Chapter 30
Intelligent IoT-Based Healthcare System Using Blockchain

Sachikanta Dash, Sasmita Padhy, S. M. A. K. Azad, and Mamata Nayak

Abstract It has seen an inescapable interest in medical services issues and quicker and more secure assistance for patients. Using the new pattern innovations in the healthcare area could offer other option courses in dealing with the patients' healthiness records and furthermore improve the health quality. Researchers are looking for permanent and easy ways for monitoring patient's records remotely by means of a patient monitor system. The utilization of the Internet of Things (IoT) is one of these methods where remote patient monitoring by healthcare providers is possible. However, issues in privacy and security have arisen due to the rise in the number of IoT devices. Discloser of patient data is another privacy issue. In various studies, it was presented that blockchain technology is a trustworthy network that ensures the privacy and security issues of patient information transferred through IoT devices. Subsequently, this segment traces the IoT advancement in the healthcare segment as a rising exploration and beneficial trend these days. This investigation endeavors to introduce another outline that works with the restoration and transferring of patient information using blockchain through Django by consolidating healthiness records with a patient monitoring system that exchanges data within multiple peers through a smart contract.

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T. Swarnkar et al. (eds.), *Ambient Intelligence in Health Care*, Smart Innovation, Systems and Technologies 317, https://doi.org/10.1007/978-981-19-6068-0_30

30.1 Introduction

In a short period of time, there are numerous changes undergone in the healthcare system. New technology has altered healthcare practices, allowing treatments that once took weeks to perform to now be finished in a single day [1]. The electronic health record (EHR) is the electronic version of a patient's medical record. Because no records are lost and personal clinical diagnosis decisions may be made, this is a critical component of providing modern health care. Diagnoses, prescriptions, and other information are all stored in the EHR. Medical records, diagnostic data and laboratory data, and other decision-making tools for patients [2] Patient care. Remote patient monitoring is another contemporary technology that has aided patient care. Patients are observed outside of usual clinical health contexts through remote patient monitoring (RPM). The patient's name, age, gender, kind of disease, condition, and required therapies are all stored in the EHR system, and these details are regarded to be a part of the patient's personal information. Because they may not wish to share them, the confidentiality and privacy of the patients must be protected [3]. Similarly, RPM systems require safe data communication between the doctor and the patient to avoid data breaches and protect patient privacy.

Blockchain is the fastest-growing technology that may be used in a variety of applications while remaining safe. Blockchain technology is used in numerous implementations among stakeholders. Blockchain is a public ledger that stores all committed transactions in a set of blocks. Some major characteristics of blockchain technology include decentralization, open source, and immutability. Immutability, transparency, persistence, and anonymity are all words that come to mind when thinking about anonymity. Anonymity refers to the ability for each user to interact with the blockchain using a randomly generated address that conceals the user's identity.

The following is how we arrange our research: A brief summary of historical and current work on each of the healthcare systems is presented in Sect. 30.2. In addition, an overview of blockchain technology and smart contracts is presented. The section concludes with a discussion of the major issues facing the Internet of Things. Section 30.3 contains a description of the proposed system, as well as its implementation and requirements. A comparative study with the old method is given in Sect. 30.4. Finally, in Sect. 30.5, we offer a summary of our study findings as well as a conclusion.

30.2 Works of the Past and Present

It is necessary to comprehend current and previous research that will aid in the user's quest for improvements to the present system's flaws. By resolving the problem of requirements, an automated system will be developed. We gathered a couple of the requirements and attempted to alter our system to meet them.

30.2.1 Internet of Things is Being Used in Healthcare

Because of the rapid development of smart gadgets, the professionals related to the healthcare system and patient monitoring can now transmit health-related data online. The Internet of Things is one of the interactive techniques for integrating smart devices on a system of networks. Consequently, the IoT is a global information infrastructure that connects things using evolving and existing interoperable data and communication technology to enable better services [4, 5]. As a result, it is a collection of many solutions for hospital wellness, such as resource efficiency through automated workflows and process excellence. Maximum of medicals, for example, use IoT services for managing asset in order to control temperature and humidity in operated platform [6]. While most work emphasizes on individual fitness plans, a huge number of gadgets and their business models lack interoperability and extensibility; collecting health data provides various benefits to interdisciplinary healthcare collaboration. Figure 30.1 depicts the different types of sensors that can be used for sensing the human body and collect the health information from individual patient for future reference. Figure 30.2 depicts how this medical revolution will manifest itself in a typical IoT scenario. In use at a hospital, the patient may be given an ID card that will connect them to a secure cloud, when scanned. This will store their EHR vitals, lab results, and medical and prescription history. The IoT has the potential to provide a number of health-related benefits, including remotely monitoring of health, exercise programs, continual diseases, child care, and geriatric care are just a few of the services available. It also enables for the exchange and control of information. Internet based human-to-human, human-to-object, or human-to-object communication [7]. As a result, medical equipment, sensors, and diagnostic and imaging devices can all be called IoT smart devices or objects.

Due to the complex deployment features of such systems and the severe requirements set by many services seeking to employ such sophisticated systems, many open difficulties must be resolved by new research and analysis. As a result, it is necessary to investigate how to present standardization efforts in this area might be enhanced, as well as a greater understanding of how the research community may contribute to the IoT field [8].

30.2.2 Blockchain Technology

Blockchain technology (BT) is a distributed ledger that executes using encryption programs and securely stores data through a peer-to-peer network [9]. The blockchain network's nodes each keep a complete copy of the ledger on their systems, which is updated on a regular basis once each transaction is confirmed. Originally, BT intended to be a network for digital currency (Bitcoin) for financial transactions, but it is now suited for cybersecurity solutions due to its encryption and decentralized capabilities. The ledger is made up of a series of blocks linked by a hash method. The

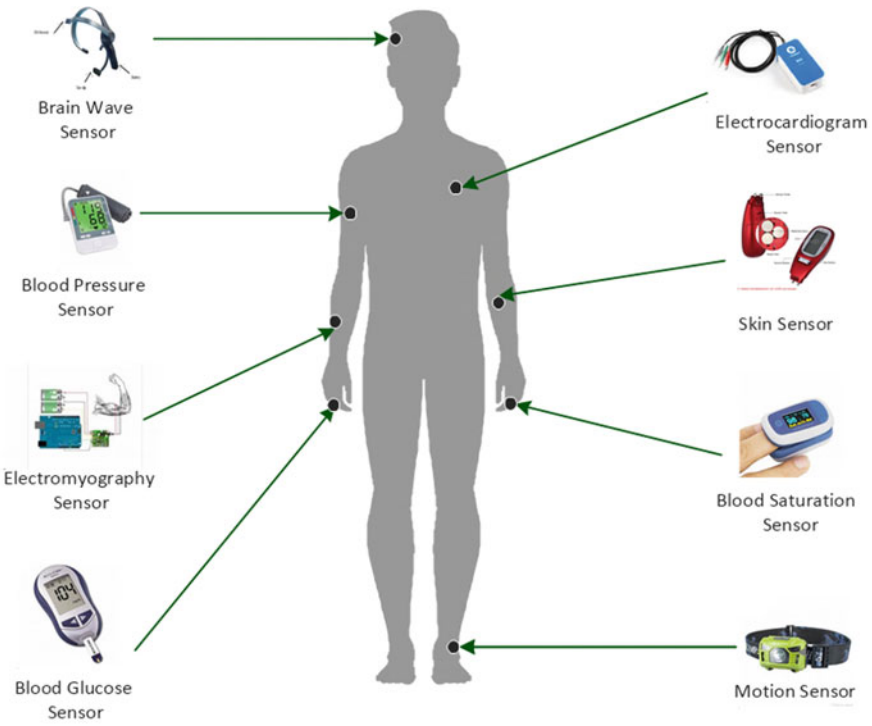

Fig. 30.1 Typical sensors for collection of patient data

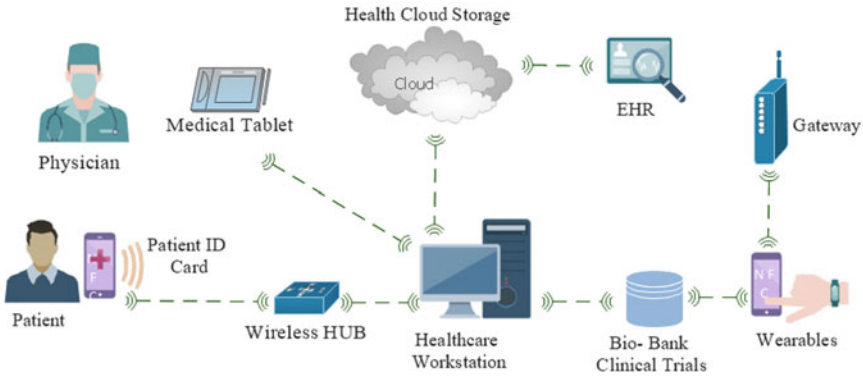

Fig. 30.2 IoT in healthcare system

first part of each block contains the number of transactions that have been completed and validated [10]. The block header is the second portion, and it includes header data such as a hash and a timestamp of the current and prior blocks. A chain of blocks is formed by connecting existing blocks in this way, and the greater the length of the chain, the less vulnerable it is to forgery. The Ethereum platform is explained in the following subsections, along with its most notable traits, as well as its relationship to BT [11].

30.2.3 Smart Contract

A smart contract (SC) is a piece of program that facilitates the exchange of data, property, and money. It becomes self-contained once it is connected to the blockchain and cannot be stopped or interfered with by a third party. In the healthcare business, BT and SCs are seen as a secure means to communicate medical records electronically, or data from RPM equipment are transferred, as SCs distinguish themselves by restricting patient's access to data and attachments to just authorized people or devices. They are also assuring record consistency by enabling via interoperability collaborative version control.

The motivation for the current study will be revealed in the subsequent review of relevant publications. In [12], various examples of the usage of blockchain technology to protect patient privacy are discussed. In order to lower the blockchain's computationally expensive charges, the authors proposed a new model for blockchain that takes advantage of the distributed nature of the technology. It necessitates a large amount of bandwidth and is reliant on advanced cryptography.

30.3 The Proposed System

The emphasis of the suggested framework is on the parameters that allow the system to meet healthcare needs while also being reliable and also to formulate the system more user-friendly and valuable.

An electronic health record (EHR) and a remote patient monitoring (RPM) system form the user interface that has been developed to meet all of the requirements of electronically healthcare system. This has been depicted in Fig. 30.3. The proposed system is secured using blockchain technology, which takes advantage of the technology's properties and algorithms. The algorithm "proof of authority (PoA)" was employed to secure the system and keep unauthorized users out. Validators will check addresses before allowing them into the system. After the user has been granted access to the system, he can be promoted to auditor.

This strategy is used to boost the number of miners. To strengthen the system's immutability and to make the block chain a multi-peer system, each user was placed in their own block, and a third peer was added. The distributed blockchain system

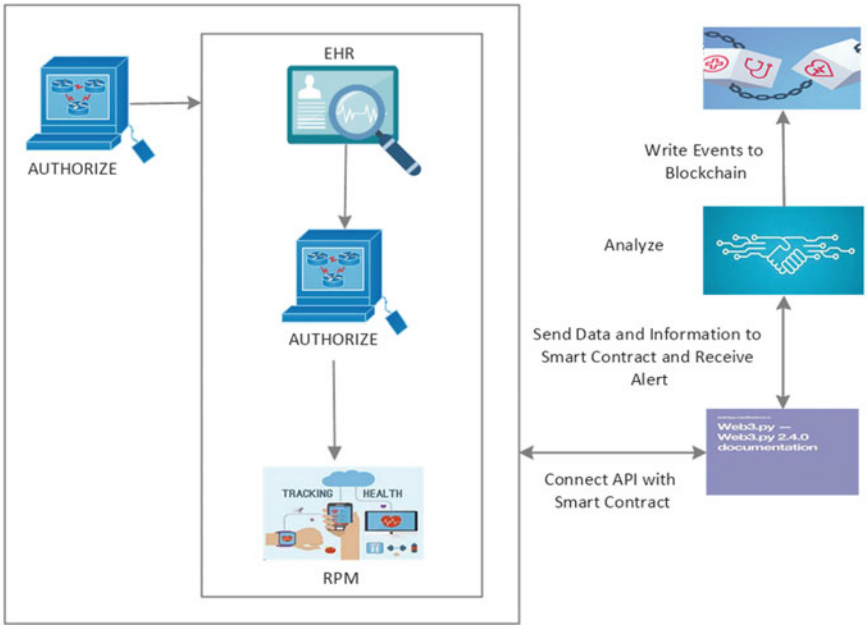

Fig. 30.3 Flow graph for proposed system

was used in this operation. Instead of developing distinct SCs for each individual, a separate SC was created, by permitting the patients to choose their desired system. Instead of sending information over the public network, Ethereum protocols were employed to send it privately.

30.3.1 System Requirements

To meet the prerequisite for our proposed work, few key requirements are listed herewith.

30.3.1.1 EHR System

A computerized record of a patient's medical information maintained by healthcare providers is known as an electronic health record (EHR). Patient demographics and progress notes are included in this data. This also includes prescriptions, as well as signature, history of health record, vaccination, test findings, and radiological records. EHR helps doctors' workflow by streamlining and automating it. Through the interface, the electronic health record can provide a detailed account of a patient's medical interaction and also assist additional healthcare issues. The suggested system

writes the required information about the patient, doctor, and healthcare center, as well as their addresses, on the BT framework, by permitting data from EHR to involve the creation of EHR smart contracts for linking and saving on the BT framework.

30.3.1.2 System for Monitoring Patient Record Remotely

Remote patient monitoring (RPM) is a technique that allows patients to be monitored outside of traditional clinical setups, likely at home or in a remote location, potentially increasing access for caring and lowering healthcare expenses. Sensors connected to different on secondary devices collect physiological information like blood pressure and individual patient information. It also collects data like weight and rate of heart bit that may be gathered with the use of a RPM system. A software program that may be downloaded and installed on PC or cellphones to collect and send patient information to the doctor's office.

30.3.1.3 Web3 Package

It is a set of libraries that allow you to develop smart contracts and read and write data to them. A connection to an Ethereum node is required by this library. These connections are referred to as providers, and they can be configured in a variety of ways. JSON RPC is used to connect Web3.py to Ethereum (ETH). Due to the fact that the ETH network is a peer-to-peer network, in which each node receives data from the others. Web3.py is a package that allows for communicating with just a single node instead of all of them using JSON RPC. With Web3.py, we can read and publish information on Ethereum with just one node.

30.3.1.4 Django Environment

A user interface with electronically patient information and a remotely data managing system is built using the Python-based Django REST Framework. The Django REST Framework is a strong and adaptable platform for creating Web APIs. The following are some reasons why you might want to use the REST Framework: Web3.py will be used to connect this interface to the smart contract.

30.3.1.5 Dataset

An electronic health record is created using the dataset [13]. Despite the fact that the dataset in contains data from IoT devices, it is used to integrate them into our system.

30.3.2 System Implementation

It is worth noting that the smart contract was written in the Solidity programming language as a proof of concept. Instead of using a public network, we employed ETH protocols to write and privately move data on the BT environment. The Django REST Framework was used to develop a user interface; after that, a decentralized application (DApp) was used to administering it. The user interface consisted of two parts: one for creating an EHR and another for RPM, both of which were linked to the same smart contract.

For each user, we will first construct an algorithm for PoA. Before being allowed access, individual users validated through a validating agent. All of the information stated in Sect. 30.3.1 is included in the EHR, as well as patient, doctor, and health facility address in a blockchain that was built using the dataset in [14]. On the blockchain, each of the three parties (Patient, doctor, and health center) is presumed to have an Ethereum address. The data are produced and processed in the user interface's back end when all of the fields have been filled out and then transmitted to the SC connected through user interface using Web3. The SC analyzes the record before sending it for storage in the blockchain.

The RPM framework is used with dataset [15] and in the second area of the user interface after fulfilling authorizes entering requirements into the system.

As shown in Fig. 30.4, for a healthcare application, the proposed system makes advantage of distributed blockchain technology. To make the system multi-peer to peer, a third peer is added, enabling data to be exchanged among peers using the same hash code. Any change in information affecting any peer will be straightforward to spot and will be rejected. As a result, the chain will be more resistant to hacking.

30.4 Evaluation Criteria

In compared to other studies on the application of BT in health care, this one stands out. We have chosen four criterions for evaluation: 1. Confidentiality 2. Comprehensiveness 3. Integrity and 4. Storage for the sake of assessment. We have created a single-user interface for an integrated electronic healthcare system because it comprises a blockchain-protected EPR and an RPM system. Here, also, an algorithm for proof of authority is used for the validation purposes, and the central system is rely on a login process through user Id and password for entering to the system. These entire tasks are validated by a validating agent. The addresses are picked after it is properly authorized by the validating agent. The miners in this operation have been raised since it will aid in increasing the system's immutability. Table 30.1 compares our solution to previous work and established systems. The PoA algorithm is time saver process for data transaction in registration as compared to other techniques used for blockchain environment. Our strategy ensures highly immutable by raising

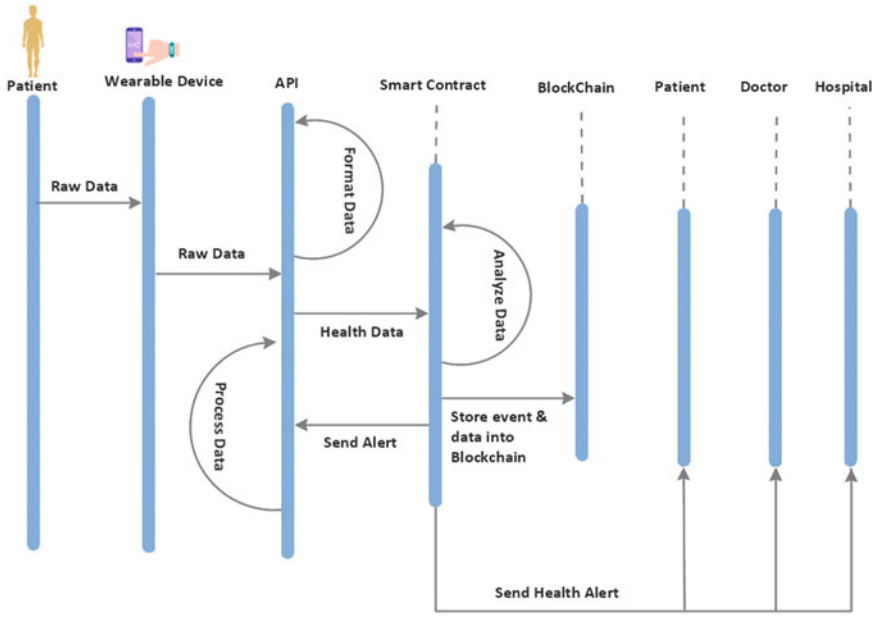

Fig. 30.4 System for healthcare application

the number of blocks in the chain. Here, the miners use SC and added a third peer to make the system a multi-peer one.

This allows us to compare the system's immutability and verify that the information is not tampered with or altered. The immutability of blockchain technology is related to the available of number of miners and blocks in the verified blockchain architectures. The database is more prone to be hacked in a conventional system but

Table 30.1 Comparison study between proposed and conventional systems

Measuring criteria	Proposed system	Traditional system
Confidentiality	Proof of authority (before being allowed into the system, each address must be authenticated)	In a typical traditional system, encryption technology is used
Comprehensiveness	The two technologies will be combined into a unique user interface and smart contract	The EHR or the RPM system is the focus on related work separately in a traditional systems
Integrity	Increase the amount of blocks and miners, as well as a third peer added, to achieve high immutability	In the traditional system, databases can be modified. In related works, hashes of blocks are used in the broad notion of blockchain technology
Storage	Storage on the blockchain with a high transaction processing speed	Storage in the cloud

making it more difficult for an attacker to calculate the hash and obtain access to the data in our proposed system.

30.5 Conclusion

The present solutions for maintaining security are inadequate due to available of constraints in central system. To make healthcare data private, security is one of the most pressing academic topics at the moment. In our study, we have presented a simplified architecture for developing a complete healthcare system that combines the feature of both HER and RPM into a unique user interface. We have employed Django Framework and BT to ensure the confidentiality and secrecy for patient record. Our solution adds to cost reduction by eradicating the concept of intermediate third party and generating an insubstantial SC that minimizes the transaction cost on the BT environment. Due to the existence of third peer and increased number of blocks in the system, our presented approach ensures no data alteration and is highly immutable.

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