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Blockchain-based Scalable IoT Cloud for Electronic Health Record using Horizontal and Vertical Mining

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Abstract: The twin technology of Blockchain with IoT(BIoT) deployed in healthcare systems has fetched out the mutative potentiality for accessing and managing Electronic Health Records(EHRs). However, this divergence also has considerable challenges, primarily in terms of the protection of data, scalability, and interoperability. To overcome these challenges, this research paper presents a new approach, leveraging Blockchain technology and mining mechanisms, to launch a secure, scalable, and proficient IoT cloud ecosystem for the administration of Electronic Health Records. This research study includes Blockchain scalable IoT cloud architecture intended to address the scalability problem of storing and managing large amounts of EHR records produced through IoT sensors. The proposed mechanism implements both horizontal and vertical mining concepts for the optimization of data storage as well as the retrieval processes. Horizontal mining concentrates on allocating and distributing Electronic Health Records data to more than one node, which can ultimately sink the overload on each node in the network and increase the scalability. Vertical mining, on the other flip of the coin, prioritizes the transactions, and optimizing the data with each transaction can drastically improve the acceleration speed of retrieving the data access competency. Blockchain technology constructs the core technology of BEHRHVM, assuring data integrity, privacy, and transparency. All the EHR record transactions are authorized as mutable blocks on the Blockchain framework. This mechanism improved patient privacy while accessing the secure distribution of EHRs among authorized health providers. In addition, the proposed system is built to integrate with current healthcare systems and the Internet of Things.

Keywords: Blockchain, IoT, Horizontal mining, Vertical mining

I. INTRODUCTION

Healthcare providers have required data protection due to massive electronic health records. Security and scalability are the two major concerns when the transactions are computed parallel and distributed [1]. The goal of integrating Blockchain with the Internet of Things is for the cloud to safeguard and secure medical data due to its vulnerability to security breaches and data attacks like forgery, manipulation, privacy leakages, etc. In many research articles, could find that the tighter these two twin technologies will provide more advanced security procedures being provided. Perhaps mining entire healthcare data transactions in the cloud environment with miners is still challenging [2]. To overcome this problem, the proposed mechanism efficiently executes all transactions through horizontal and vertical mining. Thus, this research pays attention to the metrics that proficiently handle the healthcare transactions by miners and convert them into authorized Blockchain technology in a cloud storage environment for the healthcare system's protection, eventually increasing the knowledge about Blockchain among the people [3].

Mining and authorizing healthcare transactions are essential to achieving scalability, which is the capability to enlarge the Blockchain network's current design to control higher transaction loads [4]. Scaling can be completed in two ways: a. horizontal scaling is attained by advancing the current system's configuration. b. Vertical Scaling is established by adding hardware requirements. Blockchain implementation and espousal were found to be influenced by expectancy and social fluency.

Horizontal scaling is the procedure used to increase the system's performance efficiency by adding more systems, which raises the number of miners in the existing network so that the transaction load can be equally dispersed [5]. This kind of enlargement is also known as the scaling out of the infrastructure. Sometimes, like COVID times, the health records will be quickly authenticated, the transaction loads on the existing systems will be increased, and there will be a need to expand the disk capacity [6]. Among the two scaling, horizontal scaling is significantly more straightforward than adding machines to the existing infrastructure. The important note is the data is dispersed across the nodes, with each system consisting of only one part of the data.

Horizontal scaling has a lot of benefits, like a. Easily scalable tools and b. Quickly fix the fault tolerance c. Easy to upgrade the efficiency to execute the transactions d. improved flexibility because of discrete and multiple systems in the network, e. It can employ infinite scale and manage massive instances to facilitate endless growth [7]. Horizontal scaling has some demerits, too. a. Some of them are that the change of entire architecture may be

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highly complicated. b. payment of high licensing fees c. it can raise the total utility cost d. there is a requirement to devote extra networking devices such as routers and switches. In this midst, the betterment is not to change the capacity of individual servers; as a substitution, decline the load of particular systems [8].

Vertical scaling ensures the enlargement of an existing network by adding more power and memory to the system's core processing unit. When concerned with the subjectivity of scalability, it's noteworthy to recognize that the idea is commonly implemented to execute when one needs to enhance the transactional capacity of a particular platform [9]. In a security standpoint, the scalability of the Blockchains is more functional and practical since transaction trading is involved. When carrying out the model scalability in the Blockchain technology framework, it should be emphasized that Blockchain technology is a decentralized network; raising the network's entire throughput is tedious by simply attaching more hardware elements like miners and nodes [10].

To be more precise, when horizontal scaling enhances the trust in a network framework, it is usually reflected in the entire execution of the transactional processing capacity of the system while being ruined [11]. On the other flip side of the coin, vertical scaling usually means constructing each internal element of a node becomes faster and more robust, based on the distributed ledger mechanism, which entails the application of supercomputer nodes where only a few elected miners are proficient in executing such nodes [12].

In much simpler terms, the common expression scalability enhancements are built using a model called 'Layering' in which each discrete element of a specific node is constructed to incorporate its digital equivalent in some sequential and hierarchical arrangement [13]. When it comes to blockchain in healthcare, miners are supposed to maintain the 'immutability' of their base healthcare chain, which then converts the transactions into a scalability layer to control the security of the parent chain [14]. An example that ultimately brings out the foremost scheme revealed concept is that the 'Lightning of network' is a technology that controls the protection of healthcare transactions to increase the system's entire transaction throughput [15].

The experimental results of the proposed system exhibit its scalability and can handle massive amounts of EHR data [16]. The horizontal and vertical mining mechanism promotes a potential solution to the challenge caused by the combination of IoT in the healthcare system [17. This setup emphasizes data security and scalability and endorses interoperability and data sharing among healthcare providers, leading to enhanced patient care and a digital healthcare system [18].

Objectives

Security and privacy assure the protection and confidentiality of electronic health records by applying the chain's cryptographic algorithm and distribution and employing access control mechanisms and encryption techniques to safeguard patients' data from malicious activities [19]-[20].

Scalability, it proposes the system to hold massive IoT devices and EHR data by applying a horizontal scaling mechanism. This involves installing more servers or nodes in the Blockchain network to handle heavy data traffic. Vertical mining optimizes resource allocation and increases the system's ability to execute complex computational tasks and process data [21]-[22].

Interoperability, which assists the exchange of data among different healthcare providers, systems, and IoT devices by implementing standardized data formats and communication protocols, ensures that data from diverse sources can be flawlessly incorporated into the electronic healthcare system [23][24][32].

Reliability, To ensure the reliability and accessibility of HER data, copies are dispersed on more than one node in the Blockchain network to avoid a single node failure, and redundancy and failover procedures are employed to guarantee constant access to health records [25]-[26].

Compliance, to confirm compliance with appropriate healthcare acts such as the Health Insurance Portability and Accountability Act (HIPAA) in the US or the General Data Protection Regulation Act in Europe. It facilitates patients' access to their data and offers mechanisms for consent management [27].

Efficiency, optimization of Computational resources by vertical mining procedure to diminish energy consumption and operational costs, and execution of efficient data storage and recovery mechanisms to minimize latency and response times [28].

Continuous Scrutinizing and Development, Through examining and analytics tools to incessantly evaluate the System's routine, security, and observance. It ensures periodic updating and enhancement of the system built on feedback, comments, and rising technologies [29-31].

These objectives can create a robust, scalable, and protected ecosystem for the administration of

Electronic health records through Blockchain technology and mining mechanisms. Attaining these goals can considerably develop the quality of healthcare services when protecting patient's privacy and data authentication.

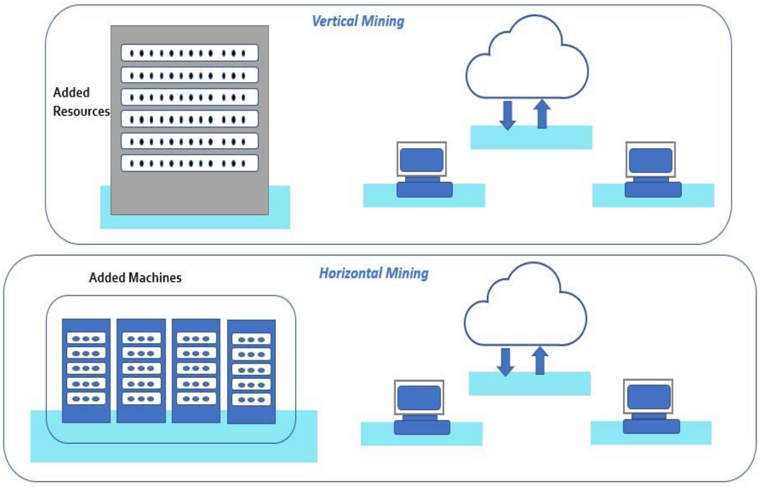


Fig. 1 Horizontal Mining and Vertical Mining

II. Literature Survey

Rathee and Sharma et al.[12] have evaluated multimedia data processing and IoT healthcare data, providing a solid healthcare framework built on the Blockchain framework. The recommended framework enlarges the Blockchain progress to ensure the security and authentication of patients' records, document accessibility, and the shipment mechanism between healthcare providers and Clients. In addition, blockchain in healthcare requires it to gather intermediate activities, such as healthcare data and drug shipment procedures through IoT devices from the provider to the client. The authors provided the experimental results of hostile IoT devices separate from illegal activity, comprising the product decrease percentage, physical attack, intrusion detection, and probability of verification, exposing an 86% success rate.

Kristen N. Griggs1 and Olya Ossipova et.al [23] have addressed the security measures for transferring and logging EHR data transactions in an IoT environment. They have implemented Blockchain smart contracts to conduct real-time analysis and log transactional metadata from medicinal data sensors in WBAN. Their system would comprise a permissioned consortium blockchain to perform smart contracts that execute patients' IoT health care data to operate smart contracts that can assess the information gathered by patients' IoT health care devices built upon customized threshold values. The smart contracts would activate for patients and health care providers and record details about verifying transactions in a Blockchain environment. The authors use a proof of concept; they coded smart contracts using solidity to express the data in the system.

Gautam Srivastava and Jorge Crichigno et. al [10] have proposed integrating Blockchain security with the Internet of Things built on Remote patient monitoring. This paper projected the applications and real-time hurdles of blockchain protection methods in remote patient monitoring by IoT devices. In addition, the paper executes several cryptographic technologies for implementation in IoT. This paper introduces a new Blockchain with IoT to offer advanced security and privacy aspects to the current IoT –RPMS (Remote Patient Monitoring System). Some challenges and issues persist through Blockchain with IoT. The author's proposed model provides reliable data communication among the storage network in the cloud with more advanced and lightweight cryptographic techniques such as the ARX encryption mechanism. They implement the concept of Ring Signatures that offer privacy parameters like signers' anonymity and signature correctness. They also execute a double encryption scheme.

Ahmed I. Taloba , Ahmed Elhadad, et al.[5] have executed multimedia data execution in an IoT healthcare system and provided an immutable Blockchain framework. Each action extracted from an IoT device is recorded within the Blockchain to ensure integrity and transparency between patients and mediators and to trace all the activities in a track. The proposed technology enlarges the blockchain progress to ensure the security and integrity of patient records. The Blockchain suggested framework research study has been built on illegal activities or interactions by IoT devices—the experimental result of unreceptive IoT devices of unlawful acts. Furthermore, future research will be implied on authenticated transactional periods or the cost of multimedia information transmission procedures in healthcare data.

Gagangeet Singh Aujla [8] has proposed a method that offers a speedy and competent way to connect IoT healthcare data to edge devices. This mechanism provides the decoupled Blockchain method to split the block headers and ledgers, which decreases the block preparation and header creation period when protecting the security since it corresponds to collecting the data. In addition, passing the data from edge devices to the cloud server, the proposed mechanism tensor train method has been used, which can reduce the memory space in the cloud along with error-free data. The outcome of this Blockchain and the tensor-based proposed mechanism will establish the efficiency of the proposed approach.

Muhammad Hassan Nasir et al.[13] have elaborated that Blockchain scalability is one of the biggest challenges that can bind pervasive usage in various application domains. This paper has elaborated on the challenges and the prominence of the current work to address this problem for blockchains. Significantly, describing Blockchain scalability as a core concept, the paper has recognized and elaborated in different dimensions, improving the concept's scope along with Blockchains. This paper has elaborated on defining the concepts in three dimensions: a. Procedures and methods aim to tend to Blockchain scalability through the execution of Blockchain functions. b. Blockchain application to attain scalable solutions c. Working Mechanisms to describe the scalability challenges by analyzing Blockchain framework settings. The author's future work consists of improving the integration of consensus algorithms to recognize and find their role in improving the scalability of blockchains.

Yang Wang et al.[17] have studied Blockchain technology of commercial vertical value chain management. The studies show how the Blockchain technology is executed to the several transaction data which are related to the requirement of Commercial vertical value chain management and explore the distributed management, reliability, and authentication of the transaction management system; the setup has been designed and implemented in various commercial purpose of Blockchain vertical value chain management. The testing simulation data is a mandatory requirement for testing the data. At last, the Blockchain solution is evaluated based on security, transparency, efficiency, and scalability.

III. Research Methodology

Blockchain-based Scalable IoT Cloud for Electronic Health Records using Horizontal and Vertical Mining work consists of two stand-in modules: Fuzzy IoT private cloud usage estimator and Horizontal-Vertical Mining infrastructure dealer. The first module is used to perceive the cloud resources' usage pattern and predict the nearest approaching resource requirement. The second module is used to allocate or to free up the cloud resources based on the requirement.

3.1. Fuzzy IoT Private Cloud Usage Estimator (FIPCUE)

FIPCUE schemes to observe the usage pattern and to predict the demand for cloud resources based on the perceived timeline. Incorporating blockchain in EHR improves Interoperability, Authentication, Security, and Transparency. Record Creation, Communion, Modification, and Deletion are some of the basic operations performed in EHR. Thus, the creation of a new Hyperledger ledger, calculation of new nonce and hashes, and calculations related to authentication and sharing are the related operations that must be performed in the blockchain. The ideology behind the FIPCUE module is to observe the sequence of these basic operations and their computational resource demands and predict the upcoming resource demand based on the timeline data. Whenever a new entry occurs, massive computational power is required to find the nonce to fulfill the security mechanism of the particular blockchain system. Moderate computational resources are sufficient to handle the intermediate authentications and data sharing. Storage resources are vital in all the creation, modification, and nullification processes. These processes are represented as Activities in the FIPCUE module initiated as set $A = \{\alpha 1, \alpha 2 \dots \alpha n\}$.

The primary computational resources are maintained in a set $R = \{rp, rc, rm, rs, rn\}$ in which rp refers, the processor rc refers the cache memory, rm refers the memory, rs refers the storage and rn refers the network resources. FIPCUE introduces an Activity Power Table (APT) to maintain the resource demands of these activities. The architecture of the FIPCUE APT format is given in Figure 2.

APT					
Activity	Resource Usage				
	r_p	r_c	r_m	r_s	r_n
α_1					
α_2					
α_3					
....					
α_n					

Fig 2. Activity-Power Table

The table entries are initialized with the corresponding values when an Activity occurs for the first time. Then for every new occurrence, the table values of that particular activity for corresponding resource will be calculated using equation 1.

$$r_{x_u} = \frac{1}{2}\left(r_{x_c} + r_{x_n}\right) \quad \text{Equation (1)}$$

where r_{x_u} is the updated resource demand, r_{x_c} is the current table value of the resource, and r_{x_n} is the new demand of the particular resource for the same activity.

The FIPCUE module follows the typical resource priority as Processor, Cache, Memory, Storage and Network in order listed from the highest for decision making. The overall normalized resource quantification r_q is calculated using the following equation.

$$r_q = \frac{1}{5}\left(\left(2^4 \times r_p\right) + (2^3 \times r_c) + (2^2 \times r_m) + (2^2 \times r_s) + (2^1 \times r_n)\right) \quad \text{Equation (2)}$$

The ratio between two successive resource usage $\rho$is calculated as in Equation 3

$$\rho = \frac{r_{q_t}}{r_{q_{t-1}}} \quad \text{Equation (3)}$$

The cloud usage estimation is further categorized into three different categories based on the following equation

$$\varepsilon = \begin{cases} Increase \;\; if\; \rho > 1 + \left(\frac{\varphi}{100}\right) \\ Sustain\; if\; 1 - \left(\frac{\varphi}{100}\right) < \; \rho \le 1 + \left(\frac{\varphi}{100}\right) \\ Decrease\; otherwise \end{cases} \quad \text{Equation (4)}$$

where ρ is the cloud resource demand ratio, and φ is the permitted inertia threshold assigned with the condition$10\ \% \le \varphi \le 20\ \%$

A typical timeline diagram with blockchain related processes and corresponding predictions of FIPCUE module is illustrated in Figure 2.

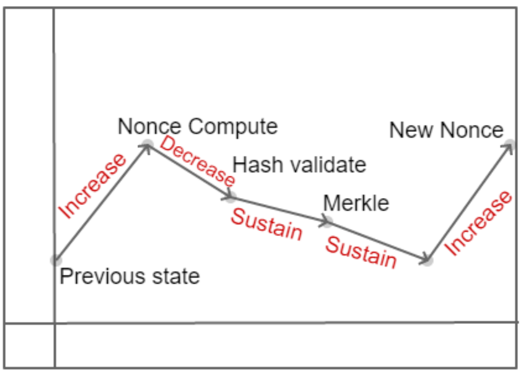


Fig 2. Timeline diagram for FIPCUE module

By this way the FIPCUE module forecasts the direction of the cloud resource utilization swiftly with adequate precision.

4.2. Horizontal-Vertical Mining based Infrastructure Dealer (HVMID)

Horizontal and Vertical mining methodologies has their own merits and limitations. Both are brought into the proposed method to cope up with the real-world EHR requirements. The vertical mining requires a single core high performance computing resources whereas the horizontal mining can be performed better in multicore computing environments. HVMID module is used to allocate the cloud resources dynamically based on the requirements for horizontal and vertical mining processes.

The vertical mining itself requires more computational power sometimes, thus allocation of more virtual machines can improve the performance significantly. HVMID module is designed in a way to monitor the requirement of multiple computational resources such as processors, cache memories, Random Access Memories, Storages and Network interfaces. HVMID module expands or shrinks the resources of a single virtual machine for faster response. HVMID also triggers the allocation of new virtual machines in two situations. The first one is when there is a severe need of single computational resource for completing a blockchain related process.

The second criterion requires more than two computational resources and more than a threshold value simultaneously. The type of computational resource is taken care of by the FIPCUE module, whereas the number of resources is taken in the HVMID module. That is, instead of using the notations r_p, r_c, r_m, r_s, r_n, the sequential representation r_1, r_2, r_3, r_4, r_5 are used in HVMID module. A resource usage change flag ς is computed in HVMID using the equation 5.

$$\varsigma = \begin{cases} 1 \; if \; \left| r_{x_t} - r_{x_{t-1}} \right| > \frac{r_{x_{max}}}{10} \\ 0 \; otherwise \end{cases} \qquad \text{Equation (5)}$$

Where r_{x_t} is the current resource demand of resource r_x, $r_{x_{t-1}}$ refers the previous demand for resource r_x, and $r_{x_{max}}$ is the maximum quantity allocated for particular resource r_x.

The high impact single resource demand change flag ξ is computed using the following equation.

$$\xi = \begin{cases} 1 \; if \; \forall i = 1 \rightarrow n :: \left| r_{x_t} - r_{x_{t-1}} \right| > \frac{r_{x_{max}}}{40} \\ 0 \; otherwise \end{cases} \qquad \text{Equation (6)}$$

Algorithm 1: Horizontal-Vertical Mining based Infrastructure Dealer

Input: Timeline resource demands $\{r_{1_t}, r_{2_t} \dots r_{n_t}\}$, $\{r_{1_{t-1}}, r_{2_{t-1}}, \dots r_{n_{t-1}}\}$, ε

Output: Resource Allocation Mode (for Horizontal / Vertical Mining)

Step 1: Read resource demand quantities

Step 2: Initiate Resource usage change flag counter $c = 0$

Step 3: $\forall \mathrm{i} = 1 \rightarrow n :: increment \; c \; if \; \varsigma = 1$ by Equation (5)

Step 4: If $\varepsilon = Increase$

Step 5: If $\varsigma > 2$ or $\xi = 1$ Add VMs to the infrastructure

Step 6: Else Expand resource on current VM

Step 7: If $\varepsilon = Decrease$

Step 8: If $c > 2$ or $\xi = 1$Remove VMs to the infrastructure

Step 9: Else Shrink resource on current VM

Step 10: Repeat from Step 1

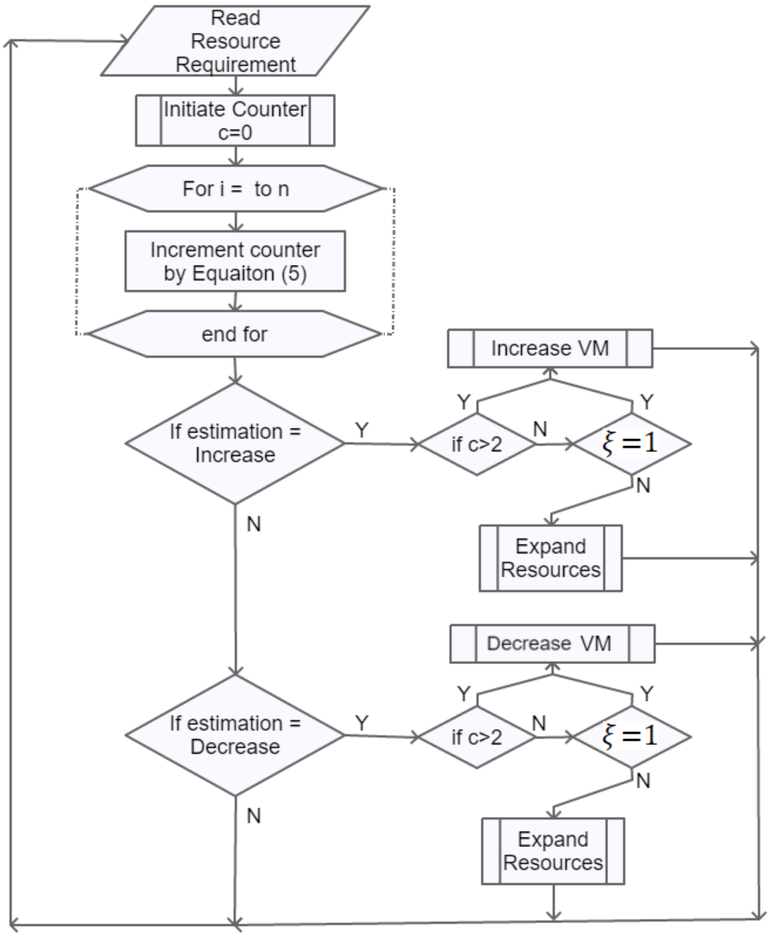


Fig 3. The top tier flow diagram of Horizontal-Vertical Mining based Infrastructure Dealer

The integration of FIPCUE and HVMID modules correlates the Electronic Health records-related blockchain processes and the power demand in the IoT cloud environment precisely to improve the overall performance of the network environment.

IV. Experimental Setup

The experimental setup of the proposed system is achieved through the Windows 10 Operating System with Intel Core TM i-5. The RAM Size is 8 GB, and a 64-bit Operating System x64-built processor. The proposed methodology has been framed with Visual Studio 2019. In the proposed mechanism, the patient is made to wear IoT-health care devices like blood pressure monitors, insulin pumps, etc., which are continuously developing in current healthcare services; the health information transactions are sent to the Blockchain network to authenticate applications. Once authentication is completed, the relevant report for the entire analysis embedded with threshold value is sent as the mined Blocks. The threshold value determines whether the particular resources in the system are sufficient to handle the mining transactions or whether the system needs to expand or include the systems in the Blockchain network. When mining the transactions, the smart contract would generate an event and alert the patient if abnormal health readings were detected. It accumulates the strange transactions to the cloud servers and will be directed to the overlaying network as a hash of the stored data. When health data is moved to the cloud server, the miner must add a digital signature to the transactional data.

The resources will be considered when mining the data. When many transactions arrive for mining, there is a need to determine whether horizontal or vertical mining is required. The proposed mechanism treats the alarm as a transaction of definite users and implements all the advanced cryptographic hashing techniques based on the algorithm described in section 4. When the healthcare provider node gets an alarm, they admittance the entire health recording of patients for authorization over the network.

V.Results And Discussion

The solutions derived for the vertical value chain management of Enterprises are built upon the Blockchain Framework; the Hyperledger Fabric platform is constructed in the Ubuntu system through the Docker environment; the version is v1.3.0.Software testing plays a vital role in the entire software construction process for fetching out the defects and bugs in the software design and operational process of the entire software by various tests, analysed data, at last, sort out the specific results for analysing the software and give the proof of the reliability of the system for ensuring the extreme quality and reliability of software.

The analysis of this paper is intended to authenticate the results, which attain the functionalities specified above and encounter the necessities of enterprise vertical value chain management.

5.1 Testing environment

The hardware environment for testing in this paper is as follows:

CPU: Intel core i5-3,210 M; memory: 8 G; Hard disk: 1 T.

The software environment is as follows:

Operating system: Ubuntu 18.04.1 LTS, Docker version 18.06.1-ce, build e68fc7a,

Go language version: go1.10.4 Linux/AMD64, Hyperledger Fabric version: v1.3.0.

5.2 Average Processing Time and Average Authentication Time

Average Processing Time: It denotes the duration taken for a transaction or execution associated with EHR data within the Blockchain frame to be accomplished. BSEHRHVM comprises tasks such as inserting new records, updating the current records, or performing any executions based on EHR in a Blockchain. The execution time can be affected by various factors such as transaction complexity, network congestion, consensus mechanisms, and overall efficiency of the Blockchain network.

Average Authentication Time: Given EHR on a Blockchain, authentication time describes the time to authenticate and access the records. This process ensures the cryptographic techniques and approval to confirm that only authorized persons or entities can verify and edit the EHR data. Authentication duration can be the duration reserved for identity verification, cryptographic validation, and consent checks before accessing particular EHR data.

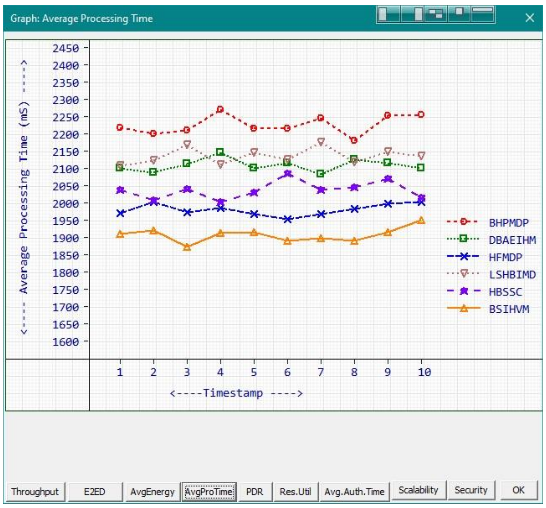


Fig 4.Average Processing Time

Fig 5.Average Authentication Time

5.3. Average Energy Consumption and End-to-End Delay

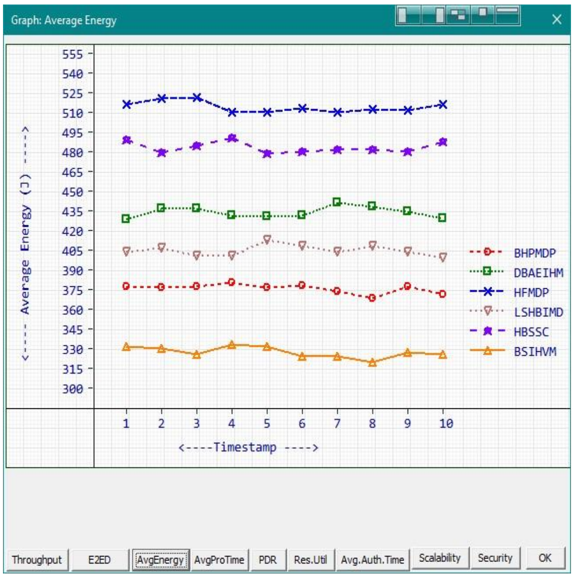


Fig 6. Average Energy

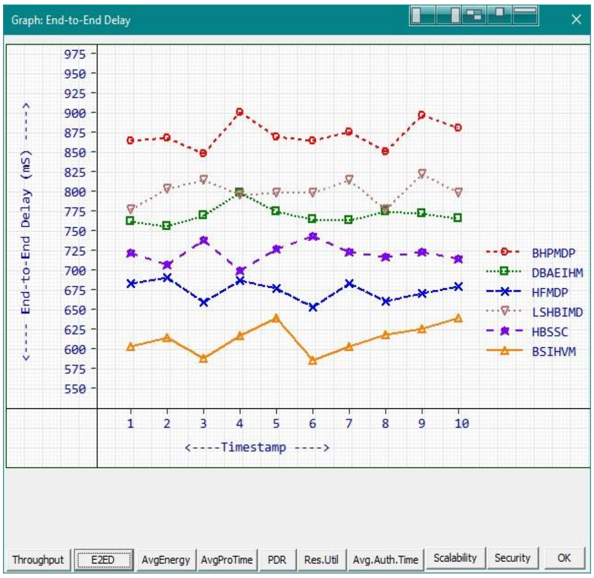


Fig 7.End-to-End Delay

Average Energy consumption is a vital parameter in Blockchain networks when it comes explicitly to IoT. All the IoT devices are probably battery functioning; therefore, the power ingesting directly impacts the entire network lifetime. The measurement of Energy consumption (εc)is restrained by using the formula $\varepsilon - \varepsilon,$ where ε → initial Energy; ε→ remaining current energy of a node. The nominal energy consumption for the entire network lifetime should govern a virtuous network architecture.

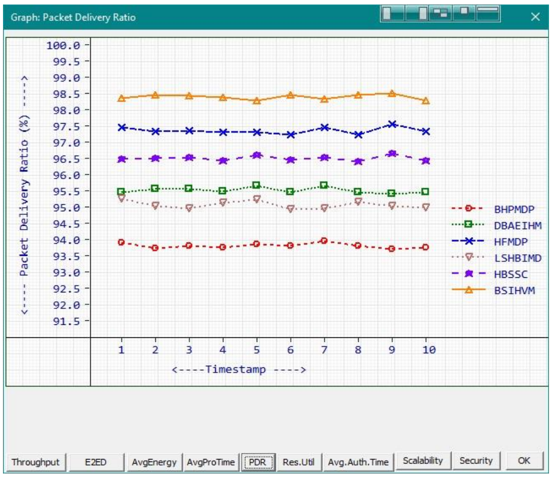
The average energy consumption is computed using the formula $\frac{1}{n}\sum_{i=1}^{n} \varepsilon ci$

n→ number of EHR tasks completed

εci → Energy Consumption during the execution of EHR task-i.

End-to-End delay: This is the summation of all the delays during the transaction authentication process, including system delay, IP delay, etc. The travel time of the EHR packet from the source to the destination system is measured. When the delay time increases, it affects the network's performance; the graph depicts the results.

5.4 Packet Delivery Ratio and Resource Utilization



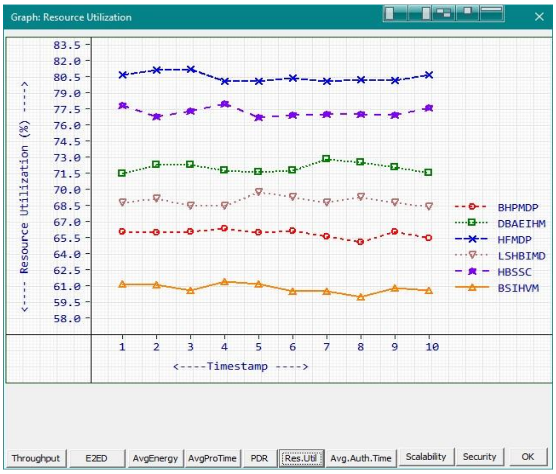


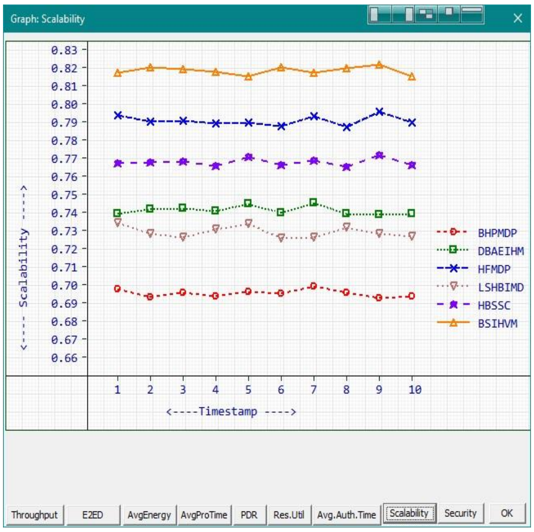
Fig 8. Packet Delivery Ratio

Fig 9. Resource Utilization

Packet Delivery Ratio: It is computed as the ratio of the number of packets in numbers that are diffused from the source system to the number of packets that are intended for the destination; the higher value denotes the lower the data loss, significantly it proves that the robust architecture of the network.

Resource Utilization: Employing fuzzy algorithms to optimize resource allocation and customize them to ensure the computational energy, loading transactions, and storage management, in addition to network bandwidth, are proficiently operated to meet the system demands. The proposed dynamic resource allocation of BSHIVM mechanisms regulates the resource usage depending on system demand and optimizing resource allocation in network peak and peak-off time. Retaining monitoring and analytics tools to consistently evaluate resource utilization parameters, detect Bottleneck problems, and optimize system performance and efficiency.

5.5 . Security and Scalability



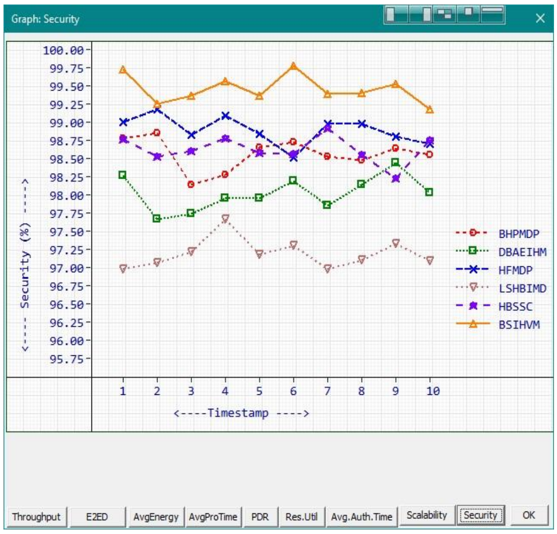


Fig 10. Security

Fig 11. Scalability

Security:

Security is an essential parameter in a Blockchain network, with security approaching the strength of the framework of the network. Monitoring continuous data values is the basis for the BSEHRHVM Environment surveilling the devices based on required decisions that have to be made. The observed values are represented in the graph and prove the strength of the network.

Scalability:

To ensure the system's scalability, its storage capability provides space for an increasing volume of Electronic Health Records. The scalability of storage solutions makes resourceful management and retrieval of EHR data as the transactions grow. The proposed system mechanism can give an alarm when a single core does not manage the transactions, and it’s time to increase the capacity through decentralizing the workload among more than one node, hence improving the network's overall performance. The system can scale up by increasing the resources, like memory, processing power, etc., of each node. Vertical scaling comprises enhancing the competencies of the current framework to operate on massive transactions.

5.6. Throughput:

The data flow rate in the given communication channel measures the throughput. It is a vital factor that requires continuous data gathering during network-environment monitoring. When the throughput quality is higher, it specifies that the eminence of the Blockchain for authenticating the EHR network is progressive. The observed value of throughput cumulated from the simulation results is plotted, and the advancement is shown in the graph.

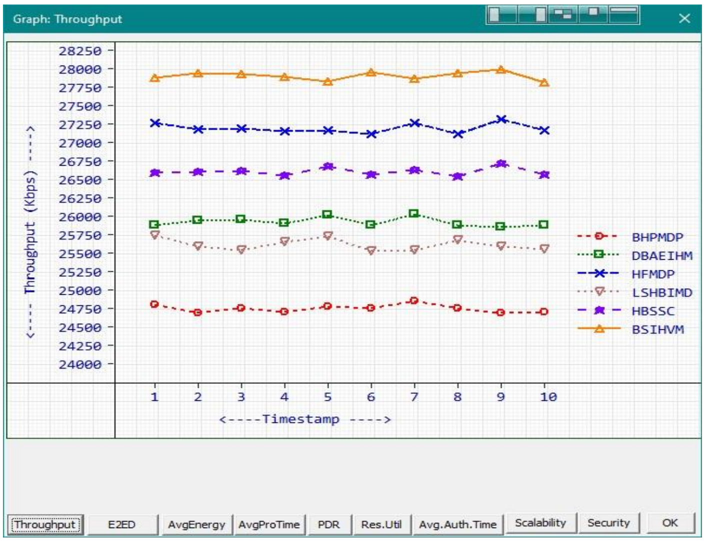


Fig 12. Throughput

V. Conclusions

The Conjunction of Blockchain Technology, Scalable IoT Framework, and pioneering mining mechanism has opened extraordinary energy in developing Electronic Health Records management. The proposed method, BEHRHVM, employing horizontal and vertical mining techniques, provides a transfigure architecture of Secure, Scalable, and reachable healthcare data management. Through horizontal mining, the decentralized nature of Blockchain enables distributed consensus, ensuring the integrity, immutability, and transparency of EHRs across a vast network of interconnected devices. This horizontal scalability allows for the seamless addition of nodes and data without compromising the system's performance, addressing the growing demand for efficient healthcare data handling. Vertical mining strategies and IoT cloud infrastructure supporting EHRs work together to optimize resource allocation and computational efficiency. This results in enhanced scalability and streamlined data processing. This approach ensures that healthcare providers and patients can access and process critical information quickly while maintaining data privacy and security. The ecosystem created represents a significant change in how healthcare information is managed. It provides real-time access to accurate and tamper-proof electronic health records (EHRs) while protecting patient confidentiality. Blockchain technology helps reduce the risk of cyber threats and unauthorized access by eliminating single points of failure. This fosters trust among stakeholders in the healthcare industry. However, as with any sophisticated system, some challenges must be addressed. These include scalability, interoperability, regulatory compliance, and the need to keep up with technological advancements. Collaboration among stakeholders, such as healthcare providers, technology innovators, regulators, and security experts, will ensure the adoption and evolution of this Blockchain-based IoT infrastructure for EHRs. To sum up, combining Blockchain technology, scalable IoT cloud infrastructure, and modern mining methods provides an excellent solution for managing Electronic Health Records. This technological collaboration improves the security and accessibility of data while also establishing the groundwork for creating an efficient, patient-centered healthcare ecosystem. This has the potential to revolutionize the delivery of medical services and drive transformative advancements in the healthcare industry. detection is vital for network security, enabling the swift identification and response to unauthorized access or malicious activities within systems.

VI. Author's Contribution

Conceptualization: Author One, Author Two.
Methodology: Author One and Author Two.
Investigation: Author One and Author Two.
Discussion of results: Author One, Author Two.
Writing – Original Draft: Author One and Author Two.
Writing – Review and Editing: Author One and Author Two.
Resources: Author one and Author Two
Supervision: Author Two
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VIII. References

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