A BLOCKCHAIN TECHNOLOGY AND INTERNET OF THINGS TO SECURE IN HEALTHCARE SYSTEM

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Abstract

The huge headway of new advances like the Web of Things and wearable innovation, the medical services industry is extending rapidly these days. To guarantee far off persistent observing, these devices are generally used. Client/server engineering is utilized in the ongoing execution. Due of the security and protection issues raised by this, medical care frameworks are currently more helpless against different assaults. The utilization of a dispersed engineering is expected to resolve these issues and submit to security rules. Block chain has drawn in a ton of interest as a modern innovation to address the security issues in IoT-based frameworks in light of its conveyed nature and its security ensures. With the new presentation of block chain and IoT, the medical care area is supposed to develop altogether and experience an expansion in monetary potential as well as security, protection, effectiveness, and straightforwardness. The client/server engineering is the underpinning of the ongoing execution. In this paper, various protection and security gives that make medical services frameworks more powerless against different assaults.

Keywords: *Blockchain technology, Internet of things, Healthcare system, Mining, Security.*

1. INTRODUCTION

The two most critical advancements that will altogether affect all organizations in the years to come are blockchain and the web of things. These two innovations will fundamentally affect the medical services area too. The organization of actual things with inbuilt innovation to impart, identify, or cooperate with their inside states or the general climate is known as the Web of Things (IoT) [1]. The reception of IoT stages has become basic for some areas as the expense of sensors and actuators keeps on declining. There are now a few medical care arrangements that main use IoT innovations. However, they have a unified data set, which is an issue. Thus, the information may not be secure and enterprises might charge something else for capacity. In any case, these issues are overwhelmed by the utilization of blockchain innovation, and the client is made the select owner of his information. Without his assent, no other person is permitted to get to the information..

1.1. Blockchain Concept

To forestall erratic information base changes without influencing all related edges and stage interest, blockchain is a conveyed, cooperative, and aggregate electronic library that is utilized to record installments through numerous gadgets. This empowers the partners to analyze installments rapidly and reasonably. A decentralized period forming information base and distributed framework are utilized to independently deal with the blockchain stage. Seen personal matters that are persistently planned act as free check [2]. The outcome is a strong technique with less vulnerability encompassing the partner's insurance of buyer information or data. The ceaseless systemic thoroughness property of computerized cash is taken out when blockchain innovation is utilized. This dispenses with the constant twofold income issue by guaranteeing that every variable of use has just been moved once. A determination for trading values was given in the meaning of blockchain [3,4,5,6].

1.2. Internet of Things

The Web of Things (IoT) is a model for powerful figuring that helps us in the activity of different frameworks used in our regular routines. As cooperations happen in these IoT frameworks, the interconnection of different gadgets considers the exchange of those gadgets. Cell phones, savvy sensors, and espresso producers are the most generally used IoT gadgets [7]. IoT frameworks make it simpler for individuals and different items to associate, but since of their quick rates, they likewise produce monstrous volumes of information, making these frameworks more troublesome as far as information related issues.

In IoT frameworks, the joining of somewhat controlled actual articles and PC based frameworks is coordinated by means of the all around existing organization foundation. IoT innovation has diminished how much human mediation expected to get done with any responsibility all the more precisely and productively. IoT frameworks can gather information from different kinds of sensors. Due of the less expensive expenses of the sensors and actuators used in IoT-based innovation, various endeavors are communicating interest in it [8].

IoT is being utilized in various medical services the executives transfers. Numerous instances of IoT in medical care:
o   Clinical Management
o   Patient's Remote Monitoring
o   Early Intervention/Prevention
o   Wireless Sensor Networks (WSNs)
o   Clear, Comprehensive Medical Record
o   Total Patient List
o   Adjudication of Arguments
o   Control of Supply Chain

2. LITERATURE REVIEW

Blockchain innovation and its applications in the monetary and non-monetary areas are talked about by Crosby et al. [9]. The review portrays exhaustively how blockchain supports fashioning arrangement in the virtual web-based space. The report likewise talks about various risks connected with the utilization of blockchain innovation, like scale and administrative regulations.

The meaning of blockchain and IoT in the modern area and their potential impacts are portrayed by Mill operator et al. [10]. As indicated by this, the framework would turn out to be more viable on the off chance that these two innovations were utilized. Also, it suggests that particular lawful, administrative, and protection claims should be accurately taken care of. There will be more IoT gadgets, and to accomplish improved results, these gadgets should offer versatile arrangements.

The ability to utilize blockchain advances to protect medical care information put away in the cloud is depicted by Esposito et al. [11]. The different useful hardships experienced are likewise featured. This concentrate additionally examines the worth of blockchain innovation for handling a few interoperability and security issues in the medical services area. Conversation likewise incorporates hardships experienced with putting away information on a blockchain.

Dey et al. [12] bring tried to the table for an answer for the issues confronting the medical services area. We depict a blockchain-IoT idea where ongoing information is accumulated by IoT gadgets and afterward put away in a blockchain. Also, it asserts that in light of the fact that blockchain is scattered and decentralized, it really works with the framework.

Hanley et al. [13] have portrayed an answer that consolidates a blockchain with off-fasten concentrated information capacity to empower patients and clinical experts to get to clinical records from any area in a flash. Alhadhrami et al. [14] catch blockchain's job in the administration and trade of electronic wellbeing records to permit specialists, doctors, centers, and other clinical partners to share information and further develop interoperability. The benefits of utilizing blockchain are featured in this paper, including how rapidly correspondence happens and how interoperability issues are managed. The benefits and disservices of different blockchain structures are analyzed, alongside the hardships they address. Likewise, this paper talks about the design of permissioned and permissionless blockchains as well as how they may be utilized in the medical services industry. Challenges connected with security and protection are additionally covered.

A. Azaria, 2016 [15] recommended a technique for utilizing savvy agreements to oversee consents and limit admittance to clinical records. In their model execution, they conveyed their shrewd agreements — which give patients control and the executives over admittance to their information — utilizing the Ethereum Blockchain organization. A Guard data set is utilized for information putting away. One more review proposed coordinating portable applications with blockchain to impart information to medical services suppliers and protection suppliers.

A. Dwivedi introduced a one of a kind Blockchain framework in 2019 [16] to keep up with namelessness in IoT medical care gadgets. They approved exchanges and encoded information utilizing basic cryptographic techniques. By and by, the framework has not yet been instituted. Another concentrate likewise considers the combination of IoT and Blockchain to fabricate a clinical stage to screen EMR trustworthiness.

Edge The total concentrate on the many purposes of Blockchain in medical services is covered by Ben Fekih et al. [17]. This section's creator basically distinguishes many purposes for blockchain, far off persistent observing, trade of electronic wellbeing records, and inventory network based drug conveyance frameworks.

"Blockchain all over - A Utilization instance of Block chain in the drug store production network," as per Thomas Bocek et al. This technique's creator presented modum.io, a framework that consolidates IoT and block chain to empower information openness and permanence and lower the HSCM framework's working expenses. To completely guarantee Gross domestic product guidelines, the creator embraces this procedure and depends for the most part on heat sensors when the item is moved along the store network.

3. PROPOSED METHODOLOGY

IoT gadgets in the medical care area as of now work under a unified server/client approach. The issue with a brought together framework is that the medical clinic controls the essential patient information and data, which could bring about higher capacity costs for clients. On the off chance that there is no reasonable reinforcement, the whole arrangement of information may likewise be lost in a brought together framework in case of a weak link [18]. The way that medical services information is private raises security issues since it would be straightforward for programmers to get to the information from an incorporated framework. One more significant issue with unified medical services approaches is interoperability. In this way, we are setting up a methodology that tends to these issues by using both IoT and block chain innovations. As portrayed in Fig. 1, the engineering is isolated into various layers.
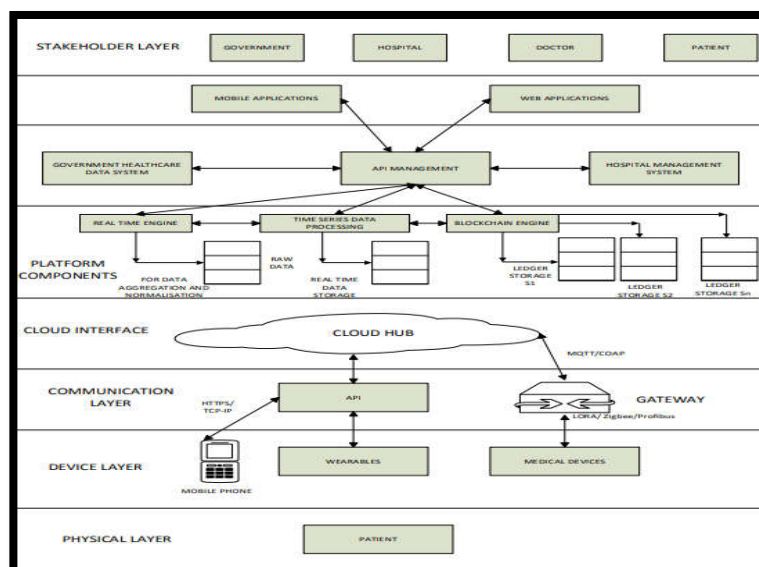

Figure 1: Proposed layered architecture

- The patient, whose information should be recorded, makes up the main layer, which is the actual layer.
- The subsequent layer is the gadget layer, which incorporates wearables, clinical contraptions (CT filter, X-beam), cell phones (which incorporate sensors), and so on. These instruments are utilized to gather and send information coming from the patient end.
- The correspondence layer is the third layer. This layer is accountable for sending information that gadgets have recorded. Gadgets can associate with the cloud straightforwardly utilizing a Programming interface or utilizing LORA, ZigBee, or Profibus. Information is likewise sent from the doorway to the cloud utilizing MQTT and COAP.
- Coming up next is cloud interface, which comprises of stage components further partitioned into ongoing motor and block chain motor.

The continuous motor gets the information being provided to the cloud first, accumulates the crude information, and performs information conglomeration and normalization. The block chain motor, which stores information, is thusly taken care of with this data. Information put away in a block chain is decentralized since the innovation is decentralized. The records of a patient, which are estimated and assembled by IoT gadgets, are put away on a block chain. Blocks are utilized to store the information, which is moreover safely secured. The numerous partners, which incorporate government controllers, clinics, specialists, and patients, can get to this information through Programming interface the executives. Versatile applications or online applications can get to this information, and Programming interface organization is shown in the design in Fig. 1.

3.1. Research plan
Building a survey methodology, downloading research articles from different web-based sources, assessing the nature of articles, deciphering and posting noticed survey results, recording survey results, lastly introducing different examination difficulties and future exploration headings are steps that were engaged with this concentrate on the utilization of blockchain and IoT innovations in the medical services and clinical area.

3.2. Research Questionnaire
The most vital phase in directing this overview was making the different examination polls, taking into account the main thrusts, and searching for appropriate distributions in different web research data sets. Table 1 records the assortment of exploration questions and the main thrusts behind the overview's plan and execution for the utilization of blockchain and IoT in the clinical business.

Table 1: Questionnaire for research and inspiration

Questions	Motivation
1. What is IoT? 2. How far along is IoT research at the present time? 3. What are the IoT's examination prospects and difficulties? 4. What different IoT applications are there?	The Web of Things (IoT) is another organization that empowers correspondence between different gadgets that are surrounding us, for example, houses, coolers, climate control systems, traffic signals, and so on. Numerous enterprises, like horticulture, medical care, transportation, brilliant homes, and so on, are utilizing IoT. It is fundamental for Track down the IoT hardships. A portion of the troubles with IoT that should be considered are security, protection hazard, and trust.
1. What is a Block chain? 2. Might the Block chain at any point be used solely for bit coin? 3. In what applications could block chain be utilized? 4. How could the block chain and web of things be joined? 5. What are the different deterrents to block chain and IoT joining?	Concerning uncommon property that makes it hearty and unhackable, Block chain is one more new innovation with various applications and regions for expanded security, protection, and trust. The protection and security difficulties of the IoT organization can be tackled utilizing Block chain. In this way, it is important to explore the potential for Block chain reconciliation and sending in IoT organizations.
1. What applications do Block chain and IoT have in the clinical field? 2. What are the numerous medical services applications for block chain and web of things? 3. What are the snags to IoT and block chain reception in the medical care industry?	The consolidation of two powerful advancements can work on the ability as well as the nature of the ongoing Medical care area. IoT and Block chain can be carried out in the Medical care and Clinical area to work on the recent concerns in the Medical services area like medication recognisability concerns.

3.3. Source of Information
To find the essential and related research assets for this review, different possibly pertinent locales were investigated. The creators of this study counseled different web-based assets, including Springer (http://www.springer.com), Google Science Direct (http://www.sciencedirect.com), IEEE Investigate (http://www.ieeexplore. ieee.org), Researcher (http://scholar.google.com), and online instructional exercises, including Edureka, Public Program on Innovation Upgraded Learning (NPTEL) for grasping the ideas, and so on..

4. APPLICATION OF IOT AND BLOCKCHAIN TECHNOLOGIES IN HEALTHCARE
Consistently, more individuals are being owned up to emergency clinics around the country, making it more testing to offer extensive clinical consideration. With the guide of IoT and wearable innovation, clinical consideration has happened to better lately. The essential strategy for tending to medical services issues is distant patient checking. IoT gadgets and

wearables with information assortment and transmission abilities are key parts of distant patient observing. These gadgets' essential targets are to offer vital information to medical services experts, for example, an individual's breathing examples, blood glucose level, and pulse [19].

Four classifications can be utilized to characterize medical services information assortment gadgets: A fixed clinical gear is one that is utilized in a solitary actual spot. Clinical installed gadgets (b), wearable gadgets (c), and wearable wellbeing observing gadgets (d) are a wide range of clinical hardware that are embedded inside or on the outer layer of the human body. RPM's essential objective is to safeguard information that programmers are attempting to get to. Utilizing block chain innovation, the information is gotten. By using the possibility of decentralization, block chains help with shielding the information from various cyber attacks. Brilliant agreements on the block chain effectively further validate the information.

To get patient information, medical services is an IoT framework application that has explicit extra prerequisites. These prerequisites incorporate interoperability and information move. The most common way of imparting information to various sources is alluded to as interoperability. The restriction to accomplishing interoperability is essential for the unified thought. The Web of Things is predicated on centralization, where information is put away in the public cloud where it isn't secured. The security challenges presented by medical care applications can be settled by blockchain innovation connected with IoT. A few block chain tests have previously been led in the medical services industry [20,21,22].

5. IMPLEMENTATION

We frame the recommended arrangement execution in this part. A confidential Ethereum Blockchain network in view of Club PoA, IPFS for information capacity, and intermediary re-encryption for information encryption are utilized to make the framework.

5.1. Node types

There are three unique kinds of hubs in the recommended arrangement:

i. **Patient nodes :** Patients' cell phones are known as "patient hubs." With the patient Dapp, which speaks with our Ethereum Blockchain network utilizing the Web3j Programming interface, these hubs approach the Blockchain. The JSON-RPC convention is utilized to lay out the association with the organization.

ii. **Physician nodes:** Specialists' PCs or cell phones are instances of specialist hubs. The subsequent kind looks like patient hubs. The qualification is that the doctor Dapp, not the patient Dapp, is answerable for keeping up with the connection with the Blockchain organization. It is facilitating light Ethereum clients like the first.

iii. **Hospital nodes:** Clinic hubs are hubs that are associated with general wellbeing associations and emergency clinics. As well as putting away the whole Blockchain, they are full Ethereum hubs that participate in the agreement method to support exchanges and add new blocks. Likewise, these hubs are a part of an individual IPFS network where we store the encoded information.

5.2. Data encryption/ decryption

The NuCypher-created Umbral limit intermediary re-encryption framework guarantees information encryption and decoding. We utilized pyUmbral, the Python reference execution of Umbral, in our work. In this work, we make portable Dapps for Ethereum and Android. Involving the Chaquopy Python SDK for Android, we had the option to incorporate pyUmbral into our Android code [20]. Python programming may now be utilized in Android applications on account of this SDK. How our technique executes the Umbral limit intermediary re-encryption is displayed in Fig. 2. We initially make a bunch of keys — public and mystery — for the patient and the specialist. The patient purposes his public key to scramble the information ($pk_{patient}$). then utilizes his mystery key and the specialist's public key to make the re-encryption key (P_{rek}). The emergency clinic (the total hub) will go about as an intermediary and yet again encode the information for the specialist after the re-encryption key has been produced. Assuming the specialist is approved to get to the information, the medical clinic checks this. Utilizing the re-encryption key without knowing the plaintext, the medical clinic re-scrambles information for the specialist on the off chance that he approaches authorizations. The specialist can then utilize his confidential key to unscramble the recently encoded material ($sk_{physician}$).
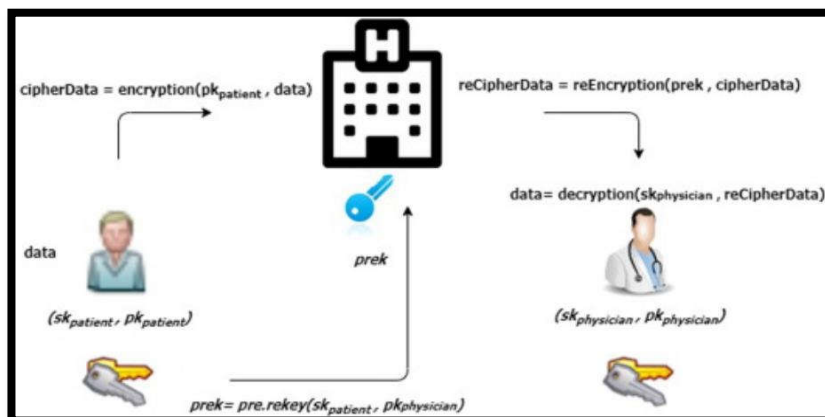

Figure 2: Proxy re-encryption is used in our architecture.

5.3. Data storage

Our Dapp then, at that point, communicates the encoded information to the IPFS for capacity subsequent to using the patient's public key to scramble it. Then, at that point, IPFS makes a particular hash for each piece of information. The Dapp saves the hash in the Blockchain when it is gotten. We involved the Java client for the IPFS HTTP Programming interface, java-ipfs-http-client [23,24], to speak with the IPFS hubs. The Ubuntu 18.04 hubs are utilized to convey the IPFS organization. A Raspberry Pi Model 3B mimics Web of Things gadgets. The means of our strategy's information stockpiling process are displayed in Fig. 3.[25]
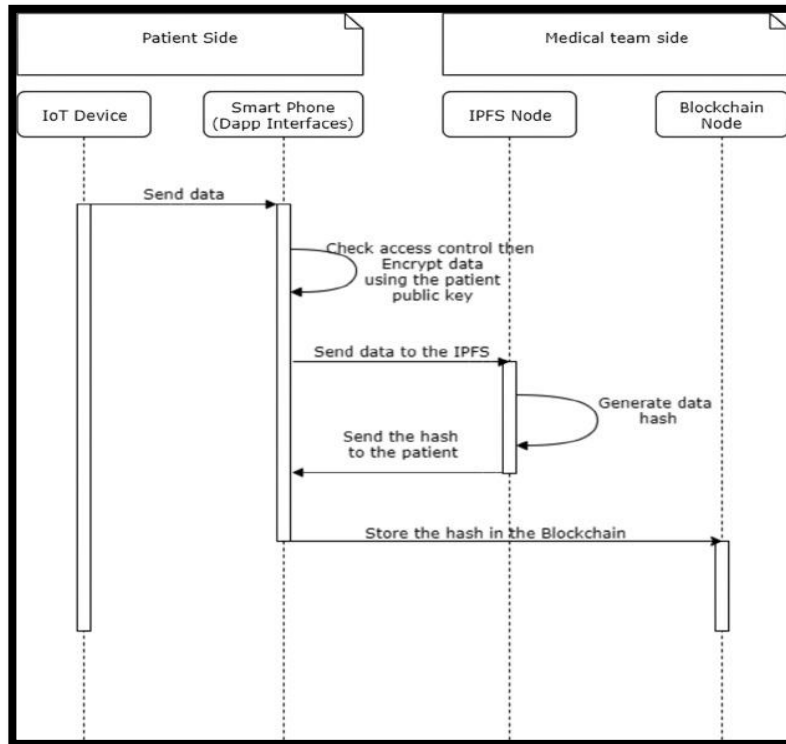

Figure 3: a flowchart for the storage of data

6. RESULTS AND DISCUSSION

We portray how the proposed procedure guarantees versatility and speedy handling time in this part. Likewise, we feature the essential security targets our procedure accomplishes and balance it with current techniques.

6.1. Processing time and scalability

The agreement calculation and the sort of information stockpiling utilized affect handling rate and versatility. The exchange throughput that a calculation offers is alluded to as a calculation's adaptability. Utilizing the PoA permits us to accomplish high throughput since it is subject to few validators. By putting away information hashes as opposed to the genuine information in the Blockchain, information adaptability is additionally ensured. By utilizing PoA, a low handling time is accomplished. Contrasted with networks utilizing PoW agreement, PoA networks have quicker exchange times. In our situation, as far as possible is set to 4700000, and the block arrangement period is set to 5 seconds. We can handle 45 exchanges each second with this arrangement (TPS). Table 2 gives an outline of the handling times for certain methods. PoA further develops execution as far as the time it takes to finish approval processes and the quantity of endorsed exchanges each second, making it more appropriate for permissioned Blockchains.

Table 2: Time spent processing in our model

Type of operation	Processing time (ms)
Block creation	6000
Physician registration	11493
Patient registration	11659
Device registration	9726
Send data	20758

6.2. Security analysis
6.2.1. Security model insurance

- **Security and availability:** Blockchain is utilized with IoT gadgets and information encryption to increment framework security due to its security properties. The decentralization and replication of information is one of the main parts of blockchain innovation. Thusly, the weak link is kept away from, and information accessibility is ensured. The use of

different clinical gadgets, cellphones, and Dapps that guarantee framework commitment helps our framework's availability too.

- **Privacy:** Utilizing numerous thoughts, the security of a patient is ensured: The first is utilizing the Blockchain's obscurity include. Every patient must be recognized by their extraordinary identifier, which makes it unimaginable for different hubs to distinguish them and limits their capacity to be recognized by their primary care physician. The second is information encryption; just his hash is kept up with in the Blockchain, while information is encoded and saved in IPFS. Controlling who approaches this information is the third.
- **Confidentiality:** The utilization of shrewd agreements, which are accountable for restricting admittance to this information, guarantees the classification of patient information in our framework. Therefore, clinical data is secure and can't be gotten to by unapproved people.
- **Integrity:** Our framework's information trustworthiness is worked on by the utilization of Blockchain innovation. One utilization of the Blockchain is for hash information capacity. Because of the permanence highlight, which prepares for information control, this hash couldn't be adjusted subsequent to being enrolled. The Blockchain's savvy contracts, then again, manage who gains admittance to the hash information. Therefore, just those with authorization can view and add information. Blockchain likewise empowers detectability by monitoring all information adjustments and activities.

6.2.2. Resistance to attacks

- **DDoS attacks:** A circulated forswearing of administration assault includes barraging a help with demands until it can't acknowledge any more, disturbing its not unexpected traffic. The proposed cure is totally founded on a decentralized and circulated framework that utilizes IPFS and Blockchain. This can upset DDoS attacks.
- **Impersonation attacks:** An enemy expects the character of a solid substance in this sort of assault. Since the ECDSA is trying to settle, the elliptic bend discrete logarithm issue is additionally difficult.
- **Message forgery attack:** It is utilized to phony or change messages, as the name recommends. Since each exchange in the organization is marked and verified prior to being put on the Blockchain, this assault is likewise unthinkable.
- **Man-in-the-middle attacks:** Without knowing without a doubt that the correspondence between the two substances has been compromised, this attack involves catching it. In our strategy, the exchange is marked and scrambled utilizing a confidential key that is simply known to its proprietor. The exchange should be endorsed by a real signature from the emanating address to be thought of as legitimate. Along these lines, it is extremely challenging for a programmer to make a phony mark without admittance to the comparing private key.

6.3. Scope of Improvement in Model

This model handles an assortment of medical care business issues, but there are still others that should be suitably addressed to get more ideal results. Sure of them are:

- ❖ **Mining:** Connecting exchanges to the current blockchain record open to all blockchain clients is a part of blockchain mining. Making a hash of an exchange block as a feature of mining jelly the reliability of the blockchain in general without the requirement for a unified organization. Mining is commonly performed on a particular PC, which requires a speedy processor, bigger utilization of force assets, and more energy utilization than expected. The principal motivator for mining is the chance of getting pay for utilizing a mining machine. IoT gadgets like the Raspberry Pi are in many cases low-end and have almost no processing power. As opposed to better quality gadgets, they are not a decent choice for hashing.
- ❖ **Processing Time:** The IoT framework will demand greater investment to do the appropriate capability, and this response time can possibly stretch.

7. CONCLUSION

IoT innovation is utilized in the present globe in each industry, including medical services, farming, and brilliant urban areas. IoT is utilized in the medical services industry for projects like routine patient wellbeing checking, drug following, and different things. IoT does, nonetheless, have various security worries that can be settled by combining it with the block chain. A decentralized strategy that can be used to further develop framework security is the block chain. Medical services and block tie innovation cooperate to safeguard patients' confidential wellbeing data from altering and breaks.

A model for the medical services area is put out in this study utilizing both block chain and IoT innovation. Continuous information is estimated and accumulated by IoT gadgets, and this information is hence put away in a block chain. We have really tried to resolve many issues confronting the medical services area notwithstanding the medical care model. In any case, there are sure things that should be possible better. IoT gadgets as of now consume more energy, however as innovation progresses, this can be diminished, empowering more individuals to utilize these administrations at decreased rates. Likewise, utilizing speedier, more productive encryption procedures and better processors, the postponement of adding a block to a block chain can be diminished. The proposed arrangement is totally decentralized and gives an elevated degree of safety by using IPFS, shrewd agreements, blockchain innovation, and block chains to oversee admittance to patient information, shield patient protection, and assurance information uprightness.

8. FUTURE SCOPE

We expect to develop this work in an ensuing exertion by trying our answer using the Hyper Record Block Chain and standing out it from the current Ethereum-based approach. To work on our framework's insight and add new capabilities, we likewise mean to incorporate man-made reasoning into it. We could offer information investigation, forecasts, and

anticipation utilizing man-made consciousness. The technique would help clinical experts in improving clinical decisions and conveying proficient consideration.

REFERENCES

[1]. Nakamoto S, Bitcoin A (2008) A peer-to-peer electronic cash system. Bitcoin. https://bitcoin. org/bitcoin. Pdf

[2]. Bahga A, Madisetti VK (2016) Blockchain platform for industrial internet of things. J Software Eng Appl 9(10):533–546

[3]. Pongnumkul S, Siripanpornchana C, Thajchayapong S (2017) Performance analysis of private blockchain platforms in varying workloads. In 2017 26th International conference on computer communication and networks (ICCCN) (pp 1–6), IEEE.

[4]. Shaikh Abdul Hannan; Ms. Preeti Gupta; P. Vanitha; Rajesh Singh; Dimple Saini; Mohit Tiwari, "Analysis of blockchain technology based on digital management systems and data mining technology", IEEE Xplore, 22 March 2023, ISBN:979-8-3503-9827-4.

[5]. Heena Vig, Shaikh Abdul Hannan, Asok Kumar, Rajshree Singh, Juhi Juwairiyaah, Neen Kuriakose, "Gender and Age Classification Enabled Blockchain Security Mechanism for assisting Mobile Application, IEEE Xplore, 22nd March 2023, ISBN: 979-8-3503-9827-4.

[6]. Shaikh Abdul Hannan, "A Blockchain Technology to secure electronic Health Records in Healthcare System, London Journal of Research in Computer Science and Technology, Vol 23, Issue 1, PP 1-13, London Journal Press, 10 Feb 2023, ISSN 2514-8648.

[7]. Ray PP (2018) A survey on Internet of Things architectures. J King Saud University-Comput Inf Sci 30(3):291–319

[8]. Sheikh JA, Akhter S, Parah SA, Bhat GM (2018) Blind digital speech watermarking using filter bank multicarrier modulation for 5G and IoT driven networks. Int J Speech Technol 21(3):715–722

[9]. Crosby M, Pattanayak P, Verma S, Kalyanaraman V (2016) Blockchain technology: Beyond bitcoin. Applied. Innovation 2(6–10):71 22.

[10]. Miller D (2018) Blockchain and the internet of things in the industrial sector. IT Professional 20(3):15–18

[11]. Esposito C, De Santis A, Tortora G, Chang H, Choo KKR (2018) Blockchain: a panacea for healthcare cloud-based data security and privacy? IEEE Cloud Computing 5(1):31–37

[12]. Dey T, Jaiswal S, Sunderkrishnan S, Katre N (2017). HealthSense: a medical use case of Internet of Things and blockchain. In: 2017 International conference on intelligent sustainable systems (ICISS) (pp 486–491) IEEE

[13]. Hanley M, Tewari H (2018) Managing lifetime healthcare data on the blockchain. In: 2018 IEEE smartworld, ubiquitous intelligence & computing, advanced & trusted computing, scalable computing & communications, cloud & big data computing, internet of people and smart city innovation, pp 246–251, IEEE

[14]. Alhadhrami Z, Alghfeli S, Alghfeli M, Abedlla JA, Shuaib K (2017) Introducing blockchains for healthcare. In: 2017 international conference on electrical and computing technologies and applications (ICECTA) (pp 1–4) IEEE

[15]. A. Azaria, A. Ekblaw, T. Vieira, A. Lippman, MedRec Using Blockchain for Medical Data Access and Permission Management 2016 2nd International Conference on Open and Big Data (OBD), IEEE, Vienna, Austria (2016), pp. 25-30, 10.1109/OBD.2016.11

[16]. A. Dwivedi, G. Srivastava, S. Dhar, R. Singh A Decentralized Privacy-Preserving Healthcare Blockchain for IoT Sensors, 19 (2) (2019), p. 326, 10.3390/s19020326 URL: http://www.mdpi.com/1424-8220/19/2/326

[17]. Rim Ben Fekih, and Mariam Lahami, (2020), "Application of Blockchain Technology in Healthcare: A Comprehensive Study", ICOST 2020, LNCS 12157, pp. 268–276, 2020.

[18]. Thomas Bocek_y, Bruno B. Rodrigues_, Tim Strasser_, Burkhard Stiller,(2017), "Blockchains Everywhere - A Use-case of Blockchains in the Pharma Supply-Chain", 2017 IFIP/IEEE International Symposium on Integrated Network Management (IM2017): Experience Session - Full Chapter

[19]. Yuan Y, Wang FY (2016) Towards blockchain-based intelligent transportation systems. In: 2016 IEEE 19th international conference on intelligent transportation systems (ITSC) (pp 2663–2668) IEEE.

[20]. P. Yu, Z. Xia, J. Fei, and S. Kumar Jha, "An application review of artificial intelligence in prevention and cure of COVID-19 pandemic," Computers, Materials & Continua, vol. 65, no. 1, pp. 743–760, 2020.

[21]. Arun Prasad, Shaikh Abdul Hannan, Kavita Panjwani, Muthe Ramu, Kawaender Singh Sidhu, Nagabhusanam Tida, "Detailed Investigation of the role of Artificial Intelligence in stock market predictions, British Journal of Administrative Management, Vol 58, Issue 06, 6th Sept 2022, UK.

[22]. Shaikh Abdul Hannan, "Heart Disease Diagnosis by using FFBP and GRNN algorithm of Neural Network", International Journal of Computer Science and Information Security, Vol 12, Number 6, June 2014, ISSN 1945-5500, United States of America.

[23]. F. Ajaz, "COVID-19: challenges and its technological solutions using IoT," Current Medical Imaging, 2021.

[24]. Chaquo Ltd. The easiest way to use Python in your Android app, online; accessed 21 December 2019; 2019. URL: https://chaquo.com/chaquopy

[25]. Community I. ipfs/java-ipfs-http-client, online; accessed 21 December 2019 (Dec. 2019). URL: https://github.com/ipfs/java-ipfs-http-client.