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AI-Based PHR System Framework using Blockchain Technology

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Abstract. In response to the changing paradigm of medical information management, there is a growing need to apply refined blockchain technology to Personal Health Records (PHR). This paper proposes a blockchain-based PHR system that addresses the issue of information asymmetry caused by centralized hospital databases while enhancing data security and accessibility. By integrating blockchain and cloud technologies, the study analyzes a method that facilitates real-time access to and understanding of patients' health conditions. The findings indicate that blockchain-based PHR systems promote active patient participation in health management and contribute to improving the quality of personalized medical services. The implementation of such systems has the potential to significantly advance future healthcare services in terms of security, decentralization, and patient-centered data management.

Keywords: PHR, blockchain, medical, modelling

1. Introduction

Various healthcare devices and services are emerging with the continuous advancement of AI technology. Many companies are leveraging cutting-edge technologies such as sensors, smartphones, and wireless communication to provide new healthcare value to doctors and patients. In this trend, efforts to use smart IT devices, including smartphones and health devices, to manage one's health and prevent diseases are increasing among patients and healthy individuals. In other words, interest in and using Personal Health Records (PHR) is steadily growing (Zheng et al., 2022; Xu et al., 2022).

PHR is a system that manages essential health-related information throughout an individual's lifetime. In other words, it encompasses all healthcare platforms related to health information based on personal healthcare services. In past systems, there were Electronic Medical Records (EMR) and Electronic Health Records (EHR), which focused on sharing frameworks based on medical information systems. EMR is created and utilized within a single medical institution, whereas EHR is used across multiple medical institutions while adhering to national standards for interoperability (Islam et al., 2020). The personal medical information stored in EMR and EHR becomes critical data for future PHR systems. Initially, PHR began as a model that integrated and shared personal information scattered across various institutions and devices. It has now evolved into a model that provides valuable services, such as disease prevention and follow-up care, in connection with self-care, medical institutions, and insurance companies (Wang et al., 2020; Zhang et al., 2022).

Generally, PHR is a system that allows individuals or families to store and manage all health-related information throughout their lives. It serves as an integrated platform that provides all healthcare-related services. Patients can access centrally managed PHRs through this platform to retrieve medical information and share it with their doctors. Moreover, patients can easily manage treatment information, medication details, insurance data, and medical records from home. Specifically, the platform enables users to input their PHR, provide health information related to the PHR (such as symptoms, causes, and treatments), upload PHR data through medical institutions, check drug interactions, search for doctors or hospitals, and more.

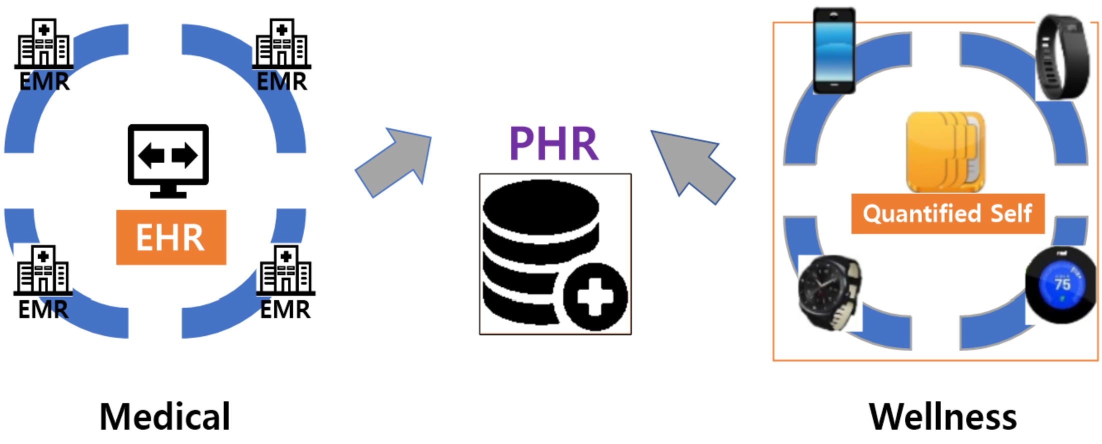

Fig. 1: Structures of PHR

Recent technology in the healthcare data field is shifting from treatment to lifelong management. This lifelong management includes not only diseases and treatment processes but also the daily health status of individuals. The healthcare information environment is transitioning from recording and storing in EMR (Electronic Medical Record) systems to PHR (Personal Health Record). PHR is suitable for customized healthcare services as it allows easy checking of a patient's health status. However, EMR systems are designed differently in each medical institution, making integrating them into a PHR difficult.

The cloud is a suitable alternative because it allows for the easy building and processing of an integrated PHR while supporting various EMR systems. Moreover, since medical information is one of the most sensitive types of information, its security and safety issues can be resolved using blockchain technology. If PHR is built in the cloud using blockchain, the medical system can be maintained while medical information can be widely applied. Furthermore, the algorithm for data distribution processing using blockchain has been applied to solve the high cost of managing individual data in the cloud environment. This method minimizes the costs passed on to each individual. Constructing a healthcare information system in this way, will have a positive impact on the medical world and help provide suitable healthcare services. Therefore, this paper proposes a framework to complete the PHR system using blockchain technology.

2. Related Works

A blockchain is essentially a list of blocks connected in a chain. This data structure is designed rationally and managed through P2P (peer-to-peer) networks. Additionally, all nodes ensure the latest state and share it in a distributed manner. Here, a block is created to record all transaction data and is shared systematically. Blockchain based on Bitcoin is a distributed ledger technology, which is intelligently distributed, shared, and managed as an encrypted database within the network. This technology is designed to ensure that it serves as an irreversible and tamper-proof repository of information. Every block has a header and a body (Lei et al., 2022; Lordon et al., 2020; Contreras & Vehi, 2023).

- Basic Block: Represents a set of validation rules.
- Parent Block: Indicates a 256-bit hash speed.
- Merkle Tree Root Hash: Represents the re-hashed value of all transaction hashes.
- Time stamp: Represents the value in time units.

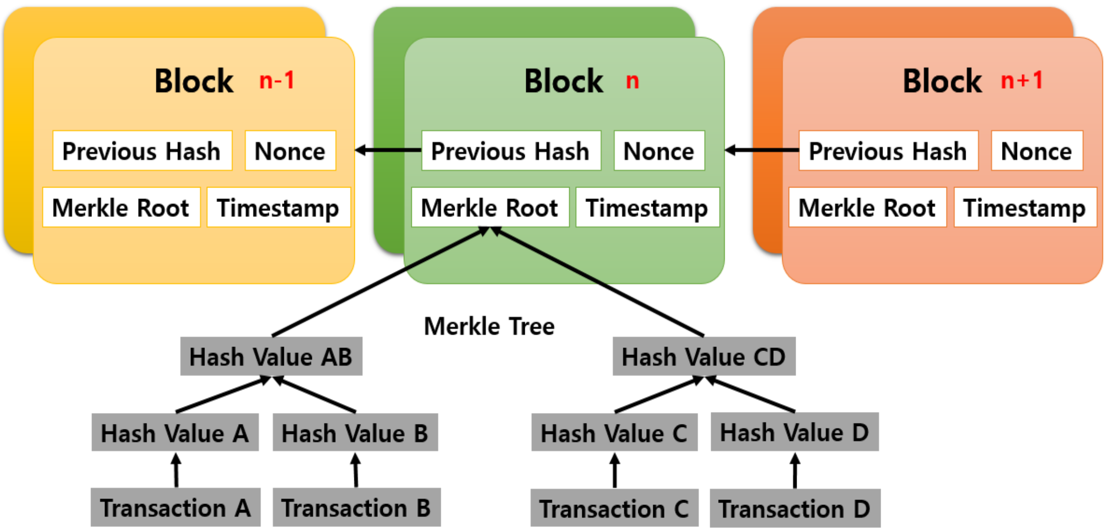

Fig. 2: Structures and elements of blockchain

AI technology provides personalized healthcare services based on big data systems for individual patients in the healthcare environment, enabling more efficient use of medical resources. Due to the global aging population and the increase in chronic diseases, such technology is becoming increasingly essential (Johari & Parihar, 2019). Along with the paradigm shift towards patient-centered care, it is becoming increasingly important to predict diseases based on symptoms and risk factors and effectively manage chronic diseases. As personalized healthcare evolves, applicable AI technologies are continuously being developed and utilized.

Existing systems are helping to predict and prevent diseases by utilizing patient-centered big data systems (Sharma et al. 2025). These technologies are used to make accurate diagnoses and recommend the most effective treatments. In the future, AI technology will have high potential for application in various healthcare settings, including patient and resource management, and will play a crucial role in improving management efficiency in hospital settings.

PHR gives individuals absolute authority over their health information, allowing them to manage it. It also utilizes electronic applications to manage and share the health information of others securely. With the shift in the healthcare paradigm from diagnosis and treatment to prevention and management, the role of PHR is expanding to include personalized health maintenance services and chronic disease management. There are three main types of PHR: standalone PHR, EMR-tethered PHR, and interconnected PHR. Among these, the EMR-tethered PHR, which is linked to a hospital's EMR, is the most widely used (Ye et al., 2020; Jiang et al., 2017; Johari & Parihar, 2019).

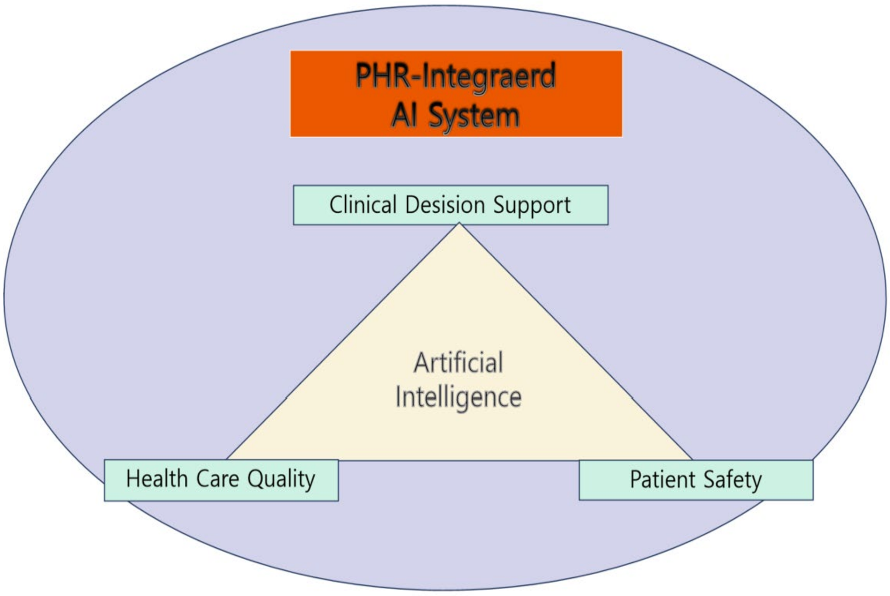

Fig. 3: PHR-integraerd AI system

This Paper proposes a framework using intelligent AI technology to apply such PHR systems. In this framework, resources are securely protected and shared using blockchain technology. In other words, we propose a structure expected to better integrate prediction, diagnosis, health maintenance, and organizational management across all hospital domains.

3. 3. PHR and Standard

The development of hospital information systems, the spread of computerized medical records, and the simplification of treatment and support processes have increased efficiency in terms of cost and time. The convergence of information and communication technology for outpatient treatment and treatment within hospitals has been continuously promoted alongside the advancement of hospital information technology. Additionally, sharing information through PHR (Personal Health Records) collected from individuals enables self-health care for various healthcare institutions and individuals.

Patients must objectively monitor their health conditions while engaging in self-management for health promotion, and clinicians should provide appropriate guidelines. Therefore, services that allow individuals to intuitively check their overall health conditions—including behavior, diet, and exercise-related information—are required beyond the primary information healthcare service providers provides through PHR visualization.

Furthermore, additional implementation of DSS (Decision Support System), which offers guidance for decision-making in personal health management using visualized PHR information, is necessary. PHR will positively impact understanding and legibility when information is presented with user-specific characteristics and personalized visualization techniques. However, the design of services providing personalized PHR information to users has not yet been diversified.

PHR can be summarized as a service that helps consumers access their medical information anytime, anywhere, and directly enter and manage their health information to support lifelong health care. Currently, information systems in the healthcare field are being developed and operated to meet increasing demands for health and medical services, and budgets for informatization are also increasing accordingly. However, existing systems are not interconnected, even though they are interrelated across various platforms, resulting in duplication or manual processing. Moreover, information within each institution is either partially connected or entirely disconnected when sharing data, indicating that consumer-centered PHR services, such as personal history management, are insufficient. Additionally, standardization or real-time networks for inter-institutional data linking have not yet been established, leading to challenges in the real-time provision of various data, such as current status information.

Standards related to PHR can be classified into three main areas: the exchange of PHD (Personal Health Device) information, the exchange of medical information between devices, and the exchange of IoT (Internet of Things) device information. First, the IEEE (Institute of Electrical and Electronics Engineers) 11073 standards was established in personal health devices. This standard has been distributed as an ISO (International Organization for Standardization) international standard to ensure harmonization between IEEE and ISO standards. The ISO/IEEE 11073 PHD Group continues establishing standards for each personal health device based on the standard protocol (ISO/IEEE 11073-20601) to measure and transfer personal biometric data. The exchange of medical information based on PHR is necessary to deliver personal health information, such as medical records and checkup results stored in medical institutions, and this process is classified as follows.

AI assists in analyzing and understanding complex human health data in the medical field. Fundamentally, it mimics human cognitive functions and applies intelligently patterned and learned innovative paradigms. This technology supports various forms of health data (both structured and unstructured), increasing availability and facilitating its application. These technologies emphasize adaptive utilization in all scenarios by offering faster analytical methods than any other approach.

AI is uniquely capable of collecting, processing, and delivering clear outputs to end users. By leveraging sophisticated and diverse real-world algorithms, AI extracts features from massive health-related datasets and provides refined insights that can be applied in clinical practice. Integrating such innovative AI technologies into healthcare helps reduce human errors and facilitates practical application. The results also contribute to improving healthcare quality and patient safety.

Moreover, AI can extract valuable information to aid real-time reasoning for health outcome predictions and health risk alerts by utilizing large-scale patient population data, including PGHD (Patient-Generated Health Data) and EHR (Electronic Health Records). AI technologies have been successfully applied in clinical practice, such as diagnostic processes, treatment protocol development, personalized medicine, drug development, patient monitoring, and management. Research related to AI in various medical specialties continues to grow steadily.

FHIR (Fast Healthcare Interoperability Resources) is a representative standard that performs such functions. FHIR categorizes healthcare data into patients, laboratory results, and insurance claims, with each category represented as an FHIR Resource. These resources define data elements, constraints, and relationships, enabling patient records to be shared in an interoperable format.

The philosophy of FHIR is to create a standardized set of resources that, individually or in combination, can satisfy most common use cases in healthcare. Each resource includes the necessary data elements for its specific purpose and links to related information in other resources. The Patient

Resource (FHIR Patient Resource) includes basic patient information and is designed to share links to other resources storing details about associated clinicians or organizations. All FHIR resources are built on modern web technologies and use Uniform Resource Locators (URLs) (commonly known as web addresses) to specify their location within an FHIR system implementation.

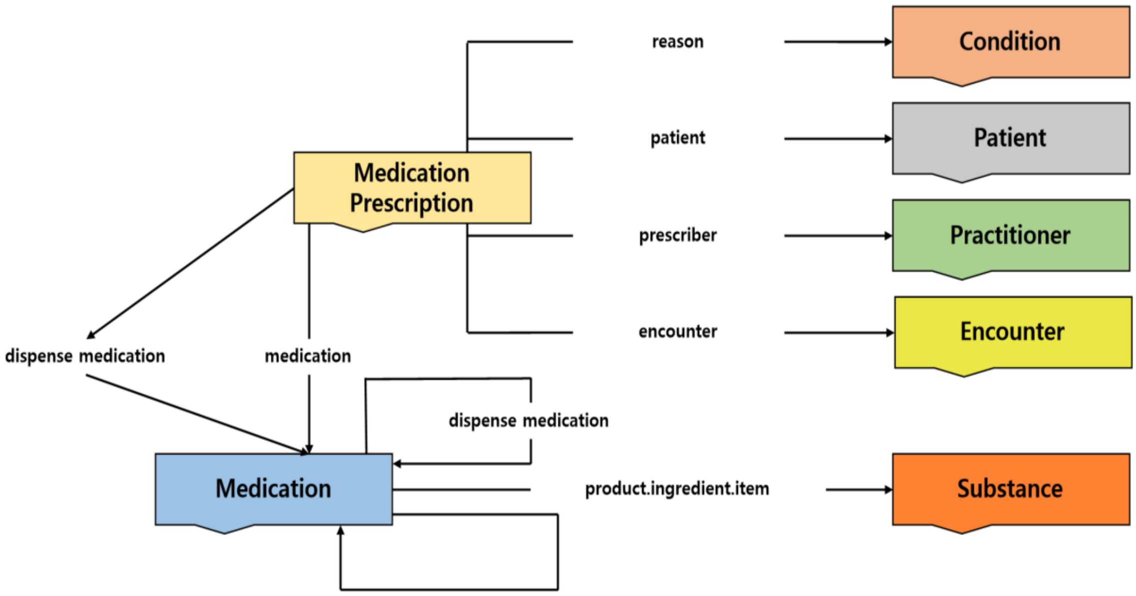

Fig. 4: References between FHIR resources

4. PHR using Blockchain

The medical industry manages medical records, disease history, personal health information, and checkup records to provide more accurate medical services. The ultimate goal is to deliver high-quality health services to everyone. This type of health information management also helps reduce unnecessary duplicate treatments and associated costs. This reduces the economic burden on patients and enhances trust in medical treatment. Blockchain technology is employed to manage such information. Blockchain technology is fundamentally well-structured, aiming for personalization, and is effectively utilized for health information management. For these reasons, blockchain technology is expected to bring innovative changes in various fields, including healthcare, distribution, insurance, and medical management.

The method for building the blockchain-based PHR system applied in this study is as follows: Fundamentally, security is the most critical element in PHR. Therefore, security-related functions must be implemented. This system operates on a cloud-based infrastructure suitable for security purposes and is utilized closed so that only authorized users, such as medical institutions and patients, can access it. Each user is provided with a private key to grant access rights, ensuring all information remains concealed and accessible only to approved entities.

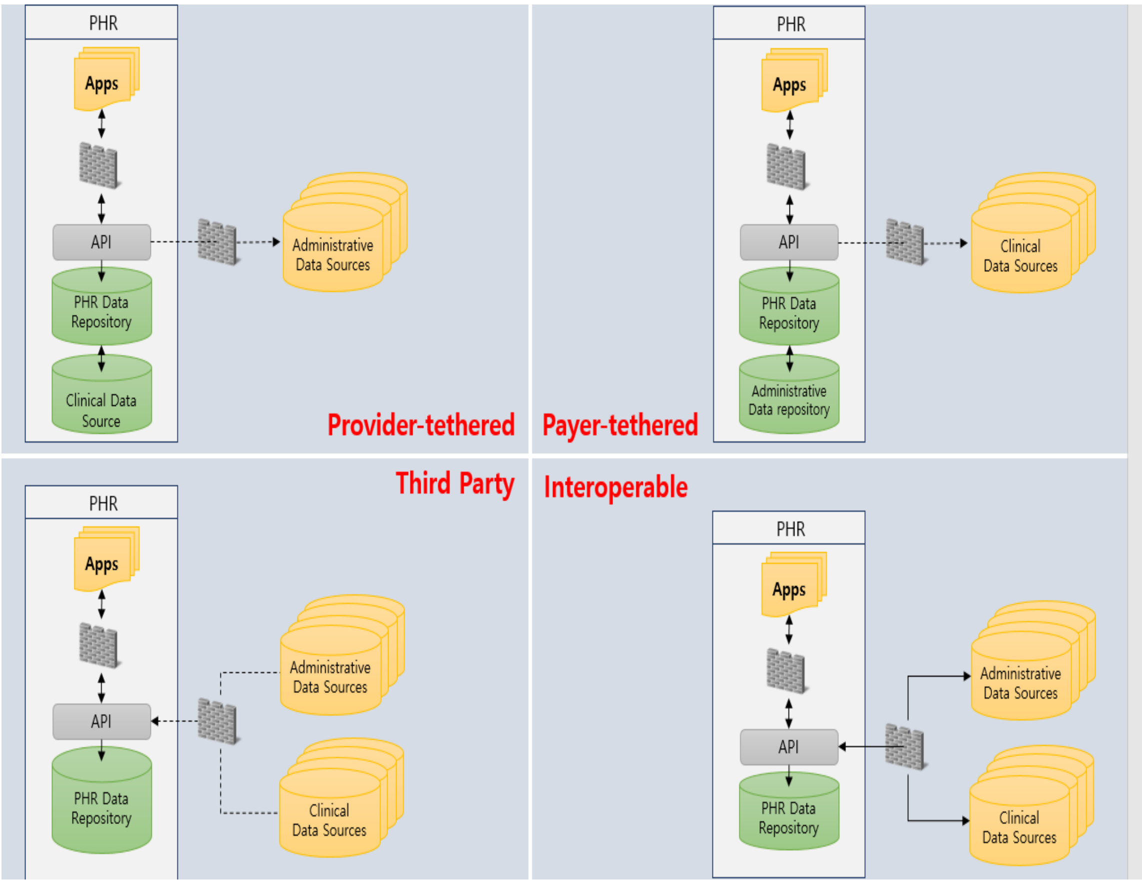

Fig. 5: Elements of blockchain

This blockchain-based system is managed through an API (Application Program Interface) that allows users to process and utilize data in their desired formats. It provides the capability to generate data and offers a flexible, scalable usage environment as the data volume increases. The applied cloud is structured into several distinct layers, each with specific functions.

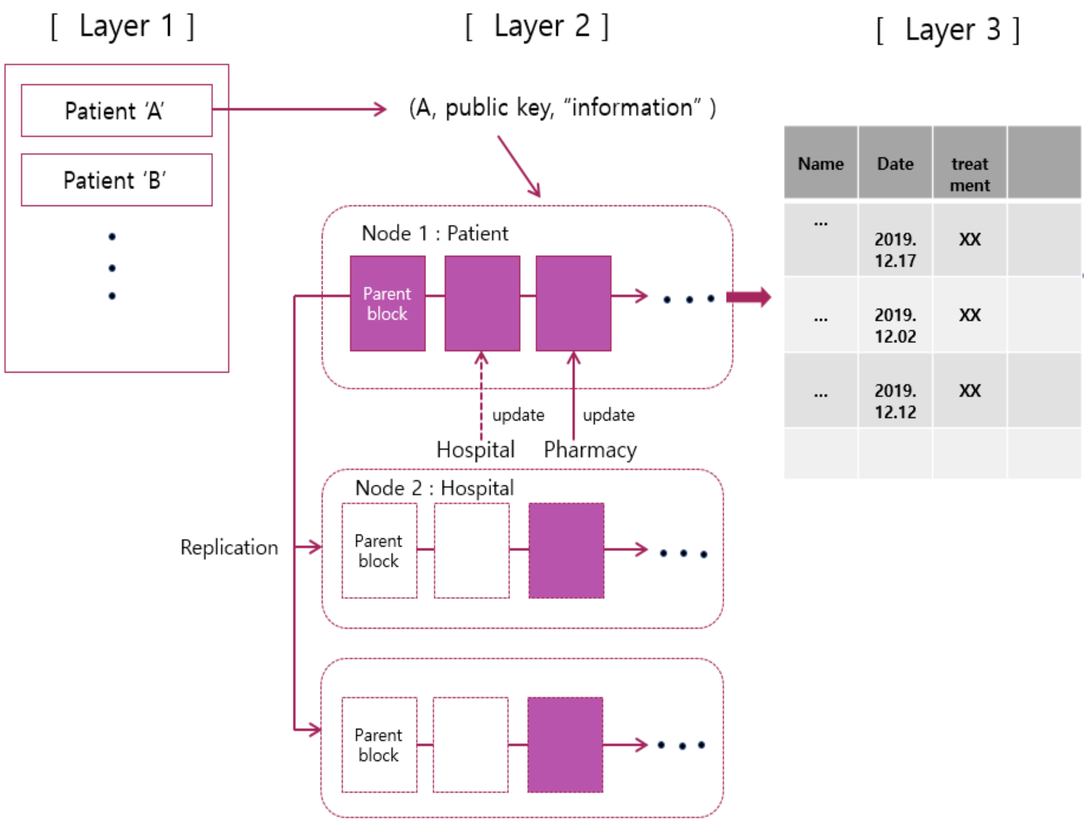

Fig. 6: PHR layer

Layer 1 stores the basic information of patients. Layer 2 saves individual patient medical information in the form of blockchain. Layer 3 stores each patient's information as a database, incorporating international standards such as HL7 and KOSTOM for seamless sharing. Additionally, Layer 1 contains a public key that can identify patients and serves as an address to locate the patient's data within the cloud. Layer 2 consists of multiple nodes, each designated for individual users, such as medical institutions. When a user updates an information block, other nodes replicate the same block and connect it to the chain. This multi-node structure ensures that the data is highly secure and resistant to tampering, providing high data integrity against external attacks.

Finally, Layer 3 utilizes standards such as HL7 and KOSTOM to build the database. The purpose of using these standards is to ensure that users can easily access patient medical information (PHR) or utilize it for research purposes. This provides a streamlined and standardized approach to managing and sharing health information.

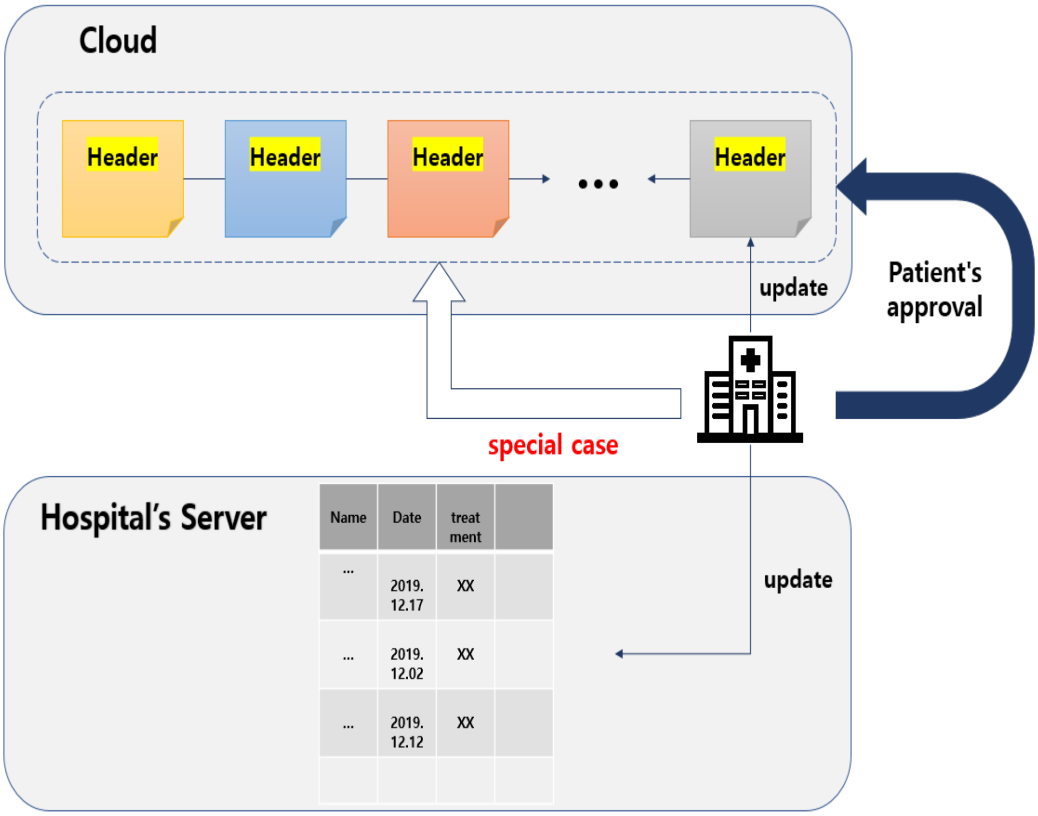

Fig. 7: Cloud based PHR

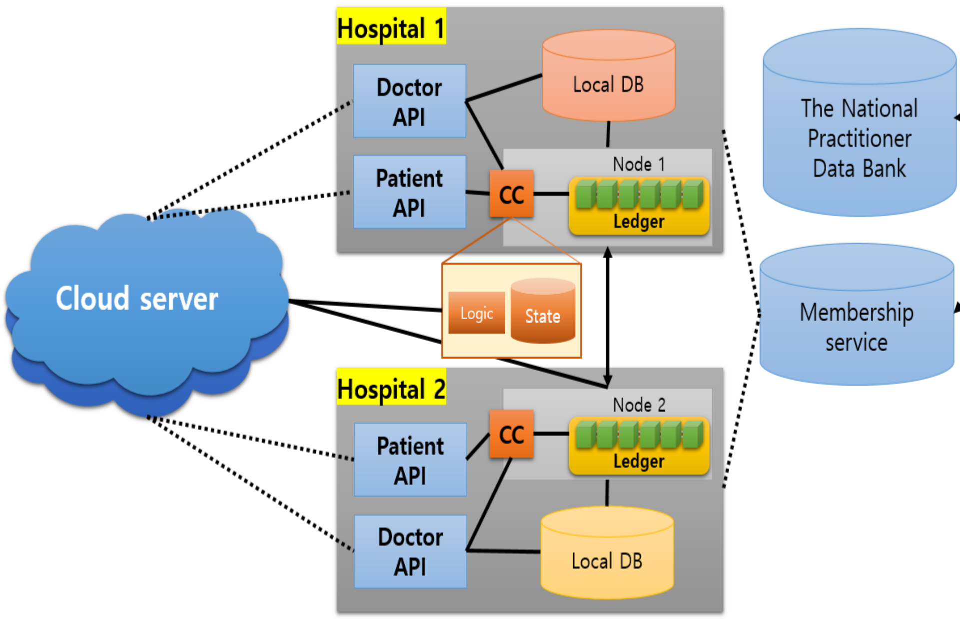

Fig. 8: PHR AI system framework

When authorized users register or update medical information, the updated information is simultaneously stored in the Cloud and made accessible to existing users through the Cloud. Additionally, users can directly update patient information in the Cloud. However, the updated information includes an encrypted address linked to the same blockchain header (block information).

This structure ensures automatic connectivity while preventing unauthorized sharing of a patient's PHR (Personal Health Records). However, there may be situations where a patient's PHR needs to be accessed. In such cases, the PHR can only be accessed with the patient's explicit consent.

Furthermore, there may be instances where medical information stored in the Cloud database (DB) is required for research purposes. In such scenarios, users can utilize the API provided by the Cloud to anonymize the data and create a new database. Researchers who are registered as authorized users can then access this anonymized database to use it for research purposes. Additionally, all data usage history is recorded in the database to ensure accountability and traceability.

5. Conclusions

Blockchain technology can be utilized across the healthcare and medical fields. In particular, with the advancement of AI technology, it is noteworthy that medical consumers—individuals who were once considered victims of information asymmetry caused by hospitals' monopoly over medical data—can reclaim their data sovereignty through intelligent blockchain technology.

As the PHR (Personal Health Record) system evolves, the medical paradigm shifts from treatment-focused to management-focused care. Various AI technologies are being integrated and operated to enable individuals to manage their own health information intelligently. In this information management paradigm, understanding the current health condition and pre-existing diseases and their treatment history is essential. Notably, the method of storing medical information is transitioning beyond the environment where data is recorded and stored through EMR (Electronic Medical Record) systems to a cloud-based PHR system that integrates EMR data with additional patient health information.

The emergence of PHR in the medical field, driven by such changes, enables an easier understanding of patients' health conditions. Specifically, cloud technology combined with blockchain provides secure defenses, making personal information manageable and protected. Therefore, an intelligent PHR system, like the blockchain-based AI technology discussed in this paper, is a highly suitable approach for delivering personalized medical services tailored to individual patients.

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