DESIGN AND DEVELOPMENT OF EHR SPECIFIC BLOCK CREATION AND POS CUSTOMIZATION USING HIERARCHICAL INTERDEPENDENCY APPROACH

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ABSTRACT

Electronic Health Records (EHR) serve as a pivotal component in leveraging technological capabilities for processing, diagnosis, and informed decision-making in the medical domain. The sharing and endorsement of EHR by medical professionals based on case studies undergo manual procedures, leading to limitations in global accessibility to EHR and resolved case data, impeding expert analysis. In this study, the we propose an exclusive methodology tailored for the establishment and customization of blockchain networks dedicated to EHR applications. The approach centers around a hierarchical interdependency paradigm that governs the fine-tuning of blockchain units and the creation of Proof of Stake (PoS) structures. This technique's calibration is executed within a hospital's private network, ensuring the generalizability of resources within the EHR context. Additionally, the technique introduces deliberate delays in the integration of federated learning models within the blockchain framework, optimizing the alignment of EHR data. Validation of the proposed technique is conducted within the framework of AWS private-public servers, utilizing a dataset sourced from 17 hospitals within the MIMIC-III public EHR dataset. The hierarchical interdependency blockchain is further harmonized with a generalized EHR setup. The study exhaustively deliberates on the outcomes of this setup, demonstrating a discernible enhancement in the performance metrics of EHR blockchains.

Keywords*: *Healthcare customization; EHR recommendations; Proof of Stack (PoS); Interdependency hierarchy blockchains; blockchain alignments.

1.0 INTRODUCTION

Electronic Health Records (EHR) hold a pivotal position in the landscape of patient care, serving as a critical repository for medical information essential to accurate diagnosis and informed decision-making. In the contemporary age of digitalization, the intricate web of EHR management and patient hospitalization processes has undergone a profound transformation, with a focus on meticulous monitoring and streamlining. From a technical perspective, medical institutions, including hospitals and healthcare centers, allocate dedicated computational resources, such as servers or data centers, explicitly designed to accommodate the storage, management, and seamless retrieval of EHR data. However, despite the evident technical sophistication, the broader significance of sharing EHR data remains surprisingly under scrutinized.

The foundational objective driving the modernization of healthcare facilities is to engender a dependable ecosystem characterized by multi-dimensional capabilities. This aims to foster an environment where data flows smoothly, supporting the expeditious exchange of medical insights during the diagnostic process. One of the central challenges in the realm of EHR management lies in fortifying the security posture of these systems while simultaneously ensuring uninterrupted and consistent availability. In the pursuit of establishing a resilient EHR framework, the adoption of blockchain technology emerges as a strategic imperative. This blockchain-centric approach introduces a novel lens through which to examine the intricate operational mechanics governing the interdependent units of EHR. Operating within this framework, the coordination and synchronization of these units are managed through a network of interlinked indices. These indices are subject to refinement either at their originating source or under the purview of administrative oversight.

In a more encompassing context, the operations executed within the blockchain structure, particularly concerning individual units of EHR data, can be aptly referred to as "EHR reports." This terminology underscores the inherent complexity associated with altering data once it has been etched into the blockchain's immutable ledger. The robustness of this approach, in conjunction with its intricate architecture, ensures that once information is refined and disseminated within the open internet, it becomes remarkably resistant to unauthorized manipulation or tampering. The security paradigm intrinsic to blockchain technology, along with the enduring integrity of data alignment, necessitates a methodical approach involving the tracking and storage of information within third-party servers and operating systems. This practice of leveraging external infrastructure ensures the safeguarding of the blockchain's cryptographic underpinnings and the unbroken sequence of transactions. Typically, the blocks forming part of a defined blockchain sequence are organized and interconnected through the medium of the internet, a factor that introduces vulnerability to potential tampering or corruption through various communication channels.

This research endeavors to present a novel conceptualization of blockchain architecture tailored explicitly for the intricacies of Electronic Health Record (EHR) operations. Within this context, the research proposes the formulation of specialized and self-contained blocks, each optimized to cater to unique data-holding capacities, customizable attributes, and fortified by a Proof of Stake (PoS) consensus mechanism. These blocks, with their customized configurations, stand apart from the conventional blockchain mold, thereby underscoring their specialized utility within the EHR landscape. Critical to the investigation is the intrinsic alignment of individual blocks with the nuanced requirements of the defined EHR framework. This alignment is meticulously engineered to function independently of the traditional block structure and its associated indexing mechanisms, reinforcing the tailored nature of the proposed solution. The primary goal of this article lies in the comprehensive exploration and explication of the rationale that drives the creation of these independent blocks within the EHR ecosystem.

This exploration extends to a detailed scrutiny of cloud infrastructure, which serves as the foundational setting for the research's scope. Through a series of systematically designed experiments, the research rigorously examines data exchange protocols enacted through blockchain technology. These experiments culminate in the establishment of hierarchical blockchain units finely attuned to the nuances of EHR functionalities, setting the stage for a new era of secure and customized healthcare data management. Within this research article, a comprehensive framework for the management of Electronic Health Record (EHR) blocks is meticulously outlined and calibrated. These discrete and self-contained EHR blocks are further integrated to forge interdependencies, resulting in a cohesive and harmonious blockchain-based network topology. This technique assumes a pivotal role in orchestrating the meticulous maintenance and sophisticated indexing of the diverse data patterns that emanate from independent hospitals within the expansive realm of EHR.

The framework's essence lies in its ability to seamlessly manage the intricacies of EHR blocks, ensuring their robustness and cohesiveness within the broader blockchain network. By interlinking these independent blocks, a collaborative and interconnected ecosystem emerges, enabling the sharing and exchange of valuable healthcare data. Moreover, this methodology governs the pivotal task of organizing and categorizing the information patterns generated through the EHR systems deployed across distinct hospital entities. This comprehensive approach not only optimizes the management of EHR blocks but also contributes to the establishment of an advanced and interconnected healthcare data ecosystem. It ensures that valuable medical information is not only accurately stored and managed but also seamlessly shared within the confines of the network. In essence, the research article provides a nuanced and intricate blueprint for the effective handling and utilization of EHR blocks, thereby paving the way for enhanced healthcare data management and exchange.

2.0 LITERATURE SURVEY

The Electronic Health Record (HER) functionalities and role is a challenging and abstraction of information [1]. The approach of EHR is to build and map the patient medical documents and treatment history. In recent times, many researchers have proposed latest versions and technological developments in EHR. The incorporation of multi-dimensional features such as data types, data formats and orientation of EHR origins influence on the change and manipulation of records [2][3]. The development of EHR in design such as policies and standards are incorporated as per the government norms. The study [4] provides a comparative review models of documentation involved in EHR development using artificial intelligence. A dedicated study by “All of Us” has developed a EHR dataset for validation with 314,994 participants [5]. This study encourages on the inclusive analysis and customization of EH based on American health standards. The EHR is customized and processed via higher technological tools and mathematical models using artificial intelligence (AI) and natural language processing (NLP) [6]. The inclusion of computation over a trivial medical document enhances the content and validates the representation of records globally. The approach of adverse drug events (ADE) is customized and processed using NLP on a EHR is a framework of application developed towards pharmaceuticals [7]. In another case-study [8], the EHR is used as a secondary source of data mining and data characterization for improving the decision standards. The article discusses the potentials of data mining and characterization to perform relevant data extraction and map the interdependencies for EHR evaluation. Further an analytical representation is proposed for user understandability.

Multi-objective datasets in EHR and medical applications have become a common factor and requirement for higher technological computation. The author [9] has proposed a study on multi-objective medical dataset clustering and representation used in EHR compilation at the source data center. The approach is enhanced with a deep learning (DL) [10] models for validation. The survey [10] demonstrated the process and requirement factors for EHR feature extraction and mapping. The study has proposed a detailed view of deep-learning algorithms and techniques used for EHR customization. The pitfall and challenges in EHR customization is relatively complicated and has to be addressed in a linear approach such that, each feature of EHR is relatively customized under the pitfall classification [11]. The approach results in minimizing the EHR breakdowns and improves the understandability. The communication challenges of EHR is wider and has to be discussed with reference to the common channel used for EHR transmission via third party service providers. The relativity complex networking ecosystem has to be analyzed with an effective and sustainable solution for computation. The TelMED [12] protocol is a dedicated framework proposed for telemedicine EHR transfers. Typically, the channel is encoded with respect to the datasets (HER) and computes a stream of data-segments used for communication under normalized scenario. This inclusion is enhanced with a blockchain based approaches under Internet of Things (IoT) standards [13] [14]. The process discuss the interoperability features of EHR and the customization challenges [15]. In recent times, the global pandemic COVID-19 combating was proposed over a e-health ecosystem and hence EHR played a major role in customizing and categorizing the patients and they severity. In the study [16] the authors have discussed the patients of analyzing the comorbidities based on COVID-19 from the aligned EHR datasets for heart diseases prediction and risk evaluation. The process requires a dedicated framework for EHR blocks to provide interdependent information structure with reference to the EHR understanding. The network of EHR customization and recommendation in the blockchain is based on the relevance of information mapping and categorization using blockchain [17][18].

3.0 METHODOLOGY

The foundation of the proposed system rests upon the intricate interconnection of independent hospital networks. Traditionally, each hospital establishes and maintains its own dedicated computing environment, often manifesting as private cloud infrastructure or localized servers situated within their respective data centers. These entities serve as repositories for crucial Electronic Health Records (EHR) and associated patient-centric documents. It's important to emphasize that the scope of EHR transcends the mere storage of files. Beyond housing medical data sheets and historical records, the concept extends to encompass a web of interdependent parameters. This includes intricate aspects such as disease categorization, treatment locations, procedural workflows, and even the different types of EHR datasets linked to specific medical scenarios. This amalgamation of diverse data facets culminates in the creation of a comprehensive EHR landscape within the confines of the hospital's data center, as depicted in Figure 1. At the crux of the approach lies the synergistic integration of all conceivable data-center units, coalescing to form a centralized server pool. This resource reservoir is intricately interlinked with the broader expanse of the internet, enabling the dissemination of EHR-related data across the global repository. However, it's pertinent to acknowledge that despite this dissemination, robust mechanisms for data indexing and informed data recommendations remain nascent or even absent within this paradigm.

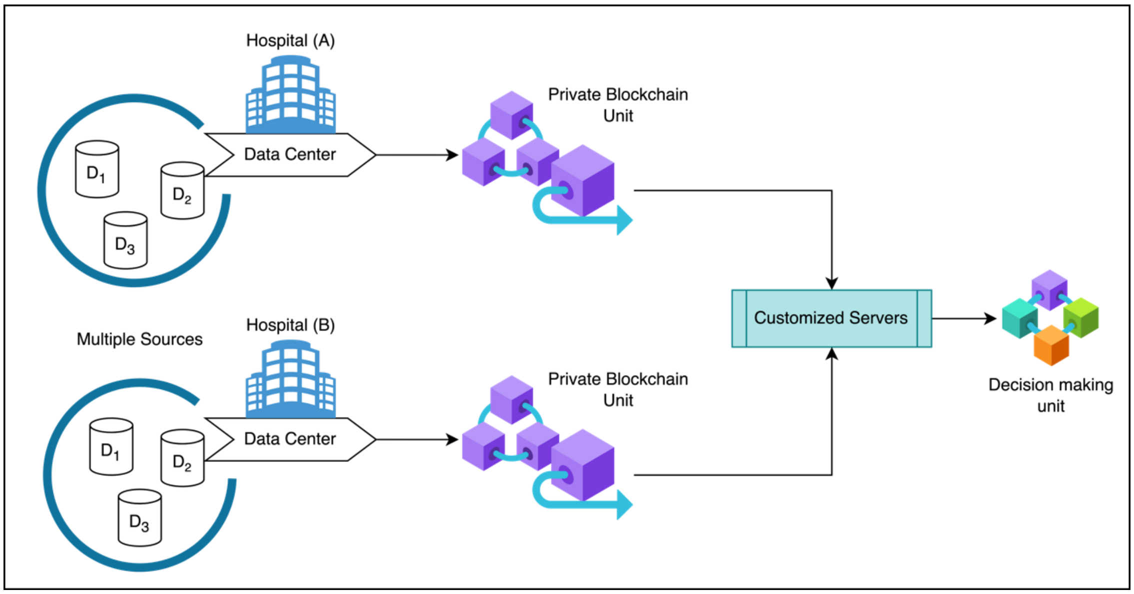

Fig. 1: Architectural representation of proposed system.

Central to the novel technique proposed is the notion of private blockchain units strategically positioned at the forefront of data centers affiliated with individual hospital units. This architectural decision engenders a cascading effect, where the configuration ripples through to a distinct server. This server is intricately tied to an interdependency map, which, in turn, interfaces with a foundational building block unit, as portrayed in Figure 2. To succinctly encapsulate this intricate relationship, the accompanying class diagram provides a structural representation, tracing the journey of data from the hospital data center to eventual alignment with the blockchain building unit. In essence, the system's complexity lies in the meticulous threading together of divergent components: independent hospital networks, intricate data centers, sophisticated cloud infrastructure, and the transformative potential of blockchain technology. Through this intricate amalgamation, the proposed system holds the promise of redefining the landscape of Electronic Health Record management, fostering enhanced accessibility, security, and seamless data exchange in the realm of healthcare. The blockchain creation unit customizes the internal blocks of independent stream to recreate the proof of stack (PoS). The PoS utilizes the management of interdependency units of two or more blockchain address, primarily the connecting and looping address for the blocks. The approach generates a EHR interdependency hierarchical blockchain unit for customization of healthcare based EHR blockchains under third party channel. The supporting approach is discussed in following section. The approach of aligning cloud services to the incubating blockchain server is the novel approach of this proposed technique.

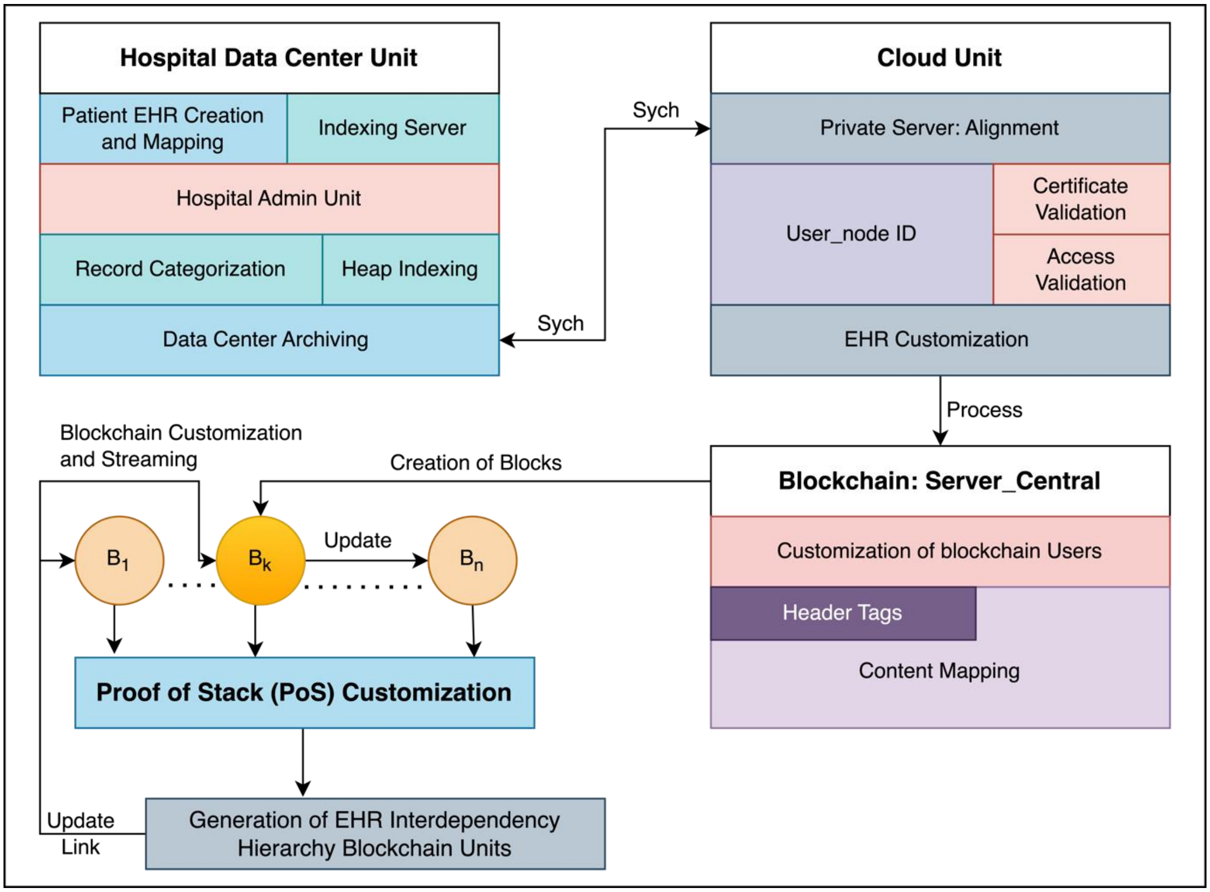

Fig. 2: Class diagram for proposed EHR interdependency hierarchical blockchain system.

4.0 MATHEMATICAL MODELLING

4.1 Health center alignment

The EHR customization and storage is reflected by the usage principle of respective hospitals. The EHR bound to hospitals can be represented as $(H_{EHR})_i$ such that $(\forall i)$ that participating servers are aligned as $(H_1, H_2, H_3 .... H_n)$ such that $[(H_i) \subseteq H_{ERP}]$ and $\forall H_i \Rightarrow \{P_1, P_2, P_3 .... P_\infty\}$ where (P_i) is the patient specific information. The EHR associated with patient (P_i) is furthers evaluated to get internal details such as diagnosis (d), treatment (t) and history (h) are internal parameters represented as (d, t, h) when associated with patent, the process is capsulated as shown in Eq. 1

$$P = [\delta d_i, \delta t_i, \delta h_i] \tag{1}$$

$$P = \sum \left[\frac{\delta d_i \oplus \delta h_i}{\delta t_i} \right] \tag{2}$$

According to Eq. 2 the diagnosis and history if given patient (P) is further associated with (δt) treatment such that, $\forall \delta t \in (H_{EHR})_{Pi}$ and $(\forall P_i \subset (\delta d_i \oplus \delta h_i))$ is generalized representation. Each incoming record parameter is associated with EHR as shown in Eq. 3

$$EHR = \int_0^\infty (P)_{i=0}^n \lim_{n \to \infty} \left[\frac{\delta(d_i \oplus h_i)}{\delta t} \right]_{i=0}^\infty \tag{3}$$

Further to the values, $\forall (i \le n \le \infty)$ is represented and mapped on the given EHR as shown in Eq. 3. Thus an association of information cycle is extracted from data stored and customized servers. The hospitals administration unit is responsible for EHR creation and updating for further computation, the EHR is associated with feature extractions and parameter coordination.

4.2 Cloud alignment and data uploading unit

The data generated from EHR is associated with three major parameters (d,t,h) and thus, the EHR generated in the hospital (h_i) is synchronized and uploaded to cloud environment. Typically, the orientation of data up-streaming and cloud monitoring is represented as (C_R) where (R) is the indexing value of cloud service (i.e) if service is public or private. Consider the alignment of (C_R) as shown in Eq. 4.

$$C_R = \left\{ \frac{\exp\left[Dataupstream(h)_{EHR} \parallel EHR(d,t,h) \right]}{\Delta T} \right\} \tag{4}$$

Where, $(h)_{EHR}$ is the healthcare EHR associated with a given hospital. The overall optimization of cloud storage is further validated with minimal latency (ΔT) and thus aggregation of indexing is shown in Eq. 5.

$$C_R = \sum_{i=1}^\infty \left\{ \frac{\exp\left[Dataupstream(h)_{EHR} \parallel EHR(d,t,h) \right]}{\Delta T} \right\} \tag{5}$$

The orientation of cloud aggregation $(\sum C_R)$ can be aligned on multi-order agents associated in the computation. Thus the output of ith cloud server under primary layer of cloud is shown as Eq. 6.

$$\sum C_R = \lim_{n \to \infty} \left\{ \frac{\delta(C_R)}{\delta t} \oplus W_{(d,t,h)} \right]_{i=0}^n \right\} \tag{6}$$

where (W) is the weight vector of uploading data stream connected for the cloud uploading operations. The orientation of weights further connects to the header tags (H_T) information in the cloud as shown in Eq. 7.

$$\sum(C_R)_{H_T} = softcompute\left(\sum_{i=1}^{n}(C_R)_i \oplus W_R\right) \tag{7}$$

where, "softcompute" is the function to generate rational identifies of the cloud aggregation instances, generated by a particular hospital on uploading (W_R). Thus, the generative header tag is correlated and mapped in a distributed manner for larger computation of datasets in the cloud. Typically, the EHR associated with hospital (h_i) can be aggregated as shown in Eq. 8. Hence according to Eq.9, the progression of data storage and the cloud unit $(C_R)_{H_i}$ is updated and synchronized via header tag information stored and archived.

$$(C_R)_{H_i} \Rightarrow \left\{(C_R)_{H_1} \oplus (C_R)_{H_2} \oplus (C_R)_{H_3} \ldots\ldots\right\} \tag{8}$$

$$\therefore (C_R)_{H_i} \Rightarrow \int_0^n \frac{\delta(C_R)_{h_t}}{\delta t} \oplus \sum(C_R) \tag{9}$$

4.3 Blockchain Building Block

The supporting infrastructure setup of cloud uploading and $(C_R)_{H_i}$ formatting and the formulation of blockchain takes the private user a regulated approach whereas the customization of blockchain requires the approach to add additional tags and header information. The computational layering of block updating and building is shown in Fig. 3. The process if building blockchain units, the cloud storage (EHR) in $(C_R)_{H_i}$ format is regenerated and customized into the operation blocks. The summarized information header is aligned and matched with the header layer from multiple cloud sources $\left((C_R)_{H_i} \Rightarrow (H_i)\right)$. The orientation assures the coordination of header is further associated with decision array.

The decision array is generated using dynamic instances of neural networks (NN) represents as (N). The fragmented blocks of data is segmented and iterative instances are added using $\sum(C_R)_i$ occurrences. The process of data aggregation and customization is added with content mapping as represented in Fig. 2. Consider the block code (B_T) made available on operations as shown in Eq. 10.

$$B_T = \left[\left(\lim_{n\to\infty}\left(\prod_n \frac{\delta(C_R)_i}{\delta t}\right)\right) \oplus \left(\int_0^n create(B_T) \times \delta t\right)\right] \tag{10}$$

According to Eq. 10 the instance of block code (B_T) is dependent on two interdependent parameters for creation. If the computational matrix $\left((C_R)_i \in (H_T)_i\right)$ is active and hence the block unit is customized and created for processing. The optimized (B_T) is represented as shown in Eq. 11. Accordingly, the optimized block unit is extracted and mapped in Eq. 11. The customization is further supported and indexed using decision array unit as shown in Fig. 3

$$B_T = \left[\left(\lim_{n \to \infty} \left\{ \sum_i \sum_j \frac{\delta(C_R)_i \cup \delta(H_T)_j}{\delta t} \right\} \oplus \Delta B_T \right)_0^n \right] \tag{11}$$

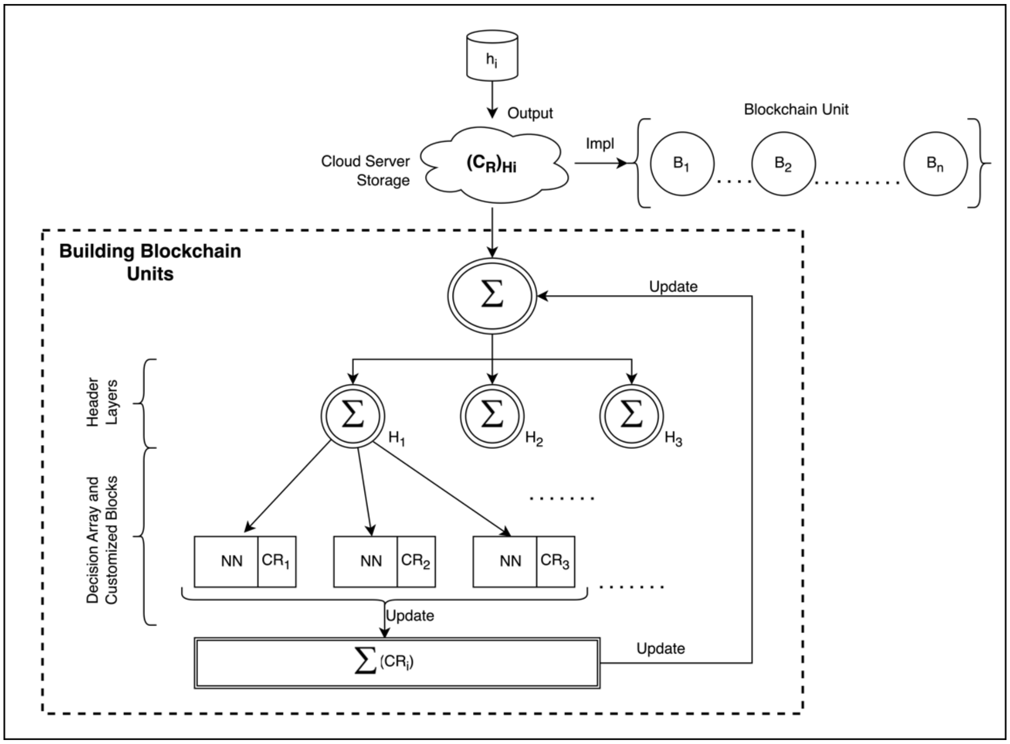

Fig. 3: Layer diagram of blockchain creation and customization unit.

4.4 Generating interdependency hierarchy based blockchain unit of EHR

The customization of blockchain as per the building unit, the block code (B_T) is generated. The interdependency hierarchy based blockchain is further generated to assure the specific blockchain units are created and indexed. The process is supported by generation of Proof_of_stack (PoS) validation. The PoS validation gather's information from internal hierarchy and synchronized with blockchain units and structure as shown in Fig. 2.

5.0 RESULTS AND DISCUSSIONS

The proposed technique is based on the blockchain application for healthcare records (EHR) security enhancement. The process is customized with blockchain parameters such as (d, t, h) with respect to hospital (H) and patients (P) such as $(\forall P_i \in H_i) \| (H_i \Rightarrow \delta(EHR))$ where every hospital generates a EHR and stores in local private servers or cloud. These information streams via block chain is fetched and customized in the proposed system. The proposed technique has developed a blockchain customization for cloud specific data from the hospital authenticated for the blockchain administrator. The approach generates a calibrate alignment of hierarchical interdependencies of EHR datasets. The comparative analysis is discussed on Table. 1 on performance matrix with current data-optimizes algorithms.

Table.1: Performance matrix on EHR indexing at private cloud

Dataset Type	Size (MB)	Precision (%)	Latency (ms)	Upload time (ms)
EHR_General	50	82.31	0.623	1.732
EHR_PDF	43	79.63	0.173	0.832
EHR_PDF (multi)	75	81.69	0.832	2.326
EHR_PDF (Image)	172	92.63	3.62	7.932

The table.1 formulates a series of uplink and latency computation for EHR_type such as PDF, multi-dataset PDF and image based PDF. The orientation is with respect to proposed approach system on private hospital cloud system. The precision computed in the process is resultant of dependency variable associated with EHR. The overall uploading time of EHR is dependent on administrative privileges, network availability (bandwidth) and access to cloud servers.

Table.2: Evaluation on blockchain building matrix

Cloud_Type	EHR Data_type	Variations			Scaling Factor (%)
		Size (MB)	Uplink time (ms)	Latency (ms)	
Public	EHR	50	1.732	0.32	91.31
Private	EHR_General	45	2.326	0.47	90.72
Hybrid	EHR_Mulit	172	7.932	0.81	91.88

Table. 3: Blockchain building matrix

Technique	Record size	F1 Score	D_{Score}	Accuracy
Public_cloud	693	0.6127	0.682	0.9323
Private_cloud	693	0.6177	0.6913	0.9271
Hybrid_cloud	693	0.7198	0.7321	0.9218
Proposed_Cloud	693	0.7123	0.6911	0.9327

Further in Table. 2 and Table. 3, the process of blockchain validation across multiple servers/cloud setups is demonstrated. The Table. 2 projects on evaluation blockchain building matrix. The cloud ecosystem used three types of cloud setup. The public cloud with EHR (general/multi) data types, followed by private cloud setup and PPP model cloud. The objective of this is to assure maximum dependency on blocks unit from EHR. The Table. 3 further project a comparative matrix with proposed cloud models.

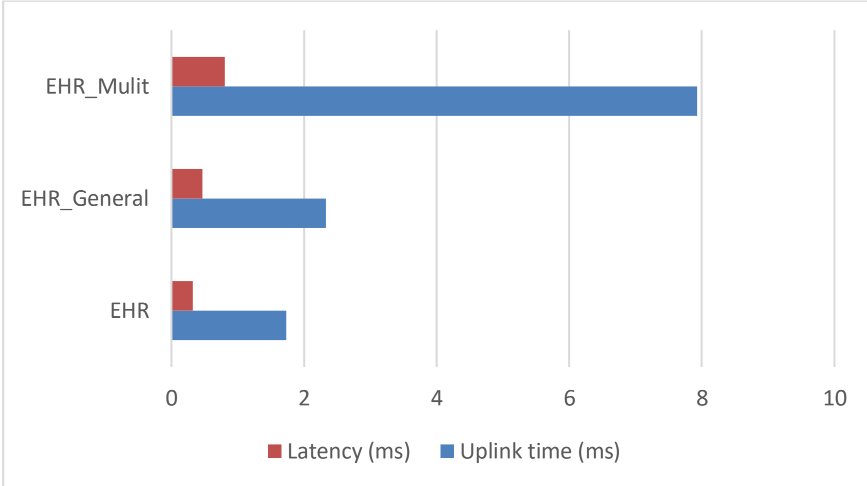

Fig. 4: Uplink time v/s latency across types of EHR records.

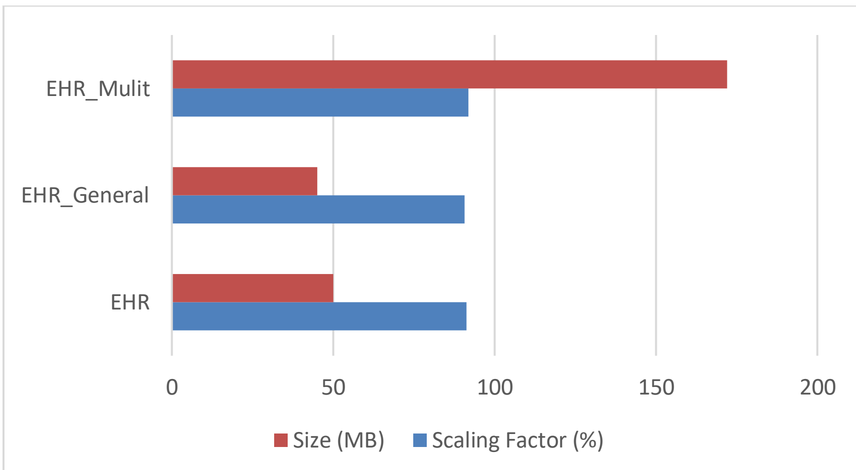

Fig. 5: Size of EHR v/s Scaling factor ratio of the proposed technique

6.0 CONCLUSION

Within the scope of this research, we have delved into the design and implementation of an innovative model tailored specifically for the creation and configuration of Electronic Health Record (EHR) units on a blockchain infrastructure. The approach we have devised represents a significant advancement in the realm of EHR data management, offering a solution that effectively addresses the challenges associated with data conservation and systematic indexing through the integration of blockchain technology. At the heart of our methodology lies a novel interdependency hierarchy approach. This approach serves as the cornerstone for the identification of critical features within healthcare data. By leveraging this hierarchical framework, we have established a robust and reliable methodology for the optimal storage of healthcare data on cloud servers. It is crucial to recognize that the operations and storage capabilities of these cloud servers are intricately linked to the specific types of cloud services that are being leveraged within the system.

To gauge the effectiveness of our proposed framework, we conducted rigorous validation using the MIMIC-III public ERP datasets. Through comprehensive performance evaluations, we were able to discern that the metrics employed, along with the accuracy of the blockchain units, exhibited remarkable enhancements when compared to existing approaches. This not only underlines the viability of our model but also reinforces its potential to significantly outperform conventional methodologies in real-world scenarios. As we peer into the horizon of future developments, we recognize the inherent potential to further refine our technique. Specifically, we envision augmenting the framework by incorporating request-response stacking mechanisms. By integrating these mechanisms, we can proactively bolster the framework's information security facets, fortifying its ability to safeguard sensitive healthcare data within the context of evolving technological landscapes. This forward-looking perspective underscores the dynamic and adaptive nature of our approach, positioning it at the forefront of innovation in EHR data management.

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