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Impact Of Blockchain-Based Automation On Healthcare Ehr Systems: Efficiency, Scalability, And Patient Outcomes

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ABSTRACT

The integration of blockchain technology and hybrid deep learning techniques in healthcare systems is a ground-breaking approach that aims to improve scalability, security, and patient care. Blockchain provides a decentralized, transparent framework for secure data storage, sharing, and access control, ensuring data integrity, privacy, and interoperability. Hybrid deep learning, combining deep learning algorithms with traditional machine learning approaches, enables accurate and efficient processing of complex healthcare data. This research proposes a permissions-based blockchain framework for scalable and secure healthcare systems, ensuring only authorized entities can access and modify sensitive health information. The framework also enables real-time analysis of large-scale healthcare data, facilitating timely diagnosis, treatment recommendations, and disease prediction. The integration of blockchain and hybrid deep learning offers numerous benefits, including enhanced scalability, improved security, interoperability, and informed decision-making. However, challenges such as computational complexity, regulatory compliance, and ethical considerations need to be addressed for successful implementation. By harnessing the potential of blockchain and hybrid deep learning, healthcare systems can overcome traditional limitations, promoting efficient data management, personalized patient care, and advancements in medical research.

Keywords: Blockchain, Automation, Healthcare Systems, Efficiency, Scalability, and Patient

INTRODUCTION

The rapid digitization of healthcare has led to the generation of massive electronic records about patients, posing unprecedented demands for data protection. Blockchain technology, a distributed ledger technology for peer-to-peer (P2P) network digital data transactions, is paving the way for new potentials in solving serious data privacy, security, and integrity issues in healthcare.
Blockchain technology offers transparency and eliminates the need for third-party administrators or intermediaries. It uses consensus mechanisms and cryptography to verify the legitimacy of transactions in a trustless and unreliable environment. In a blockchain distributed P2P network of transactions, the receiving node checks the message, stores it in a block, and a consensus algorithm is used to confirm the data in each block, known as Proof-of-work (PoW).
One of the most prominent applications of blockchain technology in healthcare is to overcome challenges related to data security, privacy, sharing, and storage. Interoperability is a requirement for the healthcare industry, facilitating the exchange of health-related information, such as electronic health records (HER), among healthcare providers and patients. This enables providers to securely share patient medical records, regardless of the provider’s location and trust relationships between them.
Blockchain technology has shown potential to store, manage, and share EHRs safely among healthcare communities. Additionally, increasing costs of healthcare infrastructures and software have caused tremendous pressure on world economies. In the healthcare sector, blockchain technology is positively affecting healthcare outcomes by optimizing business processes, improving patient outcomes, patient data management, enhancing compliance, lowering costs, and enabling better use of healthcare-related data.
Blockchain technology is currently being explored across various healthcare applications such as data management, storage, devices connectivity, and security in the internet of medical things (IoMT). The benefits

provided by blockchain technology in these areas have positively impacted the quality of experience (QoE) of most stakeholders and end users, including patients, care givers, researchers, pharmaceutical companies, and insurance companies. The ability to share healthcare data without jeopardizing users' privacy and data security is an essential step to make the healthcare system smarter and improve the quality o' healthcare services and users' experience.

LITERATURE REVIEW

Ait Bennacer, Sara et.al. (2022). Many problems with data management, data sharing, data immutability, trust, transparency, information security, and patient privacy are plaguing today's healthcare systems. Furthermore, there are a number of issues brought about by the centralization of the many current healthcare systems, which makes data management for both patients and healthcare providers more difficult. The healthcare business is one potential area that might reap many benefits from blockchain technology, which is a decentralised peer-to-peer network with the ability to digitalize and revolutionise data management. A better overview of current efforts on healthcare applications based on Blockchain is the goal of this study.

Panigrahi, Amrutanshu et.al. (2022). Financial services, supply chain management (SCM) across industries, the internet of things (IoT), and healthcare information systems are just a few of the many areas where blockchain technology is already making a big splash by offering a safe and efficient way to communicate data. Thanks to the HCS app's security features and interoperability, suppliers and patients may exchange data without any hitches. If a patient lacks these characteristics, it shows that they have trouble understanding their own health condition. Therefore, the HCS may become more efficient and effective by integrating blockchain technology, which will address this drawback. The potential advantages of blockchain technology provide the groundwork for its use in several areas of healthcare information systems (HCS), including but not limited to patient electronic health records (EHRs), electronic medical records (EMRs), billing, telemedicine systems, and many more.

Adeghe, Ehizogie et.al. (2024). An innovative paradigm shift is taking place with the potential to improve patient outcomes, privacy, and security via the use of blockchain technology in healthcare data management. The article starts off by delving into the basics of blockchain technology and how it is currently being used in healthcare. To provide the groundwork for a thorough examination, we focus on the possible advantages and disadvantages of using blockchain technology. Using decentralised architecture and smart contracts for strong access control, the article analyses how blockchain guarantees data integrity and immutability from a security perspective. Discussed further are blockchain's potential effects on patient privacy, particularly its ability to let people keep their health records private and in control. To provide a comprehensive study of the privacy environment, the research also explores regulatory compliance and legal implications. Examining how blockchain improves interoperability, simplifies healthcare operations, and may revolutionise the patient experience is key to understanding the effect on patient outcomes. The beneficial benefits seen in healthcare settings may be better understood via the use of real-world case studies. Nevertheless, in order to fully grasp the revolutionary possibilities, one must first investigate the obstacles and constraints. For a well-rounded look at the challenges to broad blockchain adoption, we cover topics including technical issues, ethical concerns, and the need of seamless connection with current healthcare systems. The article provides advice to organisations thinking about using blockchain technology by outlining potential developments in healthcare and blockchain. Finally, it presents blockchain as a driving force behind a sea change in healthcare data management by reviewing important results and highlighting the need of further study.

Chelladurai, Usharani et.al. (2022). Electronic health records (EHRs) are a product of the extensive digitization of medical data made possible by technological advancements. The current situation calls for patients to have access to their medical records at several local hospitals. Patients in critical condition have an even greater obstacle when trying to integrate disparate health information from different sources into a unified whole: the timely transfer of relevant health data from one physician to another. In this article, we outline how blockchain smart contracts might meet the regulatory needs of healthcare providers, patients, and doctors. In order to construct an intelligent e-health system, the suggested solution intends to use a blockchain platform for the sharing of health information. Launching health models on the peer-to-peer blockchain network, the proposed system includes features such as the ability to create immutable patient logs using a modified Merkle tree data structure, which allows for the secure storage and rapid access of medical records. Other features include the ability to update medical records, facilitate health information exchange between different providers, and establish viewership contracts. As a clinical data repository, blockchain in this system gives patients and their healthcare professionals easy access to their electronic health records and a full, distributed ledger record of all occurrences. This system's use of cryptographic hash functions ensures a high level of confidentiality and integrity, which is an essential aspect. The suggested technology has been tested on several trials to ensure its efficacy. The proposed system's performance has been evaluated using both quantitative and qualitative indicators. These metrics include latency, transactions per second, and resource utilisation.

Mazlan, Ahmad et.al. (2020). The decentralised ledger known as "blockchain" allows for an encrypted, private, trustworthy, and transparent transfer of data. Because there is no difference between the two databases and the records are planned to update periodically, the coordination and validation activities are simplified in this situation. The use of blockchain technology in healthcare and how it solves scalability issues are the main topics of this study. Consequently, sixteen options were classified into two primary categories: optimisation of storage and redesign of blockchain. Problems with protocols, large amounts of data and transactions, a lack of nodes, and block size are still there. Research question formulation, research methodology, article screening, abstract-based keywording, data extraction, and mapping are the six steps that make up this review. We utilised the given keywords to search for relevant articles using the Atlas.ti programme. Consequently, forty-three quotes and forty-eight codes were generated. The quotes were categorised using manual coding. The next step was to map the codes onto the network. Two primary categories, storage optimisation and blockchain redesign, accounted for sixteen solutions. There are a total of thirteen suggestions for blockchain redesign, including three for storage optimisation and twelve for blockchain models, read/write mechanisms, and bidirectional networks.

METHODOLOGY

The proposed methodology involves collecting IoT data from sensors and sending it to a cluster head. The data is then processed through blockchain, verified, and authenticated from large amounts of IoT edge devices. The data is encrypted using homomorphic encryption and outsourced to the cloud, allowing for statistical and deep learning operations. Feature extraction is then performed, extracting features like heart rate, age, sex, weight, and height. The framework uses Support Vector Machine (SVM) to classify users and data based on features and system interaction. The output is verified and validated using a validation model. The methodology aims to improve the efficiency and effectiveness of IoT devices.

Proposed Algorithms

The proposed framework uses a novel algorithm to govern it, which outlines the process of updating, creating, and revoking policies. The algorithm first creates a Patient Health Record (PHR) upon user request, updates the existing PHR, and revokes it if the user violates the access control policy. It also assigns attributes to patients and clinicians, referring to the network of medical devices and sensors that collect data from patients, medical equipment, and the environment. This includes wearables, implantable sensors, monitoring devices, and other medical instruments.

Algorithm 1 Create, Update, and Revoke Medical Records

procedure CREATERECORD(*patientID*, *data*) *record* $\leftarrow$ new MedicalRecord *record.patientID* $\leftarrow$ *patientID* *record.data* $\leftarrow$ *data* **save** *record* ▷ Save the record in the database
end procedure
procedure UPDATERECORD(*recordID*, *newData*) *record* $\leftarrow$ **fetch** MedicalRecord with *recordID*
    if *record* $\neq$ **null then** *record.data* $\leftarrow$ *newData* **save** *record* ▷ Update the record in the database
    end if
end procedure
procedure REVOKERECORD(*recordID*) *record* $\leftarrow$ **fetch** MedicalRecord with *recordID*
    if *record* $\neq$ **null then delete** *record* ▷ Delete the record from the database
    end if
end procedure

Sensing Layer in IOMT

The sensing layer in IoMT captures and transmits physiological, behavioural, and environmental data for analysis and decision-making in a centralized or distributed system. This data can include vital signs, medication adherence, patient activity, and environmental conditions. The term "Distributed QEMR algorithm" related to IoMT is not widely recognized, so it may refer to a specific algorithm or approach not commonly known.

Mathematical Model

We can represent the mathematical model as follows:

$$\begin{aligned} \text{Objective Function:} \quad & \max_{x_1,x_2} 3x_1 + 5x_2 \\ \text{Subject to:} \quad & 2x_1 + 4x_2 \leq 10 \\ & x_1 + 3x_2 \leq 7 \\ & x_1, x_2 \geq 0 \end{aligned}$$

The proposed model uses homomorphic encryption (HE) to encrypt EMR data, allowing users or AI models to perform complex statistical or mathematical operations without decryption. Algorithm 2 checks attributes by assigning a master key, signature count, and bi-linear pair group. The user selects a random value from a group of bilinear pairs, such as G1 and G2. Algorithm 3 explains the algorithm's working, including cluster head selection based on battery power. HE allows users to encrypt data at their side and outsource it to the cloud, ensuring security and privacy preservation. There are three types of HE: fully HE, partially HE, and hybrid HE. In this research, fully HE was used due to the proposed approach requirements and integration with numerous IoMT devices. The main benefit of HE is its ability to perform operations over encrypted data without decryption.

RESULTS

This section presents a detailed simulation and results of a proposed model for private information retrieval. The model was compared with a benchmark model to evaluate its performance. The proposed framework, which uses appointment allocation algorithms and stores in the B+-Tree indexing data structure, provides minimal communication overhead compared to SHealth, MedRec, and ECC-Smart solutions. The simulation results were conducted using a blockchain tool called hyperledger fabric and validated on the Ethereum test net. The publicly available data set was used in the research paper. The results show that the proposed framework transfers more transactions compared to permissionless and private blockchains, indicating its superior performance. The data set used in the simulation is publicly available from UNSW. The framework's lightweight authentication system also contributes to its superior performance.

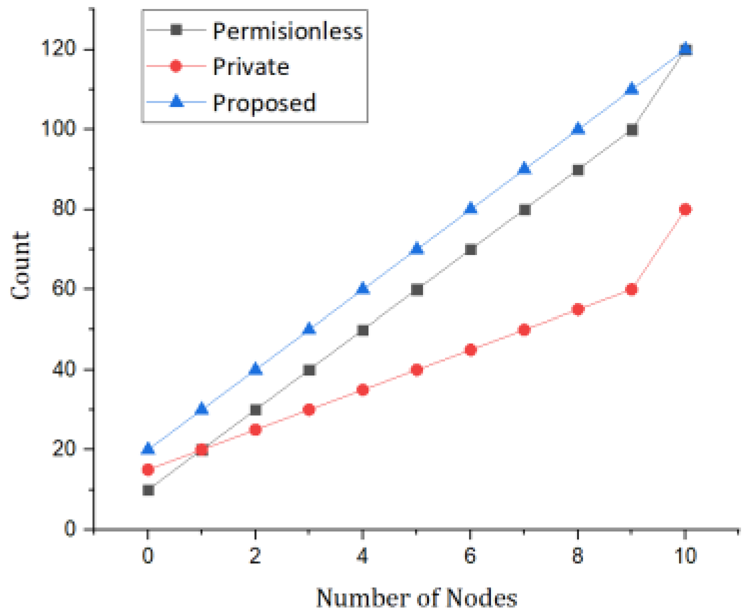

Figure 1. Simulations results based on the number of nodes versus the number of counts.

The study presents simulation results for user classification using the SVM method and an LSTM deep learning approach. The system records previous user activities and creates a log of each user's behavior, providing access rights and authorization based on their behavior. The results also show simulation results for moving sensors connected to the IoT system, focusing on the number of rounds versus latency. The study compares the proposed framework with benchmark models, comparing the number of nodes and encryption time. The results are presented in Figure 2.

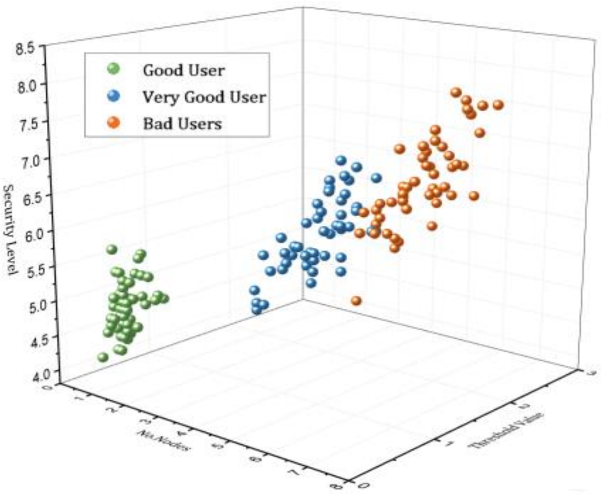

Figure 2. Classification of users based on the behavior and interaction with the system model.

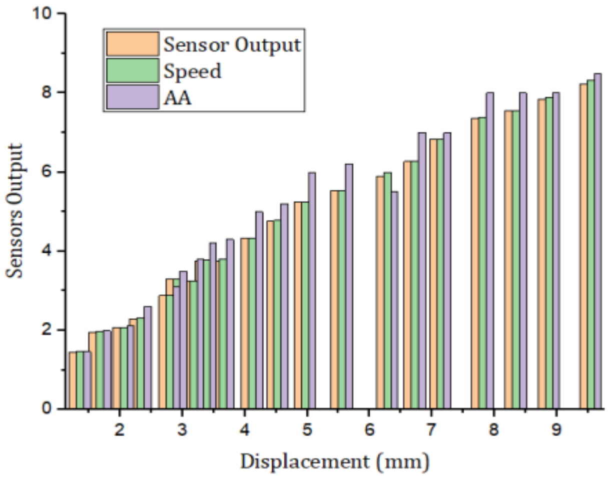

Figure 3. Simulation results based on the number of sensors output with respect to number of nodes.

The proposed framework shows low latency compared to benchmark models, indicating efficiency and robustness. Comparative analysis is presented focusing on the number of transactions and d2d distance. The network delay and optimal power and key distribution are also compared, showing less delay for the proposed approach. The framework's performance is evaluated based on distances between two nodes and the number of transactions. The proposed approach performs better than the benchmark models in terms of execution for the same number of attributes using lightweight HE. The attack resistance of the proposed framework is evaluated in Table 1, comparing it with the benchmark models. The results demonstrate the effectiveness of the proposed framework in reducing network latency, optimal power distribution, and transaction performance.

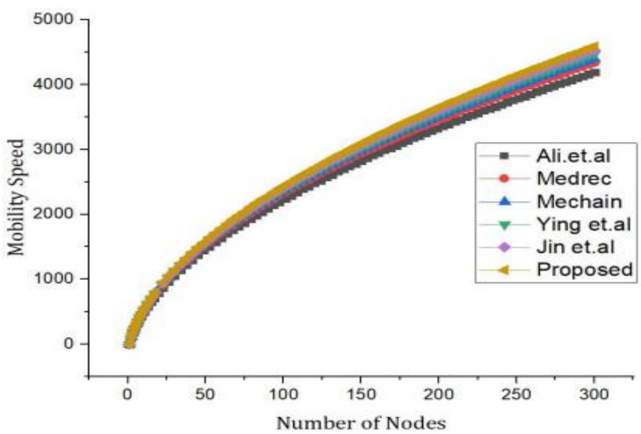

Figure 4. Comparative analysis of the proposed framework versus benchmark model based on the speed and number of nodes.

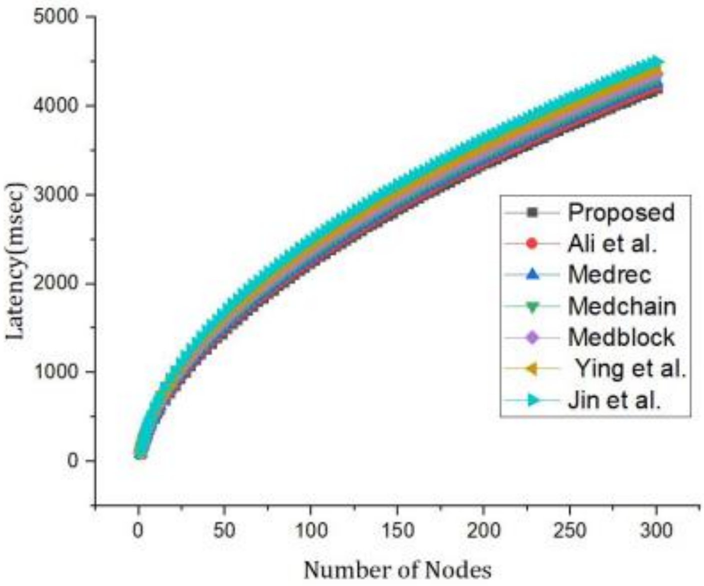

Figure 5. Comparative analysis with the proposed framework versus benchmark model based on the latency and number of nodes

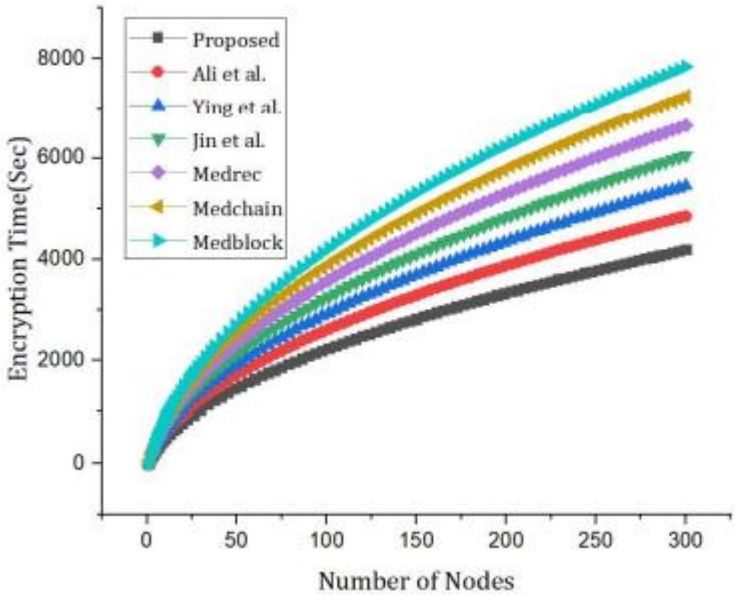

Figure 6. Comparative analysis based on number of nodes versus encryption time.

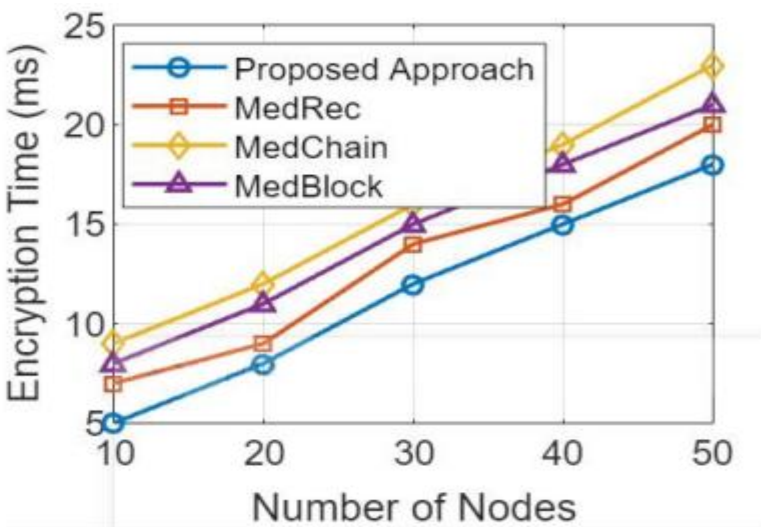

Figure 7. Comparative analysis based on number of nodes versus encryption time.

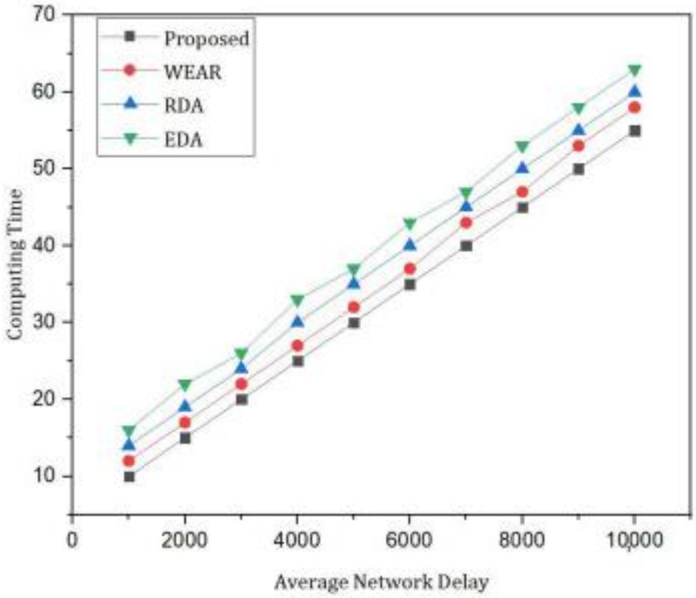

Figure 7. Comparative analysis based on number of attributes and index search.
Figure 7 provides comparative analysis based on classical optical power versus secret key rate.

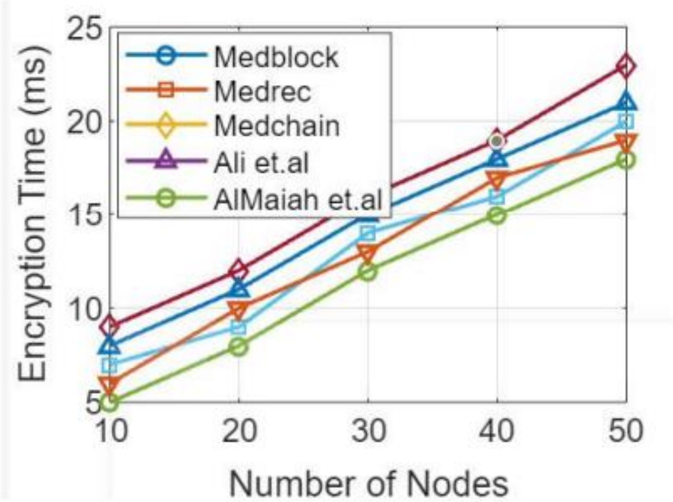

Figure 8. Comparative analysis based on classical optical power versus secret key rate

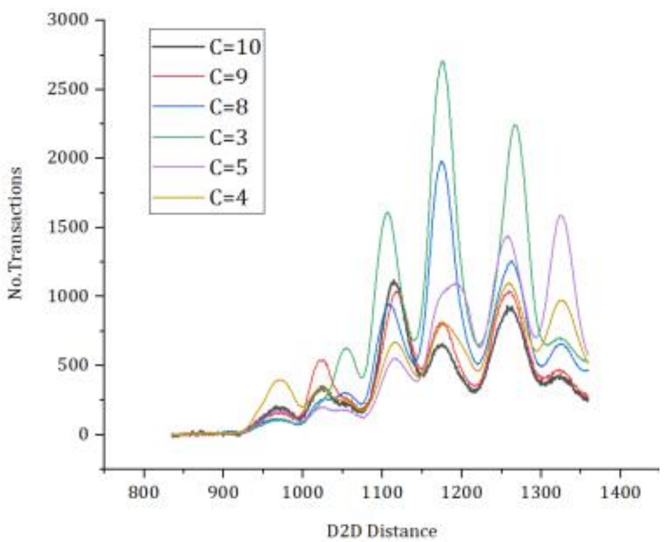

Figure 9. Comparative analysis based on d2d distance versus number of transactions.

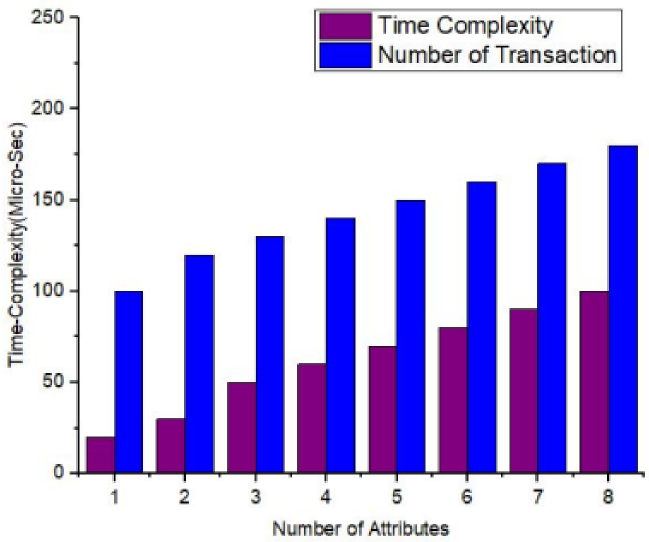

Figure 10. Schematic diagram representing the simulation results based on the number of attributes versus complexity.

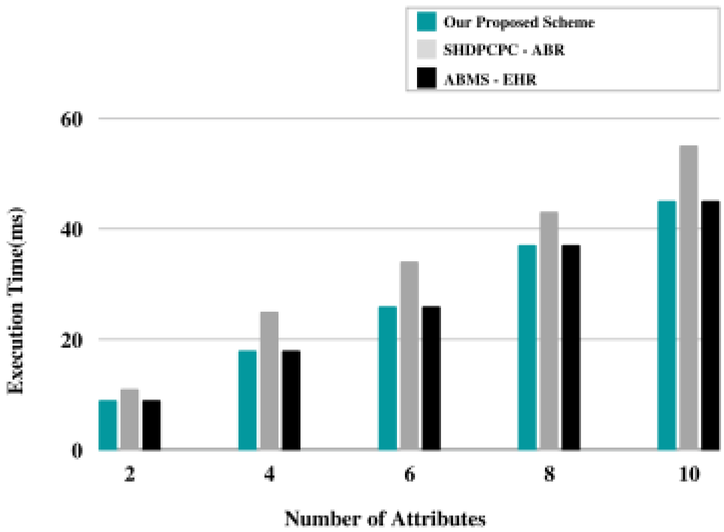

Figure 11. Comparative analysis of the proposed approach versus benchmark models.

Table 1 provides Comparative analysis of attack resistance of the proposed and benchmark models.

Table 1. Comparative analysis of attack resistance.

Models	Collusion Attacks	DoS	DDoS
Medblock [25]	No	No	Yes
Ali et al. [5]	Yes	No	No
Medchain [50]	Yes	No	No
Medrec. [54]	Yes	No	No
Proposed	Yes	Yes	Yes

CONCLUSIONS

The Blockchain-Powered Healthcare Systems framework aims to improve scalability, security, interoperability, and data privacy in healthcare data management and analytics. It combines blockchain technology with hybrid deep learning to ensure data integrity, transparency, and immutability, maintaining trust and security of healthcare information. Smart contracts automate data access, sharing, and consent management, empowering patients with control over their data. Hybrid deep learning techniques, including deep neural networks, federated learning, and transfer learning, enhance healthcare analytics and decision-making processes while preserving data privacy. This framework has the potential to transform healthcare systems, improve patient outcomes, and safeguard data privacy and security. However, continuous research, collaboration, and practical implementations are needed to advance this innovative approach and realize its full potential in the healthcare domain.

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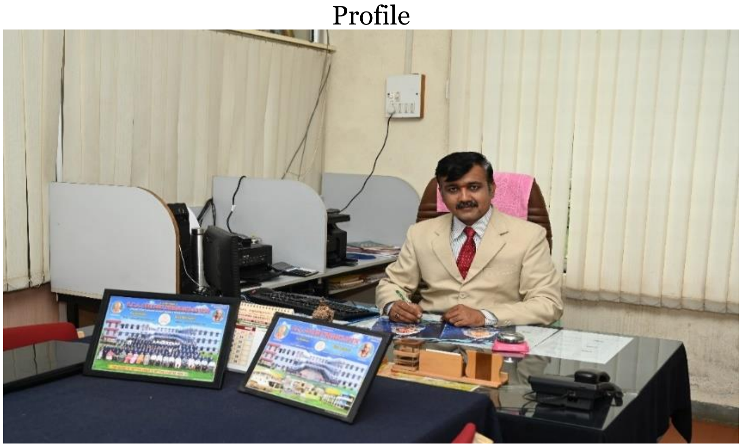
About Author

Profile



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1. Wrote an article in Yuva Wani Magazine.
2. Published a Book on "**Artificial Intelligence Structures and Strategies for Complex Problem Solving**" in October 2022.
3. Attended 3 - Days Online International FDP On "**Innovations in Techno-Management and Strategic Case Based Teaching Learning**" by Sinhgad Technical Education Society's Sinhgad Institute of Management and Computer Application, (SIMCA), Pune.
4. Participated 1 Day Online Webinar on "**Cyber Crime and Cyber Laws**" by KES's IEMSB-School (MBA), Hubli in association with Vivekanand Institute of Management, Kalburgi.
5. Attended 1 Day Online Webinar on the "**Intellectual Property**" Workshop in the month of June.
6. Attended and presented a syllabus of "**Statistical Computing in R-Language**" in 1- Day Workshop on Review of V and VI Semester NEP Syllabus at BLDEA's College of Computer Science, Jamkhandi.
7. Attended an International conference on "**Importance of Interdisciplinary Studies in Higher Education in the Areas of Engineering, Science, Management and Humanities**" on 16th March 2022 by University of Technology, Jaipur.
8. Participated in the 3-days FDP on "**Research Methodology**" on 20th, 21st and 22nd December 2022, A2Z Edification, Kerala
9. Shri B. M. Halabhavi has attended an International conference on "**Importance of Interdisciplinary Education in Context of NEP-2020 Implementation**" on 6th and 7th January 2023 by University of Technology, Jaipur.
10. Attended an International conference on "Challenges and Opportunities in future Research and Innovations" on 13th March 2023 by University of Technology, Jaipur.
11. Presented a Paper on "**An Innovative Blockchain-Based Healthcare Electronic Health Record Security Automation System**" in two days National Level Conference organized by Shivaraj College of Arts and Commerce D. S. Kadam Science College, Gadhinglaj.
12. Presented a Paper on "**Blockchain Technology**" in a one day International Level Conference organized by University of Technology, Jaipur (Rajasthan) on 2nd March 2024
13. Published a book "**Blockchain in Supply Chain Management: Enhancing Transparency and Efficiency**".
14. Published a book "**Blockchain in Healthcare: Advancements in Medical Data Management**".
15. Published a Research Paper and Article on "**Design and Implementation of Blockchain-Based Security Solutions for Electronic Health Records (Ehrs): Enhancing Data Integrity and Privacy**".

16. Published a Research Paper and Article on “**Impact of Blockchain-Based Automation on Healthcare Ehr Systems: Efficiency, Scalability, and Patient Outcomes**”.