CLOUD COMPUTING WITH BLOCKCHAIN IN HEALTH CARE SYSTEM

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Abstract

Blockchain is a series of blocks that holds data with digital identities in a distributed and decentralised network. Blockchain technology is utilised by healthcare institutions in addition to financial and social services. Through a variety of cloud service models, cloud computing, one of the network-enabled technologies, has been widely embraced in the sector. Integrating blockchain technology with current cloud systems has significant promise for improving security and privacy as well as functionality and performance. Preserving the integrity of patient data is one of the fundamental issues facing the healthcare industry. Because every patient has unique physical traits, the course of treatment for a common ailment changes depending on the circumstances. Blockchain has the ability to improve patient care and reduce treatment costs by offering a transparent and stable framework for digital health record keeping. In addition to demonstrating how cutting out middlemen can save costs and increase system stability, this paper illustrates how smart contracts can be used to create interoperability in the healthcare system.

Keywords: Cloud Computing, Block Chain, Data Security, Digital health record.

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1. Introduction:

Deep learning can draw well-informed judgements, its popularity has skyrocketed in recent years. A large number of deep learning systems in use today are centralised server-based and lack characteristics that ensure accountability, operational visibility, security, dependability, and reliable data origination.[5-1] Moreover, the single point of failure issue arises when deep learning models are trained utilising centralised data. The significance of combining blockchain technology and machine learning is examined in this paper.

Nearly every aspect of healthcare has seen the potential of deep learning. In the medical industry, for example, physicians employ deep learning models to accurately identify a patient's illness based just on their symptoms.106–10 Deep learning algorithms were utilised during the most recent pandemic brought on by the spread of the coronavirus disease (COVID-19) to forecast the disease scatter rate in a certain area and help authorities control the pandemic by using the anticipated outcome.

Moreover, utilising a dataset of CT and X-ray pictures, advanced learning techniques have assisted medical professionals in identifying COVID-19 patients. 11] Airport security staff have also used deep learning, outside of the healthcare industry, to authenticate and identify forbidden items in travellers' luggage or to protect software against mistakes.**12–17** Supervised learning algorithms work with biometric scanners and face recognition software to help law enforcement detect physical threats fast. The calibre of the data utilised in the model training stage determines the efficacy and efficiency of a machine learning system.[18]

A change made to the data used in deep learning procedures could contaminate the model used for training. Decentralised technologies like blockchain make it simple to maintain data confidentiality, privacy, and integrity.[19] Numerous advantages, including automated and validated decision-making, efficient data market management, data security, improved forecasting model generation, model sharing, and increased resilience of deep learning-based systems, could result from the combination of deep learning and blockchain technology. (20– 23) A few data mining techniques and their advantages are displayed in Figure 1, along with a description of each user's function. In terms of effective information processing, deep learning can be used for text prediction, voice recognition, image processing, sensor data analysis, and OCR-based systems.[24] Conventional deep learning systems manage and store enormous volumes of data using cloud-based technologies in order to train the models. Artificial intelligence learns more quickly because of cloud computing, which uses clusters of CPUs and GPUs to rapidly execute compute-intensive tasks[25]. Wearable devices, for example, can gather and transmit massive volumes of medical data to cloud servers via a trusted edge server for telehealth and telemedicine-based applications. (26) The second stage involves processing this healthcare data to look for trends using learning models on resource-rich cloud storage. On the other hand, the centralised architecture of existing systems places limitations on many conventional approaches, preventing them from realising their full potential. Moreover, centralised processing and storage arrays raise the risk of a single point of failure. Because data in a deep learning system is so important, it needs to be well-defended against attacks from the inside as well as the outside.

Deep learning techniques become more robust due to the unique qualities of blockchain, which shield data from a variety of adversarial attacks. By definition, blockchain technology is impervious to tampering and resistance, which makes it easier to monitor data and make sure it hasn't been changed since it was initially produced. The primary benefits of new blockchain technologies are data preservation, openness, privacy, traceability, authenticity, and operational transparency—all of which are envisioned by the decentralised and peer-to-peer (P2P) architecture of blockchain.

By automating healthcare tasks on the blockchain, self-executing smart contracts can eliminate the need for service providers to perform the tasks. The development of a cheap, fast, and reliable deep learning system is made possible by the smart contract. (28) Blockchain technology makes it possible to verify the legitimacy of deep learning techniques, producing AI systems that can be trusted.29] It documents the many stages of the model's creation, adjustment, or application and tracks the advancement of deep learning methodologies. More precisely, it helps identify the owner of deep learning models, databases, data sources, users, thebase form, and model-building operations by using the blockchain's record of irreversible activities. The consensus mechanism, data integrity, and encryption features of blockchains prevent attacks against AI models such as information, prototype, and algorithm poisoning. [30]

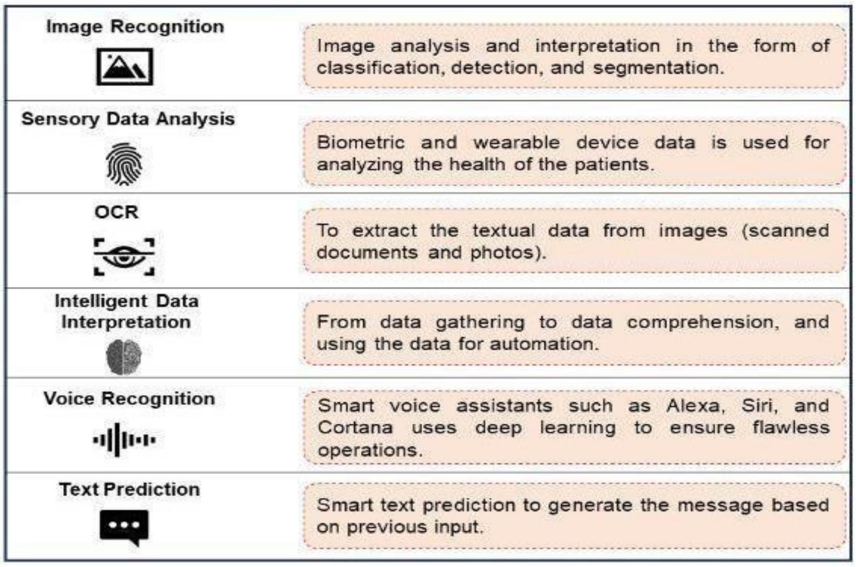

Fig. 1: Deep learning algorithms have many advantages in the healthcare field.

2. BACKGROUND

This section outlines the salient features of deep learning and blockchain technology, along with the benefits of merging them for improved decision-making, database security, and system resilience.

Blockchain Technology

It will be extremely impossible for hackers to alter, distort, or remove any data that is kept on the blockchain. It is composed of a large number of nodes that store and verify transactions as blocks. Smart contracts are digital programs that only run when specific requirements aresatisfied. They are another crucial part of blockchain technology. Smart contracts are intended to assist businesses in cutting expenses and risk. Smart contracts, decentralization, consensus protocols, and data integrity are all important features of blockchain technology that contribute to increased organizational efficacy. Blockchain technology can be used to secure patient electronic health records (EHRs) and personal health records (PHRs). Patients may benefit from having management and control over their data, as well as knowing that their authorization management policy governs when and how information is shared with other users. Markers andconnections can be very helpful in reducing data size so that blockchain can be completely utilized in different healthcare systems. Decentralized storage systems may also securely store enormous volumes of data without experiencing single-point-of-failure problems. Decentralized storage systems like Cassandra, InterPlanetary File System (IPFS), Storj, SWARM, Skeps, and OrbitDB are among the most widely used ones in the healthcare industry.

Deep Learning

A subset of machine learning and artificial intelligence is deep learning. In contemporary deep learning systems, a model examines the hidden space structure of the most basic type of input, such as text, audio, and visual data. Figure 2 shows the connection between AI, machine learning, and deep learning. With deep learning, hardware can now accomplish a lot of jobs withprecision comparable to that of a human, or in some cases even better than a human. Deep learning has a wide range of applications, some of which include voice management, object recognition, disease prediction, and image categorization.[33]

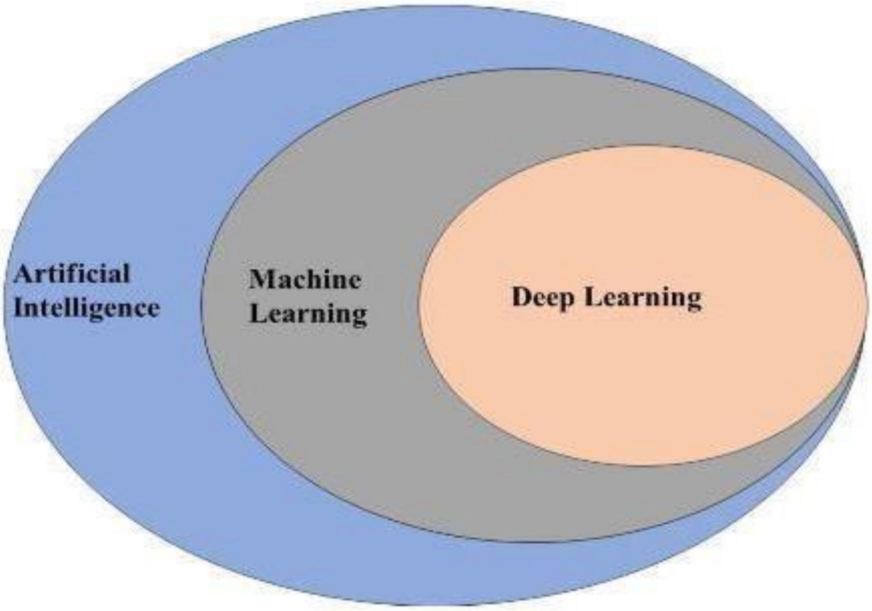

Figure 2 Relationship between deep learning, machine learning, and AI

By using data representation schemes, ML algorithms are able to learn multilingual data sequences[33]. Because machine learning algorithms rely on time-series data to draw accurate conclusions, data integrity is essential. Consequently, feature engineering is valued for its ability to facilitate data restoration through the use of feature sets that are extracted from the original data [34].

Blockchain-based Deep Learning

Blockchain technology can meet requirements for deep learning algorithms, including their secure distribution and use. Similar to this, auditability, data verification, result authentication, authenticity, ownership tracking, utilisation, and fairness guarantee are the main drivers for the integration of deep learning with blockchain.

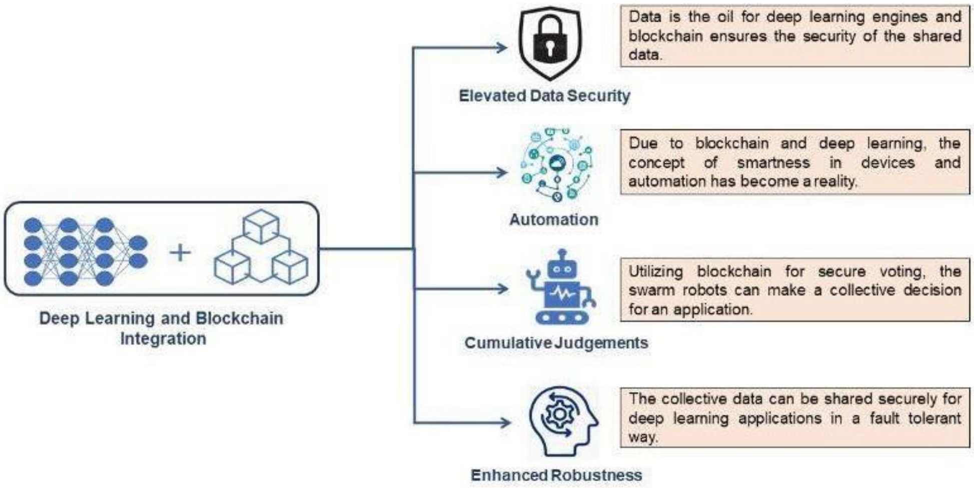

Fig. 3: The combination of DL and blockchain technology yielded benefits.

Deep learning algorithms are fed large quantities of data with a range of instances so that the models can learn the attributes and provide probability vectors as an output. Even while DL models exhibit remarkably high performance on original data, the quality of the input still plays a major role in many real-world settings when making predictions.(355) The blockchain is a global, verifiable, decentralised technology that enables data storage and exchange across all nodes.

TABLE I Features of blockchain and deep learning in the healthcare system

Deep Learning	Cybersecurity	Immutable	Transparent	Integrity
Blockchain	nsive ofdata	Scalable	Layered	Resource intensive

otential results	Upgraded data security	Learning strategy flexibility	Update of the collaborative model	Increased scalability

Table I [25] displays some of the essential characteristics of deep learning and blockchain that facilitate the development of deep learning applications. The primary classes that benefit from such connectivity are highlighted in Figure 3. Deep learning-enabled applications will collect, analyse, and use vital data, and blockchain technology and deep learning together can create a robust, resilient, and decentralised framework for it.

3. RESEARCH CHALLENGES AND OPPORTUNITIES

This section provides a quick overview of some of the research issues and opportunities surrounding the application of blockchain technology and deep learning to the healthcare sector. The large amount of data collected from sensors, platform connectivity support, transaction processing latency, platform scalability, confirmation of secure data exchange, and computationally demanding consensus procedures are all significant obstacles to the effective integration of these technologies.

Scalability of Platform

Deep learning system architects take accessibility of different blockchain versions and configurations very seriously. A robust blockchain network can manage the high number and speed of transactions produced by many users. To deploy deep learning services with a healthcare focus over mobile networks, a large blockchain network would require a similar number of accounts. The widespread application of blockchain technology will give birth to a number of issues, the majority of them have to do with user internet access needs, data velocity, speed, and volume of transactions generated by participants.

Secure Sharing and Data Validity

Modern encryption and decryption techniques used by private blockchain networks enable anonymous data sharing between healthcare industry participants, such as physicians, nurses, and patients. Concerns regarding data security, privacy, and confidentiality are growing among users as wearable technology and the Internet of Things proliferate inside healthcare networks. Users may be able to safely communicate data with each other if a multi-layer blockchain design allows for information fusion and enhanced analytical verification for user groups. In addition, in light of the ongoing COVID-19 pandemic, it is now necessary to meet healthcare system requirements for developing a workable, secure, and fault-tolerant system in order to verify and securely exchange immunity passports among authorised users via a smart contract. Specifically, data authenticity may be ensured thanks to blockchain's real-time validation and archiving capabilities for immutable data. It makes it possible for professionals and developers working in the healthcare industry to collaborate and safely verify data in new systems.

Improvement of Structure and Storage Capability

Deep learning is a strategy that requires a lot of data and resources to help solve a range of real-world problems. Making data extremely safe, immutable, verifiable, transparent, and visible to authorised parties is the aim of blockchain technology. Applying a deep learning approach to systematically evaluate blockchain system performance is a financially beneficial move. Using this approach, it would be possible to analyse the blockchain's current architecture and make recommendations for improvements.

4. Methodology:

Carando in Healthcare service:

Cardano is a forthcoming Web 3.0 internet system based on a crypto network with a publicly traded blockchain. Cardano uses the Ouroboros proof-of-stake technology, as opposed to Ethereum, which uses proof-of-work methods. Blockchains that use proof-of-stake use a lot less energy than those that use proof-of-work. Cardano introduced decentralised healthcare services, including the capacity to develop decentralised apps and update smart contracts.

Design:

The levels form the core of Cardano's organisation. These Layers provide Cardano greater flexibility and enable it to potentially manage complex user privacy concerns. Therefore, it is possible to add oversight and regulation to transactions without compromising security and privacy. Cardano stores medical data using two different kinds of components. A system thatlets you send data and monitor its flow is one kind. The other type is used to hold data about the conditions and causes of the patients. Blockchain scalability is yet another important issue. Giving the necessary scalability was one of the main goals of the Cardano development period.

One of the biggest issues with current blockchain technology, such as Ethereum, is scalability. Cardano prioritised fixing this issue as a result. By creating a consensus algorithm that is more effective and can match the throughput of established financial systems, Cardano hopes to accomplish this. We call it Ouroboros. In this consensus process, a limited set of trusted nodes are responsible for maintaining the record, rather than the entire blockchain. The amount of time that has passed limits this obligation. Thereafter, someone else will assume responsibility for the debt.

Implementation

The blockchain smart contract framework has been applied to the development and implementation of multiple medical procedures that involve specific medical tasks. These duties include making hospital accommodations and medical transportation arrangements for patients.

Blockchain-based smart contracts in ambulance service:

The study proposes concentrating on a particular issue concerning hospitalisation of patients during a pandemic. An approach to using IT to support hospitalization-related ambulance truck routing decisions is provided. Its basis is the division of the issue into two tasks:

1) Deciding whether to accept a hospital admission and choosing an ambulance
2) Selecting the hospital to which the patient should be transported in the designated car.

Each task has a number of parameters that are calculated, such as the number of emergency vehicles, the mean transportation time, the accessibility of beds in clinics, the cost of medical care, and qualitative variables pertaining to the psychoemotional load on medical staff, patients, and emergency responders.

The COVID-19 epidemic has caused a strain on healthcare systems in numerous countries. One of the most important tasks after a sick person is found is to transport them to a hospital as quickly as possible. When determining whether to transport a patient to the hospital, a number of factors need to be taken into account. These include the patient's reaction to being hospitalised, the availability of beds, the hospital staff's psychophysical state, the range to the hospital, the ambulance staff's automotive spots, and the prescription drugs required for the treatment regimen. It is suggested that smart contracts and blockchain be used to track the present state of this endeavour promptly. Health records for patients can be preserved and only authorised people can access them thanks to blockchain technology. Based on the main characteristics that can be applied to characterise the situation, it is also possible to preserve the current condition. The coalition game's result might be determined and hospitalisation decision-making aided by smart contracts in the form of decentralised applications.

Initial Diagnosis

Firstly, ascertaining whether hospitalisation is necessary and selecting an ambulance from a range of options are the first steps (Fig. 4).

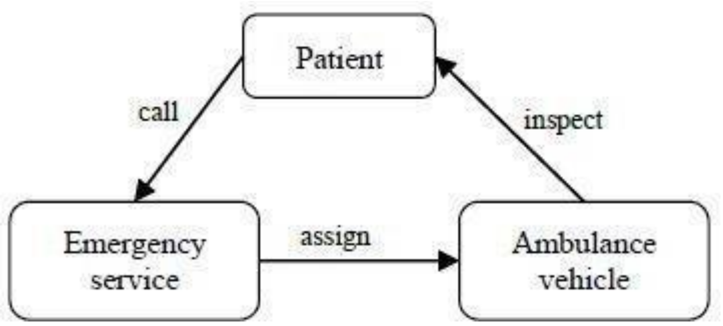

Figure 4: Initial call dispatching problem.

After a patient calls, a brief survey is answered to ascertain the possibility of a particular illness. Apart from inquiring about the primary symptoms, the questionnaire might also ask about coexisting medical conditions, age, gender, and previous interactions. The location of the patient and any health insurance are also specified. Once information has been gathered, the dispatching service should assess whether hospitalisation is necessary. An ambulance with all the necessary supplies and drugs for a preliminary evaluation and potential hospitalisation is then selected, based on accessibility and need. As part of the suggested technique, dispatchers are given access to a decision support system that assesses the need for hospitalisation and chooses an appropriate ambulance vehicle.

We got the following details from the dispatcher: The quantity of calls received each day, the typical severity of patients needing hospitalisation, and the average travel time between the patient's home and the hospital Clinic beds that are empty; typical wait times for ambulance reservations in the event that a patient is admitted The following details are provided by ambulance cars: location, professionalism of the staff, ambulance equipment, staff working hours, and data from ambulance cars. The idea is to formulate the choice of ambulance for hospitalisation as a decision problem. Moreover, the only remaining issue is deciding which hospital to visit if an ambulance is currently en route to the patient.In the event that a hospital is chosen, the previously mentioned attributes will need to be applied as limitations in the decision-making process.

Selection of hospital

Choosing the hospital where the patient will be sent is the second responsibility. The procedure for bringing a patient to the hospital is shown in Figure 5.

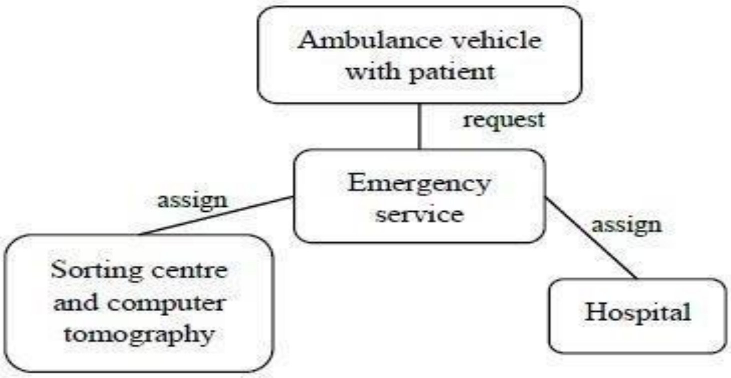

Figure 5: The process of transporting a patient to the hospital.

The ambulance crew is in charge of the patient's care when they are dispatched to a patient. They must do an initial assessment using their equipment to ascertain whether the patient has to be admitted right away to the hospital, sent to a sorting facility, or needs additional testing. For example, in the case of COVID-19, computer imaging of the lungs might be necessary to confirm the diagnosis and the need for hospitalisation. When thinking about going to the hospital, make sure the place has enough beds and all the equipment needed to treat the patient given the severity of the illness.

When resolving this issue, a number of aspects need to be considered, such as the patient's condition and the location of the ambulance. The dispatcher uses the following factors: road traffic, free seats, lab parameters, healthcare system objectives, service time for a single client, service line, resources, disinfection, and cleaning time following service.

Parameters in the hospital

treatment plans and protocols that are easily accessible; resources (medication, equipment); length of service for a single patient; size of buffer; number of beds; Methods and procedures for accessible therapy; Availability of resources (medication, equipment, etc.) This contract acts as a breadcrumb trail for users searching the system for their medical records. It maintains a record of all the participant's past and current interactions with other nodes in the network in the form of citations to PPRs. For instance, citations to all medical professionals a patient interacted with would be crammed into their SCs. Provider recommendations are more likely to come from customers and outside parties that their clients have given permission to share data with. Critical recovery and backup functions are provided by SC, which remains in the network's dispersed locations.

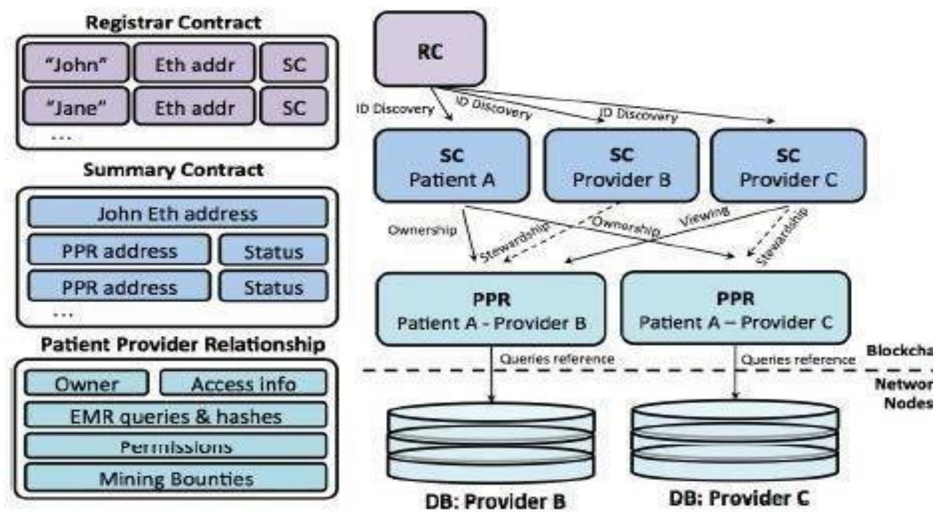

Figure 6. MedRec smart contracts, with information contained in each kind of contract.

5. Smart Contracts from Carando blockchain for Healthcare

Using Carando smart contracts, we build intelligent approximations of the current health records stored on the system within particular nodes. We draught contracts that include metadata regarding data quality, permissions, and record ownership. The blockchain activities of our system include cryptographically signed rules for regulating certain attributes. The state-transition functionalities of the contract utilise only lawful transactions guaranteeing data alternation to implement regulations. Any set of regulations governing a health history can be implemented by these laws as soon as it can be digitally preserved. For example, a policy may provide that prior to granting third-party viewing privileges, patients and healthcare providers must send separate authorization. We developed a blockchain smart contract based solution for intricate medical workflows. Smart contracts were developed to facilitate a variety of medical procedures and to manage data access permissions amongst diverse parties in the healthcare ecosystem.

Database:

Blockchain-based smart contracts enable us to monitor and control particular state transfers. Using Carando smart contracts, which link a health file with observation authorizations and data recovery instructions for outer server execution, we are able to maintain track of patient-provider interactions. Doctors may upload new records pertaining to a particular patient, and patients may consent to record exchanges between doctors. In both cases, the individual receiving the updated data receives an electronic notice and is given the chance to confirm the information before it is approved or rejected. Participants are kept up to date and involved in the creation of their records as a result. In order to establish a single standard for updating health data, this system prioritizes usability by incorporating a specified contract that gathers references to all of a user's patient-provider connections. We manage identity verification using public-key cryptography and a DNS-like mechanism that associates a user's Carando address with an already-existing, widely accepted form of ID, such as their name or SSN. "Off-chain" data transfers between patient and provider data are handled via a synchronization approach that uses our database authenticator to verify permissions on the blockchain.

The Procedure for Filling Prescriptions for Medicines

The main objective is to cut down on the number of errors that result from misinterpretations by doctors by doing away with long wait times, getting rid of the fraud component of the system, and simplifying the prescription management process for healthcare. When a patient receives a prescription, the doctor utilizes a smart contract to add the medication to the patient's medical file. After receiving clearance from both the patient and the primary physician, the pharmacy can then retrieve this prescription through the Carando blockchain smart contract. The patient can then pick up the medication. Pharmacy retailers and doctors can coordinate medication satisfaction because of smart contract capabilities. Doctors spend less time talking to pharmacy stores in general or discussing prescription requests with patients after their appointments.

Sharing Data on Laboratory Tests and Results

The main goal is to enable medical facilities, labs, doctors, and other partners to efficiently collect and share a patient's therapeutic data with other pertinent parties by facilitating information sharing through blockchain smart contracts. Let's say a patient has an appointment at a lab for a blood test. The lab will document the results in the patient's medical file following processing. Following that, the patient will receive alerts via the Carando blockchain. These notifications will contain an option to allow the lab to encapsulate the data and store it on the Carando blockchain, as well as a message once the test's processed findings are ready.

Information Exchange for Medical Payment

The primary objective is to expedite the healthcare system's payment process. Instead of needing to pause their patient's therapy while they wait for the payer to respond, doctors will be prepared to move forward with care more quickly. The use of computerised smart contracts will allow for complete process monitoring. Reducing appeals brought on by incorrect perceptions of manually prepared prior authorization paperwork, as well as minimising and finally doing away with the labor-intensive manual review and response to prior authorization requests.

Smart Contracts for Clinical Trials Based on Carando

The primary objective is to allow users to conduct clinical trial-related smart contracts on the Carando network, leading to safer pharmaceuticals and a rise in public interest in medical research. We will use smart contracts to handle protocol identification, preset research information, filtering, and enrollment records, among other metadata, during this process. The pharmaceutical company searches the Carando blockchain for information in order to find potential clinical trial applicants. A message from the group and an application enabling them to view their medical records, including pertinent lab test results, are then sent to some of the patients.

Simple Outpatient Surgery Technique

The surgical process itself can be extremely taxing in a crowded hospital. The EHR Medical Workflow Platform transforms a complex system into an easy-to-use, step-by-step workflow, making it ideal for busy practises. The practise can be integrated into the Medical Workflow platform powered by the Carando blockchain smart contracts. This enables the pre-operative to post-operative patient administration procedure to be assisted by billing, administrators, and other tasks. After that, the data is seamlessly added to the patient's prior surgical file. In our technique, several activities are included at various stages of the post-operative recovery. This process includes pre-approvals, consent papers, operation planning, health authorization, and pre-operative diagnostics. Throughout the process, notes are kept on the appointment, the therapy, and the payments paid. This could be useful for reviewing past surgical instances or postponed operations.

6. CONCLUSION

In this work, we examine the applicability of a blockchain structure to the Carando blockchain. The use of Carando smart contracts to create intelligent approximations of current health records kept in designated network nodes is covered in this research. Information on rights, ownership, and integrity of data is intended to be included in the contracts. Blockchain has the ability to improve patient care and reduce treatment costs by offering a transparent and stable framework for digital health recordkeeping. In addition to explaining how cutting out middlemen can save costs and increase system stability, this paper demonstrates how smart contracts can be used to create interoperability in the healthcare system. a fully user-operated integrated cloud infrastructure, of which the ADA token represents a portion of ownership. Cardano, an open-source software network that connects a global network of decentralised computers, is experimenting with smart contracts as a significant technology aspect that, if successful, will enable the network to engage in a wider variety of dApp use situations. Cardano has been able to quickly expand its user base by amassing a sizable number of decentralised users.

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