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Blockchain for IOT-based Healthcare: Background, Consensus, Platforms and Use Cases

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Abstract: *The area of e-healthcare is one of the most popular areas where Internet of Things (IoT) and blockchain technologies are being exploited extensively. IoT in healthcare allows for the collection of real-time sensory data through patients' devices. The collected IoT data undergo centralized computation, processing, and storage. However, this centralization can cause a number of problems such as acting as a single point of failure, mistrusts, data manipulations and tamperings, privacy invasions among others. For instance, blockchain can solve these serious issues by offering decentralized computation and storage for IoT data. Consequently, using both IoT and blockchain technologies integration can be an appropriate solution when building decentralized e-healthcare systems based on the principles of IoT technology especially block chain. In this article we first discuss briefly what Blockchain is all about then go ahead to study the leading consensus algorithms used in the field of health care using Blockchain. Then get an overview on which platform works best with E-Healthcare Systems that are built on IoT. In conclusion there will be few use cases provided methodologically showing how main peculiarities between IoT and Blockchain could be used to support health care services and ecosystems. And also we introduce a Data Flow Architecture named IOB Health which combines Internet-of-Things with Blockchain for storing accessing managing healthcare records Accordingly it is possible to note that combination of IoT with BCDN is expected to result into some unique innovation in medical practice.*

Keywords: Basics of Blockchain and IOT For e-Healthcare, IOT and Blockchain for e-Healthcare.

I. INTRODUCTION

The Internet of Things, or IoT, has become a crucial technological component in overcoming obstacles related to interoperability, heterogeneity, and Internet awareness in recent years. However, blockchain is also preparing to support trust less infrastructure, security, and immutability. Another industry that has a direct impact on people's lives is healthcare.

Up until now, there has been little emphasis and a deluge of research done to integrate and put these three sectors under one technological roof. In order to accomplish this, this article analyzes the operation of blockchain on various platforms while also making the case that IoT devices and ecosystems with limited resources cannot support full-fledged blockchain implementations. The main issue with the current blockchain is that it uses very computationally intensive hash operations, which are not necessary for noncritical systems. Examples of these systems include resource-constrained systems like the Internet of Things, which may be willing to trade some degree of data integrity for reduced computation and energy costs.

The first goal of this essay is to go over the different consensus algorithms that are already in use in blockchain networks of all kinds and identify which ones work best with IoT-based infrastructure to facilitate healthcare services. Next, popular IoT-blockchain platforms are examined to determine whether they are suitable for use in healthcare applications. To understand how these platforms differ or are comparable to each other, comparisons with consensus algorithms are also carried out. Methodological examples are provided for four use cases where IoT-blockchain can be effectively applied to improve healthcare applications. To satisfy the needs of health data management, a blockchain-layered architecture driven by organizations and patients is described. Lastly, a brand-new blockchain framework based on the Internet of Things is put forth that can combine the three major players in the healthcare industry: government agencies, health plans, and healthcare organizations. Additionally shown are the data flow, smart contract structure, and IoT-health block structure.

1.1. Related Work

To locate the most relaxing works that are similar to the proposed study, we search the IEEE Xplore, Springer link, and Science direct digital libraries using a set of different key words: {Blockchain AND IoT AND Healthcare}, {Blockchain AND IoT AND e-Health}, {Blockchain AND IoT AND Platform AND Healthcare}, and {Blockchain AND IoT AND Platform AND e-Health}. Ten articles were chosen from a total of 27 that were found through this search based on their importance, appropriateness, applicability, and uniqueness regarding blockchain-centric e-healthcare that is centred around the Internet of Things.

A remote electronic health care system with patients, healthcare providers, and professionals was proposed in [2]. In an Internet of Things scenario, sensors were utilized to measure patients' health conditions in real time, and the health records were saved onto a blockchain utilizing the TESTRPC Ethereum smart contract framework. Security and privacy of medical data are critical in real-world situations; as a result, a model was put up to address this problem [3]. The P6 need for smart e-healthcare, which encompasses the following qualities: 1) participative; 2) personalized; 3) precision; 4) predictive; 5) proactive; and 6) preventative aspects, has also recently been addressed with Ethereum [4]. Abdullah and Jones [5] looked into the patient safety and survival strategies that might be used on a health industry scale by combining blockchain technology and the Internet of Things.

A general review of distributed ledger and blockchain technology was presented in order to meet the demands of the e-healthcare and biomedical industries of the future [6]. For the purpose of enabling a patient to view, confirm, and edit his medical records on an Internet of Things multi layered system, researchers presented the Pseudonym-Based Encryption with Different Authorities concept [7]. Because trust is such a delicate topic, Yu et al. [8] suggested the IoT Chain architecture, which uses the Internet of Things and blockchain to manage patient health devices and data. An IoT-based blockchain-assisted dyslexic mobile health management system was created in [9] so that dyslexic people and those who provide care for them could utilize, save, and retrieve the dyslexic pattern within a framework for multimodal information sharing.

A few significant research holes in the current IoT-blockchain infrastructure for e-healthcare were identified by the literature review; these must be recognized and filled in order to fully employ IoT-centric health services. We discovered that:1) there isn't a survey or review that addresses the quality requirement of the current e-healthcare upgrade using the IoT and blockchain;2) there hasn't been a discussion about consensus algorithms in such a scenario;3) IoT-blockchain platforms haven't been looked into for use in health services; and4) methodological use cases for IoT-enabled blockchain e-healthcare haven't been developed. In order to foster a similar level of interest among the scientific community, this article helps to close these research gaps.

II. BASICS OF BLOCKCHAIN AND IOT FOR E-HEALTHCARE

Background of blockchain:

A blockchain is an expanding list of records connected by encryption, known as blocks. A cryptographic hash of the preceding block is contained in each new block. To put it succinctly, the blockchain is a straightforward yet clever method of securely and entirely automatically transferring information from point A to point B. By establishing a block, one participant to a transaction starts the process

1. Blockchain technology: The blockchain is the public ledger of all upcoming and completed transactions (such as those involving Bitcoin and Ether); a ledger is a record-keeping book that keeps track of all the transactions of an organization. Because it consists of a chain of blocks, this history of transactions is known as the block chain. Because miners are constantly adding new blocks to it to capture all of the latest transactions, it is expanding steadily. The order in which the blocks are added to the blockchain is consistently chronological and linear.
2. Miner: Adding transactions to the public or private ledger of a blockchain is known as blockchain mining. A node, or member of the same network, that may validate transactions through consensus-building is called a miner in a blockchain.

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3. Attack: An attempt to seize control of more than 50% of a network's hash rate, computing power, or mining power is known as a 51% attack on a blockchain by a single miner or group of miners. Such miners have the ability to prevent new transactions from happening or being validated.
4. Smart contract: is an application designed to carry out digital facilitation, verification, or enforcement of contract negotiation or execution by adhering to predetermined computer protocols. Typically, smart contracts enable transactions that are credible, trackable, irreversible, and do not involve the involvement of third parties.

   5.Smart detector: A revolutionary programming approach called a "smart detractor" is designed to prevent suspicious contract executions from occurring.

Blockchain Features for e healthcare:

1. Decentralization: With decentralized technology, you have the ability to store your assets (such as contracts, documents, etc.) and retrieve them via the Internet. Because the owner has complete control over his account, he or she can transfer ownership of the assets to anybody they choose.
2. Transparency: A blockchain's transparency arises from each public address's holding and transaction being visible to all.
3. Immutability: Data cannot be changed once they are entered into a ledger. Who you are doesn't matter; you are powerless to alter it. In the event of an error, the error must be corrected by creating a new transaction. Both of the transactions are viewable throughout that period.

Working principle:

These are the steps that make up the blockchain's operation.
1. A user of the blockchain network makes a transaction request.
2. The other members (i.e., nodes) are then shown this transaction request.
3. The transaction is subsequently approved by the network of nodes using validated algorithms.
4. They finish the transaction once the nodes have approved the request.
5. A new, unchangeable block is added to the blockchain network right away following the transaction.
6. Next, a new block of data is created by adding the verified transaction along with other transactions.

A public address and a special key are required for anyone wishing to add information to the blockchain; the private key is used to sign transactions. Because this kind of data is encrypted and replicates hundreds of times, it is extremely secure. To alter it, a hacker must take over over51% of the nodes.

Types of blockchain:

There are now four different kinds of blockchain networks that can be used: hybrid, private, consortium, and public.

1. Public blockchain: This kind of blockchain is not subject to any unique restrictions. Anyone with access to the Internet can join this kind of network and send transactions. Additionally, he or she can serve as a crucial validator by helping to ensure that consensus methods are executed efficiently. Public blockchains typically rely on methods that provide financial incentives in order to effectively use a certain kind of consensus algorithm to secure the system.
2. Private blockchain: This kind of blockchain is frequently referred to as permissioned, meaning that access to it is restricted to those invited by the blockchain network administrator, with limited roles for validators and participants. The majority of organizations and applications that need to handle sensitive data and maintain records use a private-permissioned approach to access blockchain technology.
3. Consortium blockchain: Also known as semi decentralized blockchain, it is a system in which several companies collaborate to make decisions that enable consumers to use blockchain services. Thus, the blockchain infrastructure is subject to rights limits while users are fitted with the permissioned approach.
4. Hybrid blockchain: It is defined as a blockchain network consisting of both public and private services. In practice, this kind of blockchain is employed when a user's access to both private and public data is seamlessly

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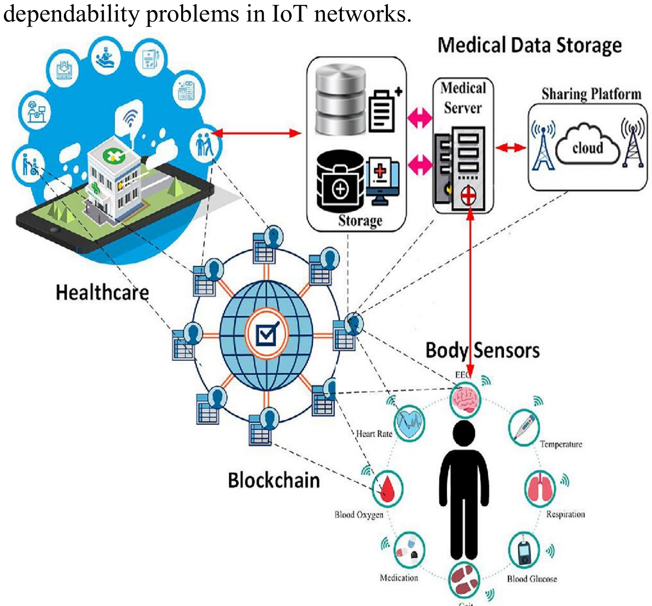
combined. Accordingly, a user in this blockchain might be granted free or permissioned access depending on particular implications as required by the application.

IOT and Blockchain for e-Healthcare:

The Internet of Things (IoT) is the expansion of Internet connectivity into tangible items and daily objects. These devices may be remotely monitored and controlled, and they can communicate and interact with others over the Internet thanks to their embedded electronics, Internet connectivity, and other technology. Blockchain is very appropriate for two purposes: 1) protecting the network from manipulation attempts that target stored data, and 2) offering a secure platform for all devices in the network to communicate with each other, especially considering the strict criteria for IoT networks. Let's talk about the drawbacks of the current paradigm and the opportunities blockchain presents for the Internet of Things-based e-healthcare system.

1. The majority of IoT networks in use today are built on the server–client architecture, in which every device is recognized, verified, and linked by means of cloud servers that need a massive amount of processing power and storage space. Furthermore, even if the devices are near to one another, all communication between them must occur via the Internet. Large-scale IoT networks also incur enormous costs for setting up numerous communication links, managing centralized clouds, and networking all devices. In addition to the expenses, the architecture is vulnerable to a single point of failure because of its reliance on cloud servers. IoT devices also need to be resistant to physical manipulation and information threats.

2. By dividing the processing and storage needs among all the devices in the network, blockchain creates a peer-to-peer network that lowers the installation and maintenance costs of centralized clouds, data centres, and networking equipment. The single-point-of-failure issue is resolved by using this communication model. Blockchain uses cryptographic techniques to overcome privacy issues for Internet of Things networks. By employing tamper-resistant ledgers, it also resolves the dependability problems in IoT networks.



Types of Block Chain Nodes:

For blockchain-based operations, there are two kinds of nodes that can be used: full nodes and lightweight nodes. The blockchain network's nodes are in charge of mining, data storage, block creation and validation, cryptocurrency purchase and distribution, and peer-to-peer information sharing.

1. Full Nodes

In a decentralized network, full nodes function as servers by generating, validating, and storing copies of the blockchains. Pruning nodes and archive nodes are two main categories into which these nodes can be classified.

a Pruned nodes: They start downloading blocks at the beginning and remove the oldest one when the predetermined limit is reached.

b. Archival nodes: They are conceptualized as servers that store the entire blockchain within their databases. There are four main kinds of archival nodes, and they can do the following functions.

Master nodes: are unable to validate transactions, add new blocks to the blockchain, or maintain a record of previous transactions.

Mining Nodes: These nodes have the ability to add blocks to it.

Staking node: Staking nodes are cryptocurrency purchase and storage devices.

Authority nodes: These kinds of nodes share knowledge with their colleagues.

2. Lightweight Nodes for Internet of Things e-Healthcare

These nodes just check the current status for which block is the last and broadcast transactions for processing (Header of Block); they do not store a copy of the chain or perform basic payment verification.

III. BLOCKCHAIN PLATFORMS FOR E-HEALTHCARE

Blockchain is a disruptive technology that has the potential to significantly impact a wide range of businesses. Since there are so many platforms and they are always changing, it is hard to analyze them all; therefore, we concentrate on the most well-liked and best suited for Internet of Things domains in this part.

1. Ethereum: Ethereum is a public distributed computing platform and operating system built on the blockchain that is available to the public and features smart contract capability. Through transaction-based state transitions, it facilitates a modified form of Nakamoto consensus.
2. Bitcoin: The original cryptocurrency, Bitcoin is an open-source digital asset. It is the original digital money to be decentralized. With Bitcoin, we may send and receive money from anywhere in the world and use it to make purchases of goods.
3. Ripple: Ripple is a real-time network for remittances, currency exchange, and gross settlement. It is based on a distributed open-source protocol and accepts tokens that stand in for fiat money, cryptocurrencies, commodities, or other value units like cell phone minutes or frequent flyer miles.
4. Quorum: Quorum is the best option for any application that has to conduct private transactions inside a known group of participants at a high speed and throughput. Quorum tackles certain obstacles to the adoption of blockchain technology in the banking sector and other domains.
5. Hyperledger Sawtooth is a modular platform that facilitates the creation, deployment, and operation of distributed ledgers. Distributed ledgers offer a digital record that is kept up to date without the need for central administration or implementation, such as asset ownership.
6. Hyperledger Fabric: One of the Hyperledger initiatives run by the Linux Foundation is Hyperledger Fabric, a blockchain framework implementation. Hyperledger Fabric is designed to serve as a framework for creating modular applications or solutions by enabling plug-and-play components like membership services and consensus.
7. Stellar: Any pair of currencies can be quickly transacted across borders with Stellar, an open-source decentralized payment system. This cryptocurrency uses blockchain technology to function, just like others.
8. NEO: Neo is a nonprofit, community-based blockchain project that uses digital identity and blockchain technology to automate asset management through smart contracts, digitize assets, and create a distributed network-based smart economy.
9. Medicalchain: Medical chain gives patients complete access and control over the electronic health record (EHR) that contains data. With the patient's consent, authorized healthcare professionals and physicians are permitted to "read/write" data on the EHR. As a result, a clever telemedicine service is established along with a cutting-edge EHR licensing structure.

Blockchain Consensus Algorithms in e-Healthcare

Blockchain uses consensus to establish a medium of agreement amongst all of its nodes. Numerous consensus algorithms exist for various cryptocurrencies. The following is a list of chosen consensus algorithms that can be applied to various use cases, including the provision of e-healthcare services [12].

1. Proof of work (PoW): According to a 1993 journal article, C. Dwork and M. Naor invented the notion. The PoW, which was first introduced and defined by M. Jakobsson and A. Juels in a 1999 study, is also referred to as the CPU price function, client puzzle, computational puzzle, and CPU cost function
2. Proof of stake (PoS): A node is selected at random or by lottery to mine the next block. It is the most democratic. There are no mining rewards or coins created; instead, rewards come in the form of transaction fees. A transaction fee may be awarded to a node in response to the Nothing at Stake issue. We believe that applying for e-healthcare applications could be a wise use of it.
3. Leased proof of stake (LPoS): It splits the benefit with wealth holders, resolves the centrality issue in the PoS, and allows the nodes with low balances and the lease contract. Using such an algorithm could promote an extremely high caliber e-health service.
4. Proof of importance (PoI): Compared to PoS, it is better. Nodes reputation plus balance are taken into account. The network is more effective now. We advise using it for e-healthcare services since patients may use the reputation of their doctors to help them make decisions.
5. Proof of capacity (PoC) is a better method than proof of work (PoW). In order to likely mine the next blocks of other nodes, it must store a large amount of data. The IoT should not use it. Additionally, it is not advised to use it for services related to health.
6. PoA, or proof of activity, is a cross between PoW and PoS. First, the PoW is finished. After a PoS, a collective of validators signs the transaction to add it to the miner's header. It is not a good option for e-healthcare because of its lengthy delay, making it unsuitable for the IoT.
7. Sending bitcoin to an address that cannot be recovered is known as "proof of burn" (PoB). A miner is prioritized to mine more burnt coins. Because cryptocurrency design is dependent on the existence of a monetary framework and coin burning, it is both good and harmful for the Internet of Things. Its random burning approach makes it unsuitable for applications linked to e-health.
8. Proof of elapsed time (PoET): suggested by Intel, it is an extremely low-energy upgrade on proof of work (PoW). The miner that wins is selected at random using a random wait time. IoT-friendly trusted execution environments include those made possible by Intel's Software Guard Extension (SGX). It may be evaluated against the e-healthcare system because of its extreme specificity to the SGX-based environment
9. The Stellar Consensus Protocol (SCP) is preferable than PBFT. The nomination protocol and the ballot protocol are the two steps that make up the SCP. low-latency microfinance services. As a result, the d APP developer may find it useful to frame a healthcare service using the SCP. A comparison of blockchain-supported consensus methods for e-healthcare features based on Internet of Things is shown in Table III.

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Uses Cases:

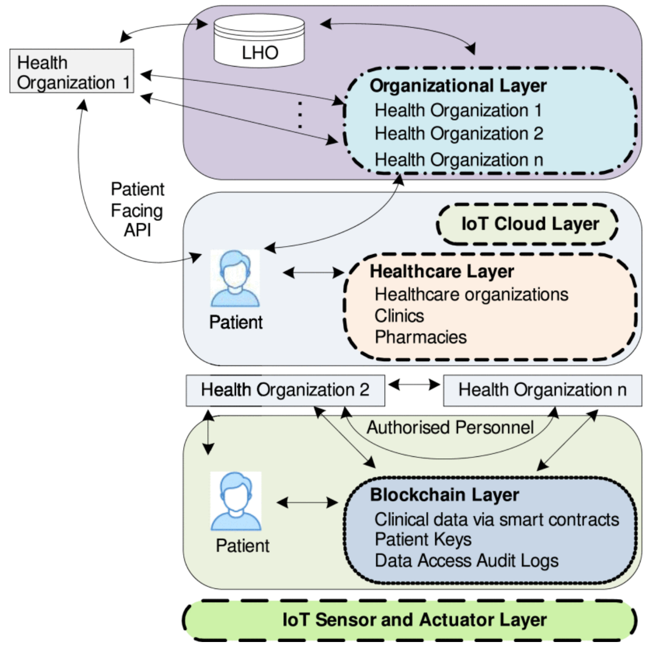

Fig: Blockchain ecosystem powered by patients and IoT for EHR data.

- **Medical Record Access**: proposes a hybrid e-healthcare layered ecosystem that addresses three key areas: 1) patient-driven interfaces; 2) organization-wise interfaces; and 3) blockchain integration within a sophisticated IoT-based framework. Under predetermined business agreements, the architecture can provide patient care through involvement from the local health organization (LHO) or direct healthcare organizations [13]. Healthcare businesses engage in entity-to-entity interfacing, wherein blockchain technology and patient-driven inseparability are seamlessly connected with Internet of Things (IoT)-based sensor, actuator, wearable, and cloud services. These companies may provide new patient-facing application programming interfaces (APIs) that could be used to obtain a patient's electronic health record (EHR). Smart contracts are utilized to enable patients to approve the exchange of EHRs between businesses 1 and n, even in cases where a previous commercial relationship may not exist.
- **EHR Claim and Billing Assessment:** The most significant losses associated with e-healthcare that must be prevented and eradicated are fraudulent billing and claims. Fraudulent activities related to billing occur in the ordinary e-healthcare sector. Such activities are typically caused by claims about the billing of e-health services that were not conducted, overcharging for the initial e-health services, utilizing pointless e-health services for a patient's medical condition, and accurately representing the noncovered e-healthcare services. While the current situation permits intermediaries to verify and decide claim-related data, it does not facilitate efficient communication between the parties to the bill settlement. By automating the essential operations and allowing the parties to share a single copy of the transaction, the blockchain-based IoT e-healthcare ecosystem may assist to mitigate most of these difficulties.
- **Clinical Research:** Highly deidentified patient data are necessary for clinical trials. The deidentification of patient data through consolidation is a time-consuming and expensive procedure that requires a significant investment of time and resources. Achieving exactness in the results of the underlying clinical trials is mostly dependent on two factors: 1) huge patient datasets must be deidentified; and 2) these datasets must be readily available. In a subsequent stage of the process, a meta-analysis is also required to determine whether the majority of e-health users are willing to submit their electronic health record (EHR) for clinical analysis and research, given that confidentiality and privacy are preserved. Building the blockchain would enable the visualization of this kind of trust-leveraging endeavor, which would have increased transparency. With an

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integrated hybrid blockchain facility, a ubiquitous e-health patient can leverage the Internet of Things architecture to secretly store and openly change their own EHR data. In order to facilitate the secure exchange of clinical information across community-driven clinical research and study, hybrid key cryptography can be used to communicate the DLT. IoT-based patients may quickly access and manage their own EHR and allow or deny access to EHR-data to the medical community. This greatly assists healthcare organizations in accessing the DLT through a sizable EHR library of precise and comprehensive clinical data.

- **Drug Supply Chain Management**: The use of fake medications causes a great deal of suffering and even death for a lot of patients each year. Pharmaceutical companies also suffer significant reputational damage and financial losses as a result of drug counterfeiting. The steps in the supply chain process could begin with the production of the drug and end with the patient. They could include: 1) shipping; 2) receiving; 3) warehousing; 4) redistributing; and 5) selling. Situations can go awry because of intentional activity or human error. To make every stage of the process visible, the IoT-based blockchain architecture may be used in place of the conventional supply chain management system. It is simple to enter a drug's supply chain records in the blockchain DLT, which is by nature permanent, immutable, and decentralized.
- **IOB Health: IOT Based Blockchain Integrated Framework For e-Healthcare:** In order to enable the smooth integration of blockchain technology and the Internet of Things for the provision of e-healthcare services, we present a novel data-flow architecture in this subsection called IOB Health. Three primary subsystems make up this framework: 1) IoT-based blockchain platform; 2) IoT-based e-health provider node; and 3) IoT-based e-healthcare patient node. It makes use of two different kinds of blockchain nodes: patient and healthcare provider nodes...

It is anticipated that the suggested framework will be able to enable the following benefits over traditional healthcare systems:
1.immutability and traceability for patients using the Internet of Things to facilitate the retrieval of EHR data without worrying about corruption or manipulation;
2.assured protection of EHR information;
3.Patients giving and withdrawing permits to third parties seeking access to EHR data;
4.providing patients with incentives when their EHR data is used flawlessly.
5.offer a cooperative framework for clinical research and trials pertaining to drug discovery, prescription, and delivery services to various healthcare organizations and pharmaceutical corporations via the worldwide DLT database;
6.reduced upkeep costs, enhanced compatibility, all-encompassing accessibility, and elevated integrity;
7.providing of integrated solutions for chronic health condition monitoring, payer/provider business-to-business communication, remote patient monitoring, asset monitoring, and e-healthcare adherence;
8.establishing a new ecosystem and business model based on the suggested IoT-blockchain e-healthcare scenario.
effective, hackle-free, secure, irreversible, transparent, and Providing highly decentralized EHR transmission and administration throughout the healthcare industry's stakeholder base is the primary motivation behind the IOB Health proposal. The architecture's suggested data flow properly captures the interplay between different healthcare industry players and the EHR transmission mechanism involved. The primary driving force behind the architecture is the consensus algorithm-enabled automated interaction between assumed blockchain and Internet of Things parts. The architecture shows the secure and uninterrupted paving of EHR transmission.

IV. CONCLUSION

The paper covered the use of IoT and blockchain technology to enhance e-Healthcare services and systems. Additionally, we put forth an enhanced Internet of Things (IoT)-based blockchain e-healthcare framework, known as IOB Health: the IoT-based blockchain framework for highly efficient, transparent, safe, and trusted access to and management of e-healthcare EHR data.

More effort will be put into integrating the IOB Health data-flow architecture with IoT-based EHR administration through the use of tool sets and protocols that are practicable, affordable, dependable, and resource-constrained. Our goal is to create a more efficient approach that reduces the amount of EHR transfer and management while utilizing the greatest blockchain platform currently available. To make sure that the entities or stakeholders in the system may

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lawfully access the secure EHR data, two-factor and multifactor authentication systems could be validated against the suggested data-flow architecture. In order to make the suggested design more beneficial in the given situation, we also believe that research into a workable and quicker consensus mechanism should be conducted.

Furthermore, it is possible to test machine learning methods as predictors of underlying time-series EHR data, particularly recurrent neural networks and long short-term memory models.

REFERENCES

[1] T. M. Fernndez-Carams and P. Fraga-Lamas, "A review on the use of blockchain for the Internet of things", *IEEE Access*,

[2] H. L. Pham, T. H. Tran and Y. Nakashima, "A secure remote healthcare system for hospital using blockchain smart contract", *Proc. IEEE Globecom Workshops*, pp. 1-6, 2018.

[3]. S.Chakraborty, S. Aich and H. C. Kim, "A secure healthcare system design framework using blockchain technology", *Proc. 21st Int. Conf. Adv. Commun. Technol.*, pp. 260-264, 2019.

[4] A. K. Talukder, M. Chaitanya, D. Arnold and K. Sakurai, "Proof of disease: A blockchain consensus protocol for accurate medical decisions and reducing the disease burden", *Proc. IEEE SmartWorld Ubiquitous Intell. Comput. Adv. Trusted Comput. Scalable Comput. Commun. Cloud Big Data Comput. Internet People Smart City Innov.*, pp. 257-262, 2018.

[5] T. Abdullah and A. Jones, "eHealth: Challenges far integrating blockchain within healthcare", *Proc. IEEE 12th Int. Conf. Global Secur. Saf. Sustain.*, pp. 1-9, 2019.

[6] T.-T. Kuo, H.-E. Kim and L. Ohno-Machado, "Blockchain distributed ledger technologies for biomedical and health care applications", *J. Amer. Med. Inform. Assoc.*, vol. 24, no. 6, pp. 1211-1220, 2017.

[7] S. Badr, I. Gomaa and E. A. Elrahmanb, "Multi-tier blockchain framework for IoT-EHRs systems", *Procedia Comput. Sci.*, vol. 141, pp. 159-166, 2018.

[8] B. Yu, J. Wright, S. Nepal, L. Zhu, J. Liu and R. Ranjan, "IoTChain: Establishing trust in the Internet of things ecosystem using blockchain", *IEEE Cloud Comput.*, vol. 5, no. 4, pp. 12-13, Jul./Aug 2018.

[9] Md. A. Rahman, E. Hassanain, M. M. Rashid, S. J. Barnes and M. S. Hossain, "Spatial blockchain-based secure mass screening framework for children with dyslexia", *IEEE Access*, vol. 6, pp. 61876-61885, 2018.

[10] Md. A. Salahuddin, A. Al-Fuqaha, M. Guizani, K. Shuaib and F. Sallabi, "Softwarization of Internet of Things infrastructure for secure and smart healthcare", *Computer*, vol. 50, pp. 74-79, 2017.

[11] M. A. Uddin, A. Stranieri, I. Gondal and V. Balasubramanian, "Continuous patient monitoring with a patient centric agent: A block architecture", *IEEE Access*, vol. 6, pp. 32700-32726, 2018.

[12] M. Salimitari and M. Chatterjee, "A survey on consensus protocols in blockchain for IoT networks", Mar. 2019.

[13] J. G. William and C. Christian, "Blockchain technology for healthcare: Facilitating the transition to patient-driven interoperability", *Comput. Struct. Biotechnol. J.*, vol. 16, pp. 224-230, 2018.