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Smart Health Care System using Blockchain and Machine Learning

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Abstract: *Blockchain and Machine Learning together can be beneficial on a large scale. The greatest answers for carrying out diverse duties in a smart healthcare system come from combining them. Whenever we enter any hospital, document verification is the first thing which a patient has to go through. But since it is a very hectic and time-consuming process, it becomes very risky at the time of emergencies. In the past two decades the health care industry is one of the most targeted industries in terms of data breaches. The consensus in blockchain technology can make sure that the data is legitimate and the transactions are secure. Real-time patient conditions can be recognised or diagnosed using machine learning. It can be used in the healthcare system as a result of this ability.*

Keywords: Blockchain, Machine Learning, Healthcare, Security, Ethereum, Smart Contract

I. INTRODUCTION

The modernization of the clinical infrastructure has given the smart healthcare system particularly significant attention. "Smart healthcare," a breakthrough idea, refers to a set of guidelines that encompass prevention, prognosis, remedy, and control. Smart medical systems are able to connect and exchange information anytime, anywhere, unlike traditional medical systems. Smart healthcare differs from traditional clinical treatment in that it is immediate, preventable, and statistically connected. Every patient's case information is available to doctors at all times, allowing them to quickly expand a diagnosis and treatment strategy (immediately). Medical staff can check in to the clinical device from anywhere to request clinical pictures and clinical recommendations. They can also obtain patient referral data at any medical facility via the clinical network (interconnection of statistics). Blockchain adheres to strict privacy standards to identify the customers involved in transactions. It is specifically used to manage data structures to benefit from transactions, reliable storage, process automation along with other applications. Machine learning is the primary technology for sophisticated analysis, wise judgement, and original issue solving in healthcare.

In general, early research on the application of virtual technology to smart healthcare was limited to observations in a single area or nation. The current reputation of those technologies inside the clinical field has not been mapped by any research. Additionally, there may not be a relative observation that specifically addresses the relationship between authors, affiliations, keywords, and the study hotspots. Students from many different disciplines have shown a lot of interest in smart healthcare over the past five years, which calls for us to integrate their perspectives and research the situation to make deeper discoveries. As a result, this research suggested using bibliometric visualisation to demonstrate the current state of use of two types of digital technologies—machine learning and blockchain—in studies of smart healthcare.

In this paper, we have provided a thorough analysis of the application of blockchain and other machine learning techniques within the healthcare industry. In terms of nations [5], authors, institutions, book volume, funders, problem areas and journals, we evaluate the studies' reputation. Additionally, this paper divides the therapeutic topic into the main utility scenarios of the earlier artwork. Our studies will offer healthcare practitioners with a perception to hold machine learning and blockchain technology absolutely utilized.

This study offers a smart contract architecture for the healthcare business that can manage patient data and streamline complex medical operations. It is based on cutting-edge healthcare blockchain analysis and a robust approach to healthcare management. We looked at the newest blockchain research in the healthcare sector and offered a blockchain-

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based solution for healthcare management. As evidenced by a number of projects in many countries and economies, governments and key corporate sectors are becoming more involved in the digitisation of healthcare systems. Blockchain, AI, and other widely available technologies must be used to integrate technology into each company's DNA if it is to be successful.

II. LITERATURE REVIEW

2.1 Medical Data Breaches

Between 2009 and 2021, 4,419 data breaches of more than 500 records were reported to the Health and Human Services Office for Civil Rights. These violations resulted in the loss, theft, disclosure, or improper disclosure of 314,063,186 medical records. This is more than 94% of the population of the United States in 2021, and in 2018, 500+ medical data breaches were reported which almost accounted about one per day. Even after more than 5 years that percentage doubles. In 2021, an average of 2 data breaches were reported daily from over 500 records.[2]

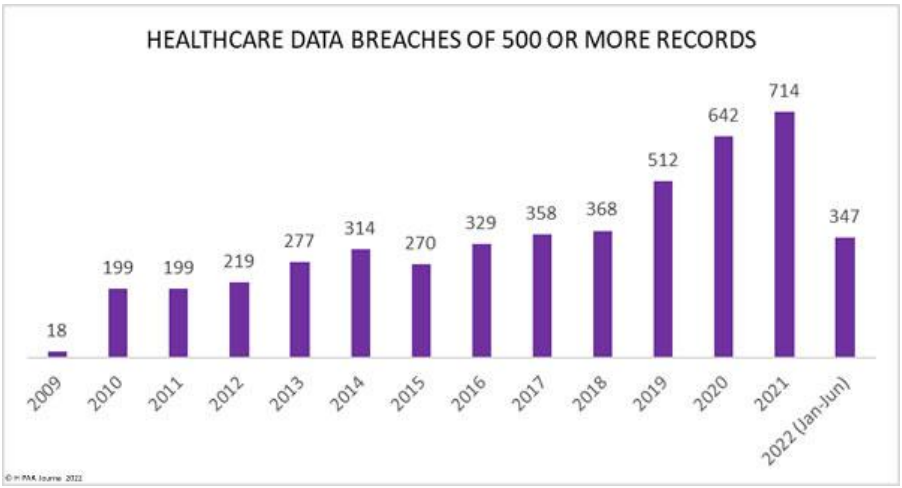

Fig. 1. Number of Data breaches over the years [2]

The number of records disclosed each year is generally on the rise, with 2015 seeing a notable uptick. With almost 113.27 million records exposed, stolen, or inappropriately revealed, 2015 was the worst year ever for medical record leaks. Due to the three significant health insurance data breaches in 2015—at Anthem Inc., Premera Blue Cross, and Excellus—it was an especially bad year. [2]

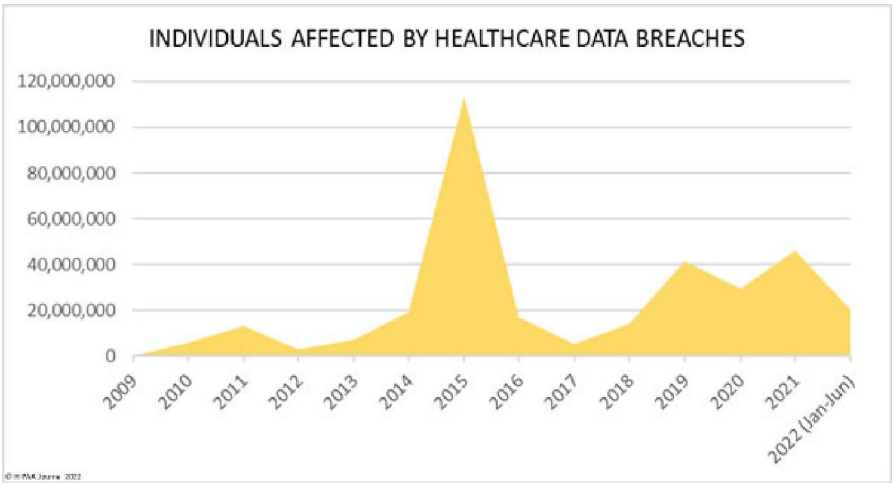

Fig. 2. Frequency of people affected by healthcare data breaches [2]

In many circumstances, data breaches are potentially fatal and can put a lot of innocent people in danger of major security issues. There have been instances of leaked medical records, particularly in India. It happens often. These are a few of them:

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- According to an article posted on a technology portal on January 5,2021, the information of tens of thousands of patients' COVID-19 test results was leaked online via numerous public domains like the Delhi Government's websites(delhigovt.nic.in,delhi.gov.in,revenue.delhi.gov.in). Individual lab test results were also available. [3]
- **Kerala's Multi-Specialty Private Hospital:** In an unprecedented data breach of this magnitude for India, all of a large multi-specialty private hospital's patient record over the past five years—including tens of thousands of test results, scans, prescriptions, and other details—were posted online. The full database could be searched using each patient ID. It is yet unknown how long these records were available to the public. The majority of hospitalizations in Kerala, according to the most recent data, takes place in private hospitals, making Kerala only one of the few Indian states having both a robust public sector and a significant commercial healthcare delivery system (2017-18).
- Out of the 101 privately owned NABL-accredited RT-PCR testing laboratories in Kerala, only one of the hospitals runs one of them, the hack led to the online publication of a significant no. of COVID-19 test results leaked on public domain. Both a number of antigens and the results of the CBNAAT test could be recognized. [3]

2.2 Blockchain In Healthcare Industry

Blockchain can be set up to securely and impenetrably record online financial transactions by acting as a distributed ledger (database). Each transaction on the blockchain is digitally signed by its participants, assuring its security and legitimacy. By consensus, distributed ledgers operate (smart contracts). Each transaction in the ledger will be stored into a block, verified, and added to the chain by both parties. Each block includes bits of information and data. Last but not least, this chain is secured by cryptographic techniques and cannot be changed or interfered with. Blockchain is a decentralised system that guarantees data security; since there are numerous copies of transaction data on many computers, nobody can alter it. Data assets kept on centralised systems are susceptible to cybercrime.[6]

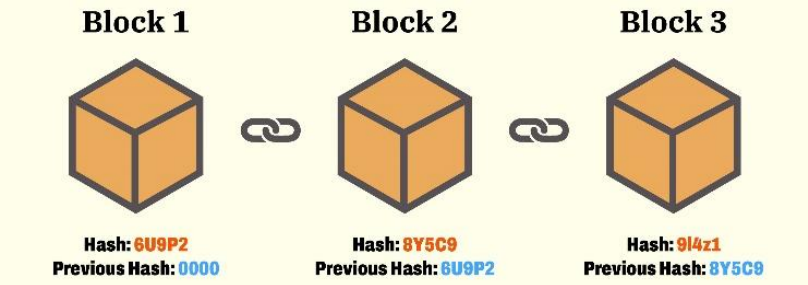

Fig.3. Blockchain Networking model

The market value of blockchain technology has considerably increased in recent years. In comparison to conventional systems of record, blockchain technology is more dependable and secure. Every node within the network can access the same file in a distributed ledger. By using blockchain technology to automate time-consuming traditional operations, it also helps to increase productivity and speed. By avoiding the need for a third party to purchase and sell goods, it also lowers costs[6]. The monitoring of medical records using blockchain technology has become increasingly popular. Theoretically, it might be a tool that, in a modern, secure healthcare environment, combines and displays all of the clinical records of a patient's health in real-time to support personalised, reliable, and safe healthcare. [6]

The storage along with the management of medical data, which includes the output of all wearable sensors, patient treatment records from service facilities, health documents, and health data, must be done in a consistent manner using access control. Along with authentication, and data immutability principles. Ensure the report's reliability, secrecy, and integrity. Due to the sensitivity of the data and the privacy and confidentiality issues surrounding the retention of medical records, data upload and processing consent should be based on a role-basis. We can use an audit procedure to document requests, record them, and gain access to tracked data. Blockchain gives multi-party businesses an effective framework for creating private/public networks with a secure data access control system. It has lately been investigated if blockchain technology can create a reliable, decentralised network for data exchange. [6]

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However, there are several drawbacks to blockchain technology in terms of where blockchain data is stored. There aren't many projects that deploy blockchain as a catalyst for reliable healthcare networks as a result, instead they used blockchain to support the processing or to govern the knowledge, but it was rejected as a data layer. Monitoring and managing encrypted off-chain data was to be done using blockchain-based decentralised user authentication. A healthcare utilisation scenario and a health data-sharing method known as FHIRChain is governed using a smart contract which lacks of exact clinical data in the blockchain.

Some of the issues the technology confronts that have prevented growth include limited interoperability, scalability, a shortage of blockchain developers, inadequate standards, excessive energy usage, and a lack of legislative certainty. In addition to the challenges of developing secure blockchain-based EHR systems, there are a number of fundamental factors to take into account. [6]

2.3 Machine Learning in Healthcare Industry

Machine learning, a branch of artificial intelligence, is extensively utilised in the medical sector. Due to the advancements in Information and Communications Technology and the beginning of the big data era, information such as information charts, patient data, & the advanced medicine status have been digitalized and employed in the medical and healthcare fields. Machine learning has become a crucial topic of research since it is used in the healthcare sector to analyse complex medical data. [7]

The study looks at how various ML methods such as deep learning, advanced neural networks, and feature fusion etc can be used in the medical sector to analyse and mine data. The goal of smart medicine is to advance through the implementation of health monitoring, human activity detection, diagnosis and disease prediction.A component or branch of machine learning is called deep learning. We anticipate a time when data, analytics, and invention will come together to benefit enormous numbers of ignorant people as machine learning technology in healthcare continues to advance. Applications powered by machine learning (ML) and that populate real-time data of various patient from dozens of healthcare systems across various nations will quickly spread and increase the effectiveness of previously inaccessible treatment alternatives.

For the automatic detection of cancer cells, deep learning is essential. While DL uses machine learning to work alone or automatically, ML uses humans to do numerous tasks. Unlike ML, deep learning automatically resolves the entire issue. Any problem can be recognized with the use of deep learning, and data-driven performance is always preferable. Learning algorithms are straightforward, which makes them simple to learn, perform, and apply. Due to the non-linear nature of machine learning, classical deep learning may be able to produce accurate patient data rapidly and effectively for language acquisition. Similar to learning about a patient's condition in real time, representing patient information or data in several formats, such as photos and text, can be learned.

On the other hand, modern deep learning models for healthcare applications are complex and demand a lot of computational power for training and prediction. These complex neural networks require a lot of time to train and assess data. [8] Convolutional neural network (CNN) learning is the foundation of deep learning models since it is a type of artificial neural network (ANN) used for the detecting diseases with help of different techniques such as MRI, ultrasound, X-ray, and CT scan. [8] In terms of picture classification, the convolution neural network performs well. CNN contains namely 3 types of layers, first an input layer, then comes one or more hidden layers, and at the last an output layer. The hidden layers help us to extract multiple features from the image, which is always the input. A traditional convolutional neural network called ResNet, developed by Microsoft researchers, won the 2015 ImageNet Large competition. Visual Scale Recognition Problem (ILSVRC). Figure 2 depicts the ResNet18 network's organisational structure. a maximum of 3*3 and a 7*7 convolution [9]. Shachi Mall et al. [24], Xu Wu wt al. [25], N. Shelke et. al. [26] and S. L. Bangare et. al. [27-29], V. Durga Prasad Jasti et. al. [30] have shown different methods for machine learning.

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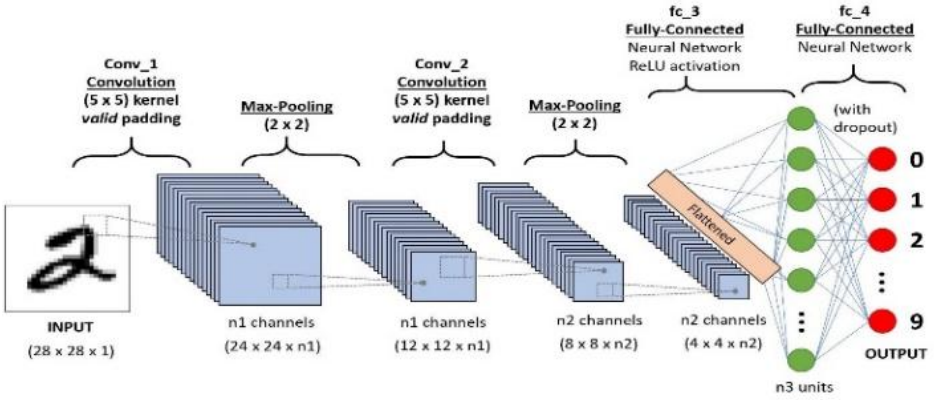

Fig. 4. CNN Architecture

III. PROBLEM STATEMENT

As we have seen in the past decade, that the healthcare industry has been at the epicentre of IT attacks and data breaches which exposes the confidential information of the patients to the public domain. Also, it has been seen that during any medical emergencies the document verification and insurance claim is a hectic and time-consuming process which generally take around 4-5 hours. This time is crucial for the patient as any delay in the treatment due to this process can be fatal to the patient health. Also, the handling of physical documents and reports of patient is a hassle task.

A system that easily verifies documents while maintaining their integrity, confidentiality, access control, and privacy is therefore required, which will also help in speeding up the process of registering the patient and claiming the health insurance in case of any emergencies. The system should also help us to overcome the problems such as identifying the disease and its severity and recommending the appropriate doctor accordingly which generally takes time in case of emergencies. As an additional feature the project can also include services such as recommending the most appropriate and nearest hospital based on the current location of the patient.

IV. EXISTING SYSTEM

Currently, the area of the healthcare industry for organizations related to healthcare systems and storing records in the cloud mainly concerns how to access, process and analyse medical or health-related data from different sources in different databases. It has some drawbacks. Stored in the cloud and accessible from anywhere. No system today stores all medical or health-related data, such as lab tests, images, and patient medications, in the cloud that can be accessed from anywhere in a secure system. Many medical departments now use computer systems and software to save data on manual systems, minimising the time and human effort needed to manually access data. and cut back on labour. However, customers still cannot access their data online from their location and have to manually access the location, which takes a considerable amount of time.

It becomes a really complex task because there isn't a single place that holds all the health-related data and other medical records and because customers can access that data from anywhere, anytime, it makes the task more challenging. Data merging is a difficult task because of interoperability and various data standards or formats. For many years, a lot of people have been working on a system to centrally or decentrally store all medically related data that is accessible from anywhere, but due to security concerns, this system has yet to be put into action.

Additionally, there is a chance that data will be stored numerous times in the cloud, which will raise record duplication, confusion, and delay. These pointless, expensive tests are not used, and they also endanger the patient. The issue of prescription fraud is comparable. From this point on, protecting data from unauthorised people is a difficult undertaking. Many firms have been working on data security over the last few years in order to safeguard stored data from theft without unauthorised access. In order to safeguard the decentralised systems or networks where personal health information is stored, healthcare providers are searching for more efficient solutions. The goal of supervised learning is to anticipate a known yield or target at first.

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There are a variety of fundamental obstacles that the healthcare system must generally overcome. The following are some basic difficulties with managing EHRs.

1. Sharing medical or healthcare information with customers while maintaining appropriate security is quite difficult.
2. For security reasons, patients have restricted access to their own data and management.
3. No data is accessible through any decentralised mechanism.
4. The patient is unable to receive regular health-related updates.

V. PROPOSED SYSTEM

5.1 Implementation of Blockchain

In order to offer a more secure solution, our suggested model combined machine learning algorithms with blockchain technology. This concept makes use of a dual blockchain architecture, the first of which is based on Hyperledger Fabric and provides access to health data. All applications and services are run by the second component of the framework, which is powered by Ethereum.

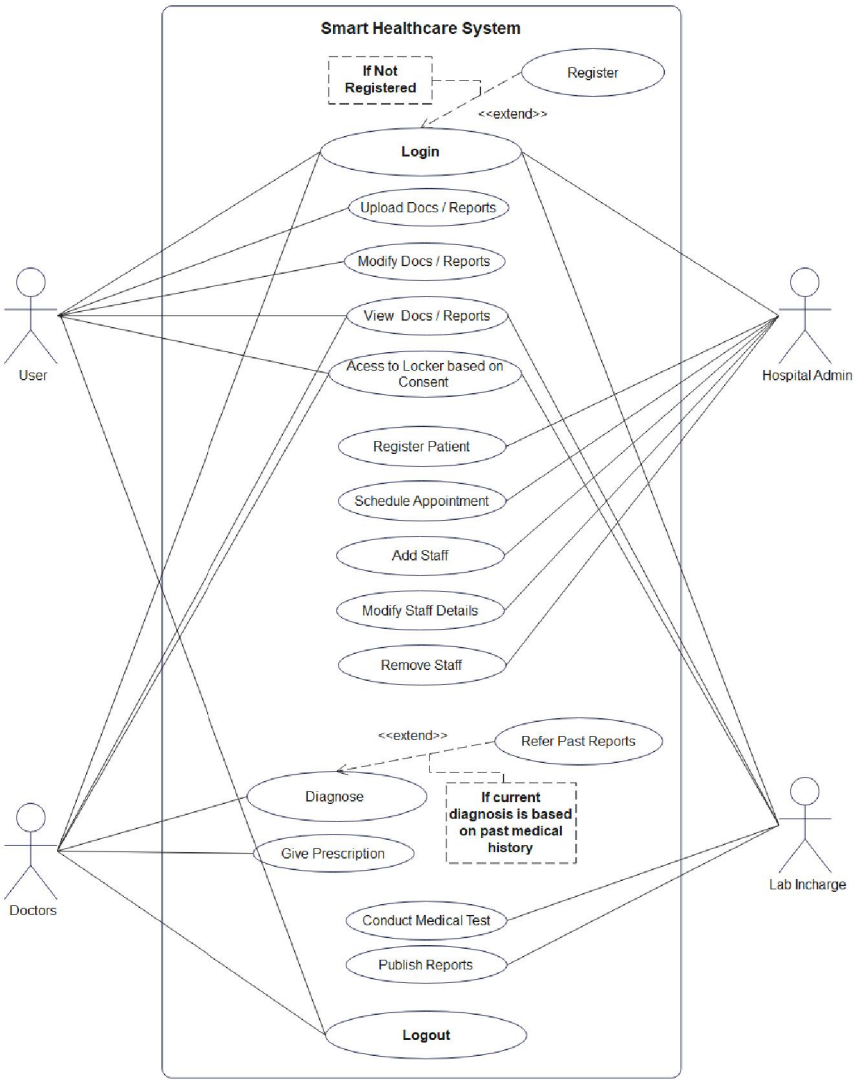

Fig. 5. Use-Case Diagram for Proposed System

Furthermore, access to or modification of patient data is prohibited. The stored data is directed to its location by the blockchain, which serves as a pointer. Any effort to access patient data will be rejected, according to this. Health information is kept private between patients and qualified doctors. The technology automatically updates the patient record history when certified physicians add new details. Only doctors with permission can view updates. As no

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physician is given permanent authorization and physician access terminates when the patient asks it, physicians will no longer be able to change or view records.

5.2 Implementation of Machine Learning

A new machine learning model is created from scratch in two steps. Obtaining the dataset and adjusting the model weights to increase model accuracy. The machine learning model is tested in a second stage on a fresh or unrelated dataset to determine its correctness. By doing this, the model is verified and overfitting is avoided. For some data sets, overfitting models are excellent, but they struggle to come up with theories for some issues.

A machine learning model can be used to carry out a variety of tasks after being trained using supervised learning, including classification and prediction on untrained datasets.

5.3 Integration Of Machine Learning and Blockchain

A certificate authority issues an approved certificate to each user in a blockchain network. Users conducting transactions on the network are given an ID by it. Digital certificates will be used as user IDs. Users sign transactions with digital certificates before sending them to the blockchain. The following are advantages of signing:

- It verifies on the blockchain that the user requesting or conducting a transaction is a genuine user.
- A user's access to the ledger for the transaction they are carrying out must be confirmed.

The authorities might issue the patient a certificate, for instance. Despite having access to their own information, patients are not permitted to view data of other patients. Information about other activities won't be available for the patient to see.

5.4 How can blockchain be used to solve issues?

1. A duplicate of the shared ledger will be sent to each authenticated user. This will take care of the issue with data collection. High-confidence data can be fed directly into your machine learning models, allowing you to forecast the results.
2. Models can be trained using real data. This improves the effectiveness and accuracy of the model while lowering additional expenses for the central agency.
3. Patients might get lifestyle recommendations. The model can be taught using suggestions made by other patients (doctors) battling the same problem or ailment.
4. The trained model can use natural language processing to identify diseases and suggest treatments when a patient completes a simple health survey.
5. Based on the patient's symptoms, the trained model can give the doctor clinical recommendations
6. An outbreak prediction model can be trained. The model can forecast an outbreak and offer advice to clinicians, for instance, if a patient is tested and the test result is submitted to the blockchain network.
7. Medical testing is done using a variety of equipment in a health care ecosystem. The service life of each machine or machine component varies. It can also foretell the need to replace or remove a machine or a component of a machine.

According to the observations made above, it appears that blockchain works well with models of machine learning and aids in the development of more efficient, accurate models. However, the following scenarios should be taken into account:

1. A transaction cannot be modified after it has been recorded as long as a ledger is added. Manual entry of information always carries the risk of human mistake. You must either comply with this or grant additional privileges to the authority.
2. Blockchain technology stores a history and copy of each transaction. It can increase the size of your database and make it difficult to process in the future.

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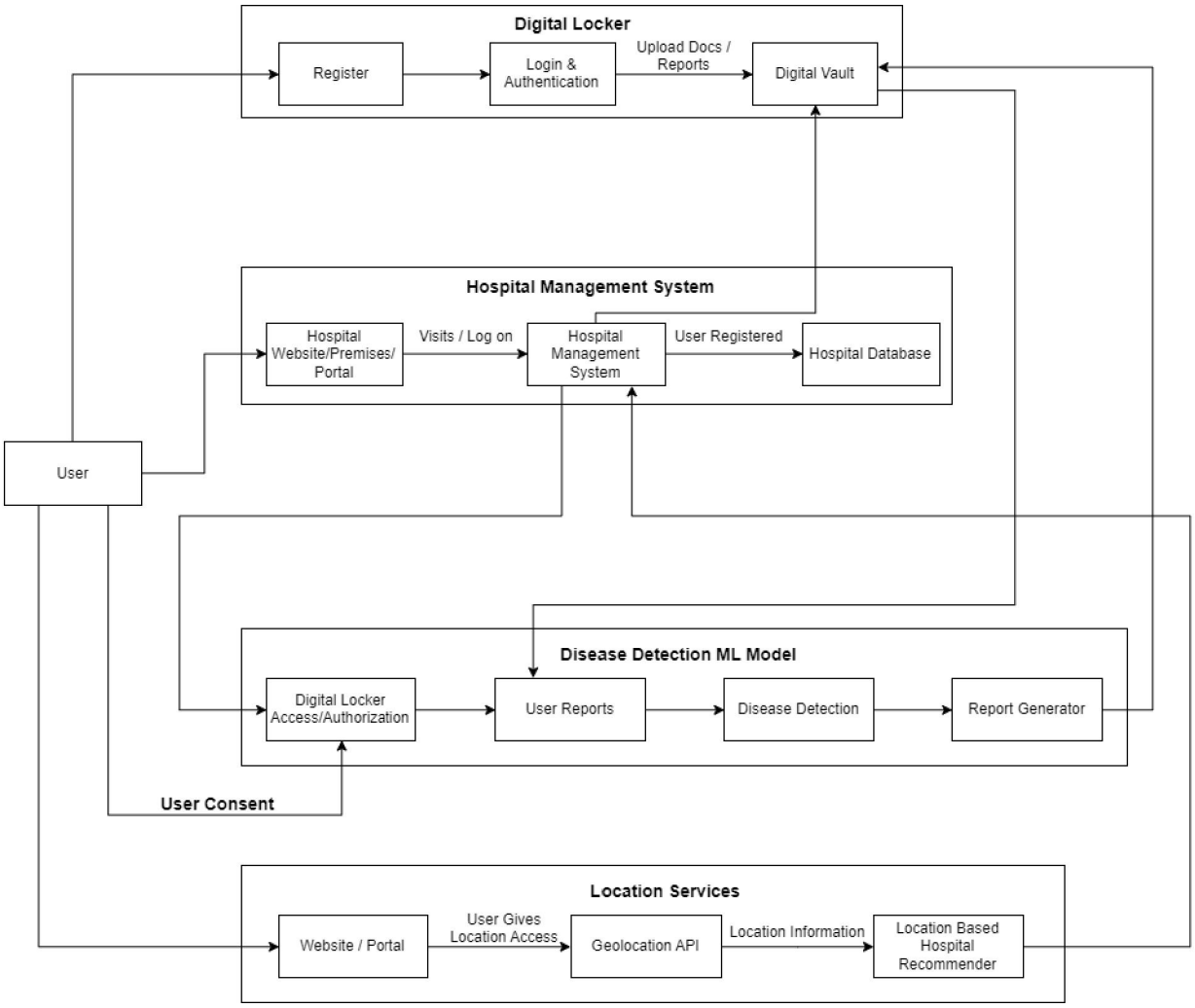

Fig. 6. Architecture Diagram for Proposed System

VI. SYSTEM DESIGN

Module 1: Digital Locker Module

In this module a digital vault will be created which will be powered by blockchain It will be used to store patient's medical health records and other health insurance related documents.With the help of this vault there will be lesser chances of leaking of insurance details as well as patient's health records.All the documents inside the vault will be connected to a unique ID (for e.g., Aadhaar Card, Mobile Number). As it will be implemented with the use of blockchain it will be decentralized and this will eliminate the role of a central authority as well as provide high availability of the documents to the users.

Module 2: Disease Detection / Prediction Module

The Disease Detection module will be used to detect diseases based on the patient's reports. The reports will be pulled directly from the blockchain vault with the help of unique ID. This module detects the presence of disease. If needed, the model can also recommend doctors based on the severity of the disease. For disease detection it will take the patient's MRI, Ultrasound or CT Scan reports (i.e., image input) and to identify the disease, we will utilize a Convolutional Neural Network (CNN). It will also generate the reports and publish it to the patient's digital locker.

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Module 3: Hospital Management System Module

The hospital management system will consist of a user interface which will allow the hospital to register patients and retrieve their data from the digital locker with the help of unique ID. All the patient's personal details such as mobile number, name, address, etc. Along with the personal details every patient's visit details such as the date of visit, doctor that examined them will also be stored. This module will contain all the administrative features of the hospitals.

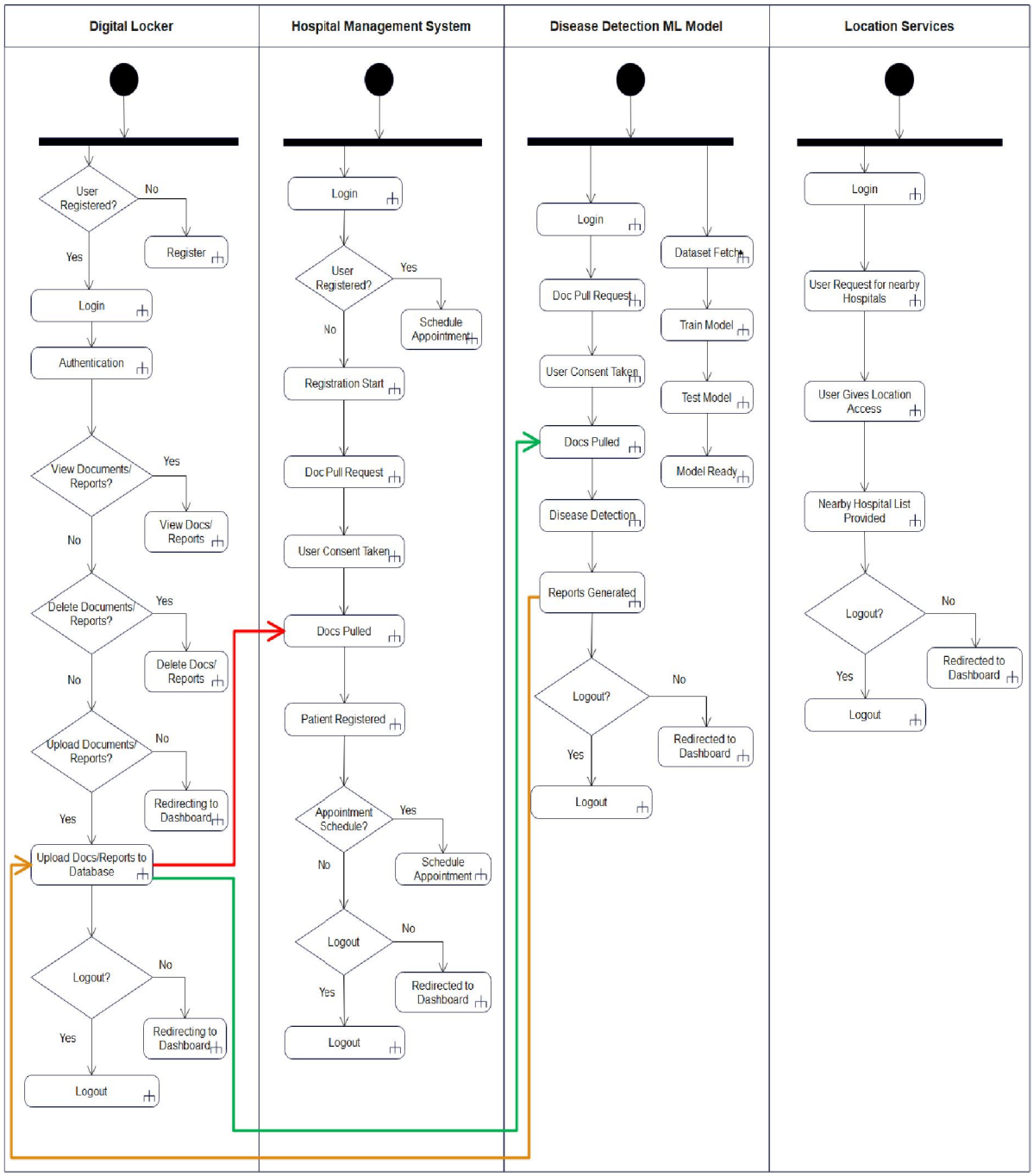

Fig 7. Activity Diagram for Proposed System

Module 4: Location based emergency services Module

This module will deal with the emergency situations in which the patient will have the provision to book or reserve the bed at the hospital from his/her home. This module will use the location of the patient to recommend the nearby

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hospitals and will show the availability of beds in that hospital. In case of emergency the patient will be able to register by submitting the documents at his/her convenience from their home

VII. CONCLUSION

At present, it is not recommended to select machine learning as a secure way of storing data because there are several data stores dispersed across numerous places and we access and analyse those data simultaneously. However, precise projections or predictions regarding future outcomes are now achievable because to advances in machine learning and blockchain technology. The blockchain will allow healthcare practitioners to examine patient medical records, and AI will make use of a broad range of algorithms, use different tools that make decision taking easy, and a lot of data. The medical system will become more cost-effective, more efficient, and more democratic by adopting these modern technologies. Blockchain makes it possible to store the cryptographic data that AI requires. With blockchain, the commission and centralized authority's hegemony might both be eliminated. The data can be directly incorporated into machine learning algorithms (however the rights will be managed by central authority). This will improve machine learning models' precision and effectiveness, as well as their usability. The healthcare sector is directly related to people's lives. Both doctors and patients may benefit from this.

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