner, the doctor who created the report and the report ID. Once the transaction is complete, the patient will be able to see the new reports they have added to the Blockchain. This report is secure as only the owner and the people who have permission will be able to view its contents.

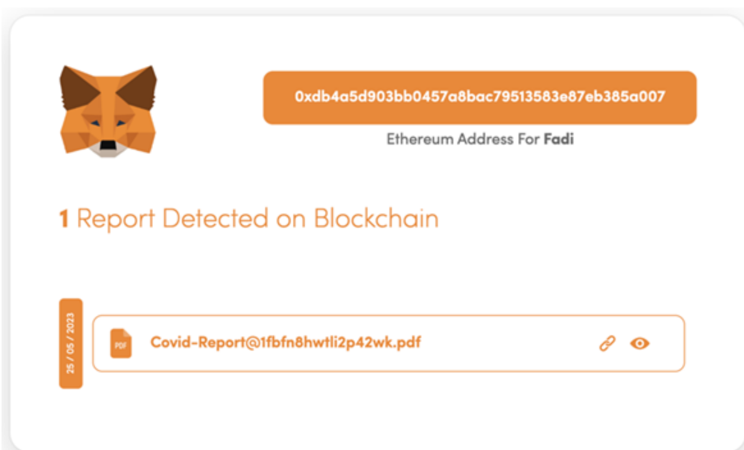

Figure 15. List of Reports on The Blockchain.

Figure 16. Report Link Guest View.

The patient will also be able to change permissions by adding new people and removing old ones who may not be allowed to view the report. However, this means that they will have to pay a price in Ethereum for any new transactions to the Blockchain. A link is also available if the patient would like to share it with a guest viewer. When someone is invited to view a report. The system connects to the Ethereum using Alchemy and checks if the viewer has the permissions to view the report. If so, the report will load, otherwise they will not be able to view anything.

4 Results and discussion

The results of the study demonstrate the effectiveness of implemented technologies in healthcare data management. The use of blockchain technology, specifically Ethereum, provided a decentralized and tamper-proof storage solution for medical records, ensuring data security, integrity, and privacy. This allowed patients to have more control over their healthcare decisions. The blockchain and cloud-based system enabled secure sharing of medical records among multiple healthcare providers, reducing the need for duplicative tests or procedures.

The integration of AI in healthcare data management proved beneficial in analyzing patient data and identifying trends and patterns that may be missed by human analysis. AI-based predictive models, such as the Recurrent Neural Network (RNN) and Long-Short Term Memory (LSTM) models used in this study, provided insights into Ethereum blockchain transaction prices. This information can assist users in understanding potential impacts of the system and market trends, enhancing decision-making processes. The developed system's architecture, as shown in Figure 1, allowed for seamless communication between doctors, patients, and the cloud storage. The doctor's dashboard facilitated the creation and forwarding of medical reports, while the patient's dashboard provided access to the received reports. Smart filters ensured accurate routing of reports to the correct patients, improving efficiency and reducing errors in data handling.

The price prediction feature, based on the RNN-LSTM model, provided patients with real-time information on Ethereum transaction prices, empowering them to choose the optimal time to upload their reports and avoid high transaction fees. The model demonstrated a mean absolute percentage error (MAPE) of 11.56% when predicting Ethereum transaction prices over a 7-day period, indicating reasonably accurate predictions. The implementation of the system utilizing Ethereum blockchain and AI technologies showed promising results in healthcare data management. The secure and efficient storage and sharing of medical records enhanced decision-making processes, improved patient outcomes, streamlined operations, and potentially reduced costs. The combination of blockchain and AI technologies offers a synergistic relationship, enabling smarter and more secure applications in the healthcare industry.

There are still challenges which remain in terms of data interoperability, standardization, data privacy, and security. Further research and development are necessary to address these challenges and ensure the widespread adoption and effectiveness of blockchain and AI technologies in healthcare. This study contributes to the growing body of knowledge on the application of blockchain technology in healthcare data management. The healthcare industry holds significant potential for leveraging blockchain technology. When combined with advanced Machine Learning/Deep Learning algorithms and techniques, it has the power to bring about a revolutionary impact.

To build a more promising system, certain changes can be implemented:

1. Enhancing speed and efficiency: Introducing new consensus algorithms can greatly improve the speed and efficiency of adding and retrieving information within the blockchain system.
2. Overcoming data quality challenges: One major obstacle in utilizing Machine Learning in healthcare is the limited access to high-quality medical data. However, by adopting the proposed architecture for storing medical records, more up-to-date and accurate data can become available. This data can be securely utilized for training Machine Learning/Deep Learning models.
3. Improving model performance: By leveraging the newly available medical data, existing models can be further trained, enhancing their performance. This additional training leads to more precise predictions and better overall outcomes.

5 Conclusion

The proposed system provides a secure platform for the storage of healthcare data in the cloud and securing it using blockchain technology. As mentioned earlier, blockchain provides accessibility, security and trust the networks for the patients' data. The findings highlight the potential benefits of integrating cloud, blockchain and AI technologies in creating secure and efficient systems for managing and sharing medical records, ultimately leading to improved healthcare outcomes and patient care.

References

[1] A. Mubarakali, "Healthcare Services Monitoring in Cloud Using Secure and Robust Healthcare-Based BLOCKCHAIN(SRHB)Approach," *Mobile Networks and Applications*, vol. 25, no. 4, 2020, doi: 10.1007/s11036-020-01551-1.

[2] L. C. S. Edmund, C. K. Ramaiah, and S. P. Gulla, "Electronic Medical Records Management Systems: An Overview," *DESIDOC Journal of Library & Information Technology*, vol. 29, no. 6, 2009, doi: 10.14429/djlit.29.273.

[3] A. Berentsen, “Aleksander Berentsen Recommends ‘Bitcoin: A Peer-to-Peer Electronic Cash System’ by Satoshi Nakamoto,” in *21st Century Economics*, 2019. doi: 10.1007/978-3-030-17740-9_3.

[4] M. Alsayegh, T. Moulahi, A. Alabdulatif, and P. Lorenz, “Towards Secure Searchable Electronic Health Records Using Consortium Blockchain,” 2022, doi: 10.3390/network.

[5] Puneet, Kumar, R., & Gupta, M. (2022). Optical coherence tomography image based eye disease detection using deep convolutional neural network. *Health Information Science and Systems*, *10*(1), 13.

[6] Kumari, M., Gupta, M., & Ved, C. (2021). Blockchain in Pharmaceutical sector. *Applications of blockchain in healthcare*, 199-220.

[7] M. Kayastha, S. Karim, R. Sandu, and E. Gide, “Ethereum Blockchain and Inter-Planetary File System (IPFS) based Application Model to Record and Share Patient Health Information: An Exemplary Case Study for e-Health Education in Nepal,” in *2021 19th International Conference on Information Technology Based Higher Education and Training (ITHET)*, IEEE, Nov. 2021, pp. 1–7. doi: 10.1109/ITHET50392.2021.9759580.

[8] P. Dhoke, P. Lokulwar, B. Verma, and H. R. Deshmukh, “Design and Development of Healthcare System using Block chain and Artificial Intelligence,” in *2021 International Conference on Computational Intelligence and Computing Applications, ICCICA 2021*, 2021. doi: 10.1109/ICCICA52458.2021.9697213.

[9] M. Mancer *et al.*, “Blockchain Technology for Secure Shared Medical Data,” in *Proceedings - 2022 23rd International Arab Conference on Information Technology, ACIT 2022*, 2022. doi: 10.1109/ACIT57182.2022.9994101.

[10] S. Panda, A. Mukherjee, R. Halder, and S. Mondal, “Blockchain-Enabled Emergency Detection and Response in Mobile Healthcare System,” in *IEEE International Conference on Blockchain and Cryptocurrency, ICBC 2022*, 2022. doi: 10.1109/ICBC54727.2022.9805544.

[11] Gupta, M., Jain, R., Kumari, M., & Narula, G. (2021). Securing healthcare data by using blockchain. *Applications of blockchain in healthcare*, 93-114.

[12] Gupta, M., & Dahiya, D. (2016). Performance evaluation of classification algorithms on different data sets. *Indian Journal of Science and Technology*, *9*(40), 1-6.

[13] Agarwal, A., Kumar, R., & Gupta, M. (2022, December). Review on Deep Learning based Medical Image Processing. In *2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-5). IEEE.