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Research Article

Blockchain and Electronic Health Records Security in Hospitals

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Abstract

Blockchain is a block chain technology with a complex encryption process, featuring security, decentralization and privacy. Thanks to its ability to authenticate data accurately and minimize the risk of fraud, Blockchain has been applied in many industries, including healthcare, in medical examination and treatment processes and record management. Storing medical and health records in digital form helps to retrieve information quickly, improve the quality of patient care and the effectiveness of medical examination and treatment. However, the issue of online information security is still a major concern for managers, patients and users. This article will present (1) the operating mechanism of Blockchain; (2) the medical examination and treatment process according to regulations; (3) the security of health records and medical records when applying Blockchain technology, and propose solutions in the application of health records and patient medical records management.

Keywords: Blockchain; Health Records; Medical Records; Patients; Security.

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1. Introduction

In the operations of today's units, most units are interested in applying Blockchain technology to their operations, because the benefits Blockchain technology brings are huge for organizations and customers.

Blockchain technology is based on distributed computing on a trusted network. Any data block that is managed will be stored in a distributed database, stored on a peer-to-peer network, also known as Peer to Peer. (P2P). At this point, chains are formed between blocks and these blocks cannot be modified arbitrarily.

To put it simply, Blockchain is distributed ledger technology, distributed numbers can process transactions without the participation of a third party. Much different from databases, distributed databases do not have a central administrator or single storage facilities. Distributed ledgers are managed by many participants, some of which rely on a decentralized network that spans multiple locations and possibly more countries. According to JinWhan (2019), the ledger is stored and managed transaction information on participants' computers connected to the P2P network instead of the organization's centralized server network (JinWhan, 2019). (Picture 1)

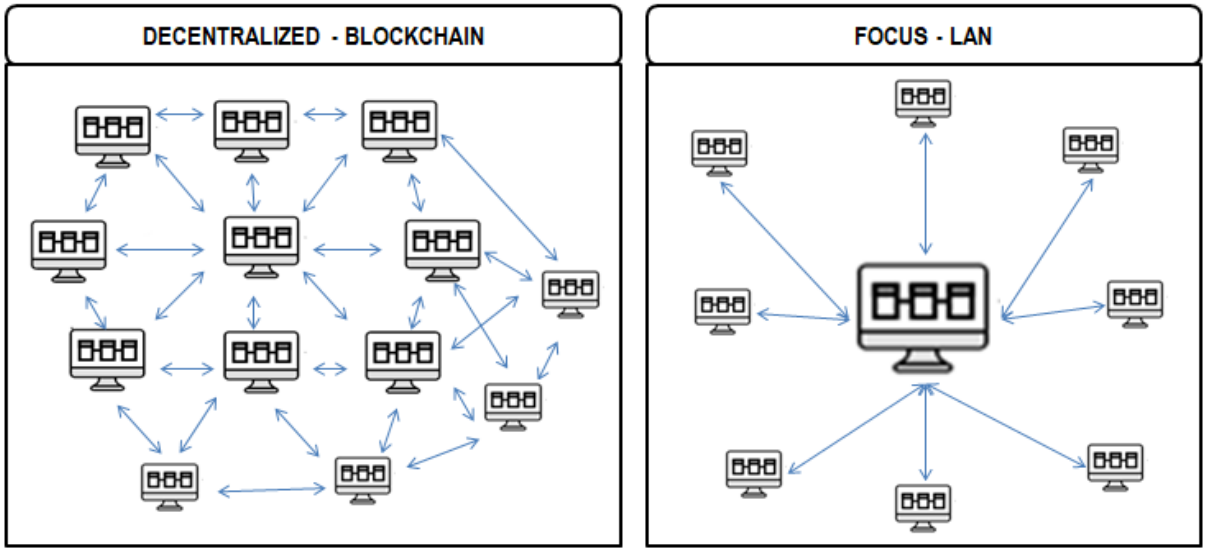

Figure 1: Decentralized and centralized network models

Blockchain technology has developed and upgraded from Blockchain 1.0 (2009) to Blockchain 4.0 (2020) and is currently Blockchain 5.0. With the superiority of Blockchain and high efficiency when applied to operating businesses and organizations, many businesses and organizations have implemented integration into business operations. As Jafar et al. (2022) stated, Blockchain has been deployed in many fields as part of the infrastructure of business operations requiring transparency, integrity and reliability.

In the medical field, health care organizations have been interested in investing in Blockchain technology to put it into operation, as Berner et al. (2005) stated, Blockchain technology helps organizations Medical activities improve the quality of patient care, improve hospital quality and reduce operating costs (Berner et al. 2005).

The goal of businesses in general and medical units in particular is to create customer satisfaction. Customers to businesses can be understood as internal or external (Nhan et al., 2023). For the medical field in particular, the main customers are the patients and also the internal personnel and departments in the unit. Therefore, to improve the quality of treatment, care, treatment safety and patient satisfaction by reducing medical errors and improving the quality of support services.
Many medical units have improved operational efficiency, improved care quality, reduced medical errors, and saved medical resources (Ahmadian and Khajouei, 2012); (Van et al., 2022); Errors in treatment are often related to incomplete information, as researched by Khue et al. (2017) pointed out errors such as errors in drug prescription; Errors due to missing medication instructions; Errors due to updates specifying the wrong time; Error in follow-up instructions; Mistake in lack of treatment information (Khue et al., 2017). To avoid errors, clinical notes need to provide clear information about clinical symptoms, findings, diagnoses, prescribed tests, and care, fully provided in the medical record. health records and records (Le Dinh, 2020); (Jansen, 2005); (Sheikhalishahi et al., 2019).

To meet and overcome problems arising from manual manipulation of data, improve data and information processing. Reduce medical errors and ultimately bring patient satisfaction. Blockchain technology has been applied in the field of health and medical care (Ben Fekih et al., 2020); (Sheikhalishahi et al., 2019); (Schiff et al., 2010).
With the widespread application of blockchain technology and the continuous development of new technologies, challenges and concerns about information security of electronic health records, electronic medical records, and medical data in particular are emerging. general is constantly increasing.

With electronic health records used to store patient data in healthcare and medical service providers. Hussienet et al (2019) stated that electronic health records provide the ability to store and manage patient data across organizations (Hussienet al. 2019). Electronic health record systems are designed to combine paper-based and electronic, digital medical records. These systems are used to store clinical notes and test results, and relevant information during treatment (Jetley and Zhang, 2019). Electronic health records help improve patient safety by preventing errors, increasing access to information, promptly handling arising problems, and solving problems that health care records based on encounter paper recording (K. Wisner et al. 2019); (Hochman, 2018). But, concerns that many health managers, researchers and patients, users are concerned about and like Yksel et al (2017); Tertulino et al (2024); Keshta and Odeh 2021); Fernández et al (2013) are concerned about information security for electronic health record systems. Keshta et al (2021). It was also stated that electronic medical records can bring many benefits to doctors, patients and healthcare services if they are applied and used properly by healthcare organizations.

But concerns about security related to patient information and clinical examination and treatment processes may cause some medical organizations to adopt relatively low electronic medical records, and this is also a concern. concerns and challenges for medical organizations and units (Keshta et al., 2021).

When applying blockchain technology to electronic health record management, will it address concerns and concerns about compromised security?
In this article, the author will present the operation and structure of blockchain technology when integrated into the field of medical operations and the level of security for medical records and patient information security. from concerns, and at the same time propose some solutions for

medical units and organizations when applying blockchain technology to their operations.

2. Theoretical Foundation and Research Hypothesis

Blockchain technology

Blockchain has been stated by Francisco and Swanson (2018) "blockchain is a distributed database, shared and unified on a peer-to-peer network. It consists of a chain of linked blocks, containing transactions that are time-stamped and secured with public-key cryptography and verified by the network community. With Seebacher and Schüritz.(2017) stating about Blockchain that "When an element is added to the Blockchain, that element cannot be changed, but turns the Blockchain into an immutable record of activity" (Seebacher and Schüritz , 2017). Thus, it can be seen that Blockchain was created to resist changes and adjustments to the database and ensure that, once data has been established and accepted, that data will not be changed. Which can be adjusted and changed? However, as observed by Wenhua et al. (2023), from a technical perspective, blockchain is not a new technology, but this is only seen as a collection of existing technologies including Peer-to-Peer Immutable Distributed Ledgers; Security technology such as encryption; Smart Contracts and Consensus Algorithms (Wenhua et al., 2023). As for smart contracts, Nick Szabo (1994) introduced and called smart contracts because it includes a set of agreements by which contract participants can enforce commitments and contracts. Smart ensures reliable transactions without third-party involvement. Kairaldeen et al (2021). It has also been stated that smart contracts provide a method of security and reduced transaction costs compared to other contracts, smart contracts ensure that all transactions between nodes are trustworthy (Kairaldeen and al., 2021).

When viewed from a principled perspective, Wenhua and colleagues (2023) believe that blockchain is a distributed shared ledger technology, establishing a decentralized, reliable ledger system, using the solution Mathematics develops mechanisms of trust and consensus among all parties involved. (Wenhua et al., 2023).

Regarding the features of blockchain, Talukdar et al. (2021) outlined features of blockchain such as sharing, consensus, fair competition, and trustworthy safety. In Trusted Safety feature: data encryption and cryptography mechanism prevents data from being tampered with; Sophisticated checksum sharing mechanism ensures integrity, availability, and security. detect attacks through encryption standards (digital signatures) and each node has a key; For the Fair Competition feature: activity at nodes is calculated by algorithm and the algorithm determines execution rights; For the Sharing and Open feature: the system is open to all participants, people with different permissions will use blockchain information differently; For consensus feature: through confirmation at specific nodes to complete transaction verification and confirmation in a short period of time. If some nodes can reach consensus without transaction-related benefits, it will consider system consensus; Authentication and integrity feature: Here, each record is recorded honestly and completely under the supervision and consensus of the system.

Regarding the important properties of Blockchain, Pilkington (2016) states that, Blockchain is a distributed digital ledger of transactions that cannot be tampered with due to the use of encryption methods and the three most important properties of Blockchain: decentralized, verified and immutable (Pilkington, 2016) with these three properties, shown by the author of the article as Figure 2 below

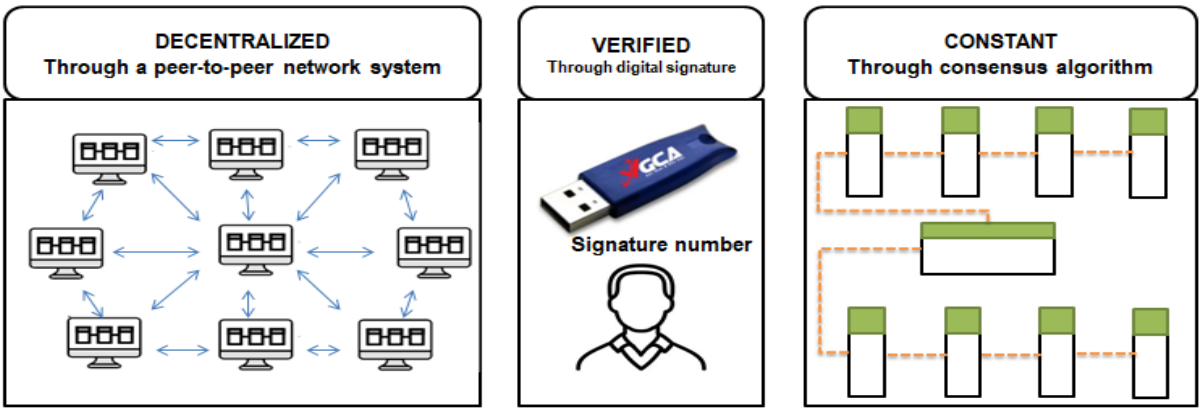

Figure 2: Basic properties of Blockchain

In short, it can be understood that Blockchain is a distributed database, shared and unified on a peer-to-peer network. It consists of a chain of linked blocks, containing transactions that are time-stamped and secured by public-key cryptography, verified and blockchain Blockchain is a distributed digital ledger of transactions that are not can be tampered with due to the use of encryption methods

Electronic medical records

According to Gunter and Terry. (2005) Electronic health record is a digital record with a collection of patient medical records, electronic medical records are stored electronically in a digital format that is used by the hospital or clinician. readiness maintained over time (Gunter and Terry, 2005). For Hufnagel. (2009). Electronic medical records include all the important clinical data that is critical to patient care stored by a care provider. Specifically, this includes MRI reports, previous medical examinations, vaccinations, laboratory reports and any type of allergies of the patient (Hufnagel, 2009). In the territory of Vietnam, Article 59 of the Law on Medical Examination and Treatment (2009) also clearly stipulates that electronic medical records are medical, medical and legal documents and each patient is only have a medical record for each medical examination and treatment at a medical facility. When this record is created, updated, displayed, digitally signed, and stored electronically to meet legal regulations, it has the same legal value as a paper medical record (Circular 46, 2018). Electronic medical records can be presented in the form of Figure 3 and Figure 4.

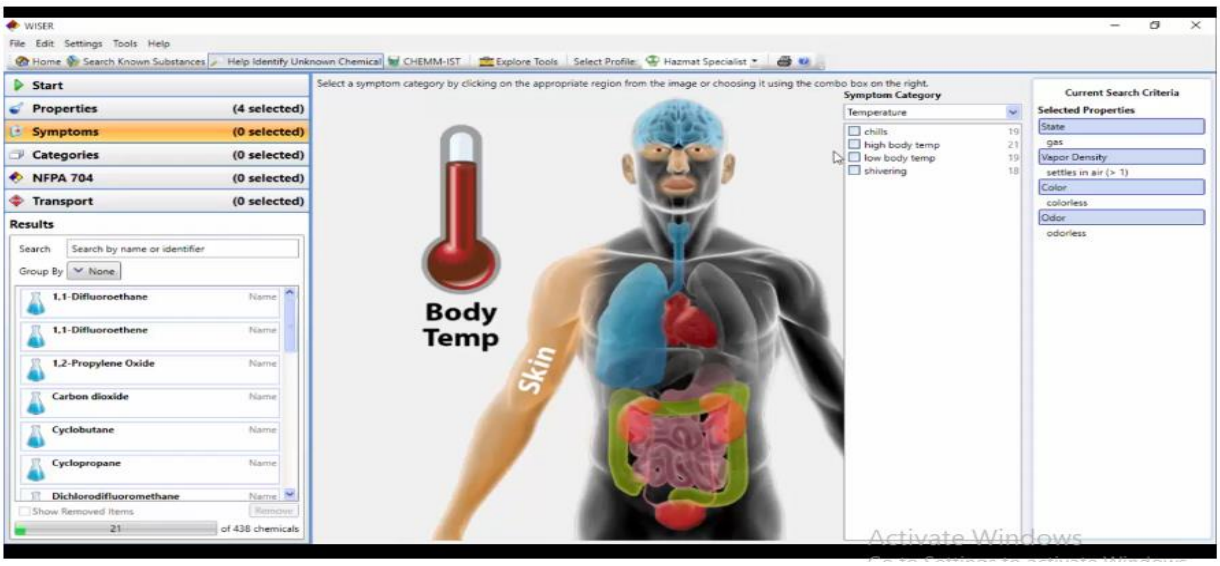

Figure 3a: Electronic medical record

Figure 3b: Electronic medical record

Figure 4: Electronic medical record

In summary: Electronic medical records are records stored in digital form with all clinical data during the examination and treatment process, and each person has only one medical record. This file is a legal document signed digitally, stored electronically according to current legal regulations.

Clinical Examination Process includes tests, images and diagnosis
In this article, the author discusses the clinical examination process with tests, imaging and functional exploration to temporarily provide an overview of relevant information in the medical record. . With this medical record, the application of blockchain in managing electronic medical records ensures the integrity of the record.
Pursuant to Decision 1313/QD-BYT (2013) and instructions on medical examination procedures at the hospital's Examination Department issued by the Minister of Health ((2020). Regulations on medical examination and treatment procedures are implemented as follows :

a. Responsibilities of the patient (MOH medical examination process, 2020)

a) Wait for the examination according to the order number written on the medical examination form.
b) Check in when notified.
c) Receive a technical indication form for functional exploration from the examining doctor.
d) Go to the technical office to explore the function, submit the appointment form and wait for your turn.
e) Coordinate according to the instructions of doctors and technicians to perform techniques.
f) Wait to receive the results of the functional test and return to the examination room.
g) Submit image diagnosis results, the doctor examines the diagnosis and prescribes treatment.
h) Receive treatment instructions or prescriptions and go to the place to complete procedures to pay hospital fees or health insurance co-payments. (MOH medical examination process, 2020)

b. Hospital responsibilities

1) In the medical examination room

According to the Health Examination Process of the Ministry of Health in 2020, it is conducted as follows:

a) Inform patients to come in for examination according to their order number.
b) Clinical examination, recording information about disease condition, specifying functional testing techniques and printing prescription cards.
c) Instruct the patient to the place where functional exploration techniques will be performed.
d) The doctor reviews the results of functional testing, diagnoses, prescribes treatment, and prescribes.

2) At the place where functional exploration techniques are performed

According to the Health Examination Process of the Ministry of Health in 2020, it is conducted as follows:

a) The best place to perform the technique is in the medical examination department to create convenience for the patient, reduce travel distance and be convenient for the patient. In case it cannot be arranged, there is a diagram with specific instructions for the patient.
b) Doctors and functional testing technicians receive prescription forms from patients.

c) Instruct patients to prepare and coordinate technical implementation.
d) Return results of functional testing, along with films and photos (ifany) to the patient.

With the presentation in section 2.3.1 and section 2.3.2, the author draws a diagram of the clinical examination process with tests, images and functional exploration (Figure 5).

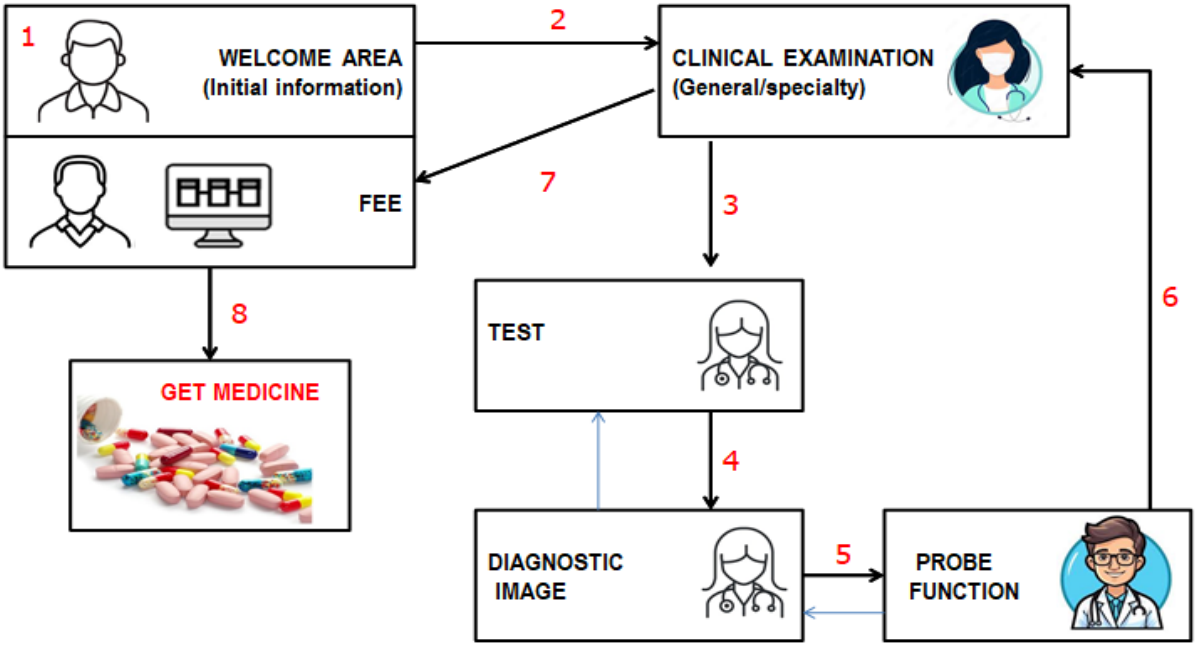

Figure 5: Examination process including testing, imaging, and functional exploration

3. Hypothesis and research model

With the presentations in section 2.3 on the medical examination process based on Decision 1313/QD-BYT (2013) and with instructions on the medical examination process at the hospital's Examination Department issued by the Minister of Health (2020) is shown by the author as shown in Figure 5 above. It can be seen that steps 1 to 8 are all stages in the medical examination and treatment process, and information at each step is recorded into medical records. electronic because it includes all important and very important clinical data through the steps of receiving information, initial clinical, testing, imaging diagnosis, functional investigation, treatment conclusion and including including MRI reports, previous medical examinations, vaccinations, tests and any allergies and complications of the patient are updated and information is entered into the medical examination book or electronic health book.

When applying Blockchain technology to medical activities, specifically managing patient medical records and electronic health records, the author proposes a hypothesis and research model (Figure 6):

H1: Initial clinical information in electronic medical records is confidential
H2: Test information in electronic medical records is confidential
H3: Image and diagnostic information in electronic medical records is confidential
H4: Functional survey information in electronic medical records is confidential
H5: Payment information in electronic medical records is confidential
H6: Medication and treatment information in electronic medical records is confidential

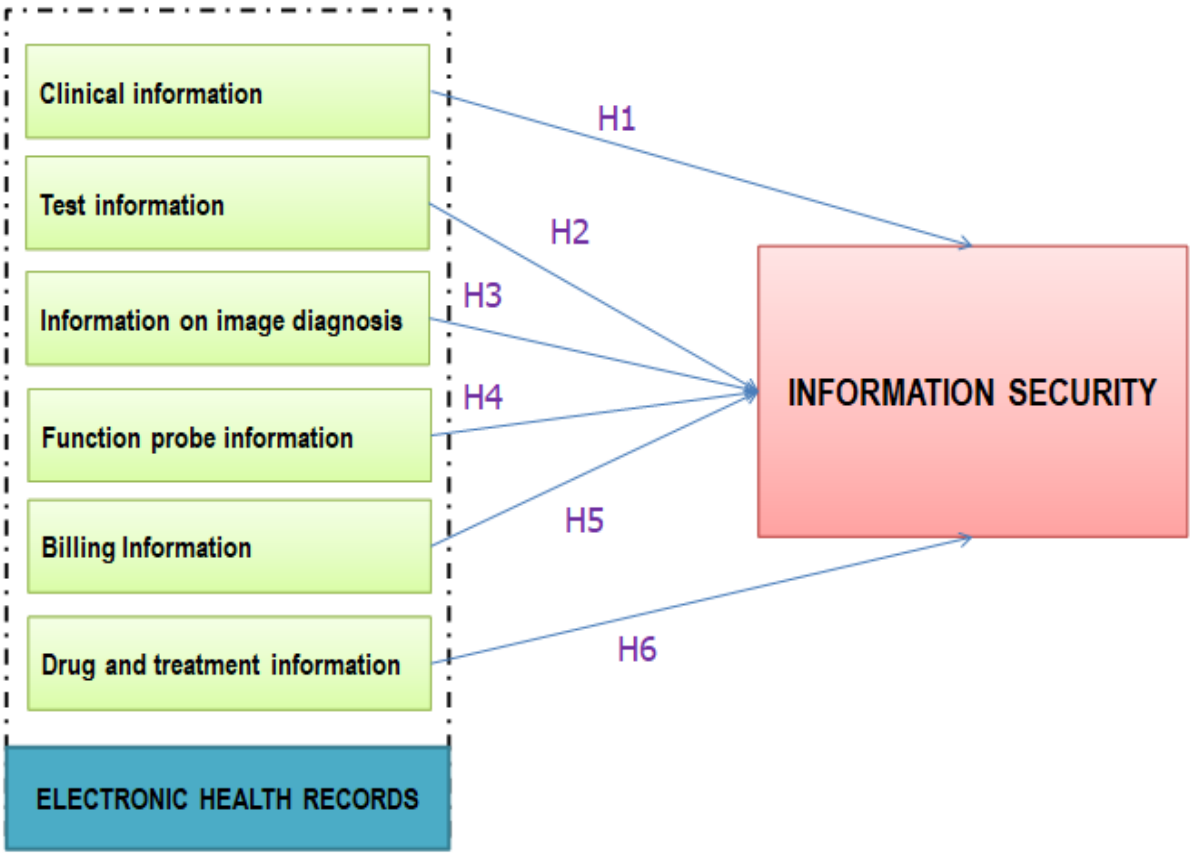

Figure 6: Research model

Source: Suggested by author (2024)

4. Research methods

The author applies a qualitative method, based on the operating structure of Blockchain, combining secondary data and related studies on Blockchain applications. The author analyzes, compares and gives assessments and comments on the effectiveness of Blockchain applications in medical record management, ensuring the safety of patient and user health records. From there, conclusions and recommendations are drawn.

5. The Current state of Blockchain technology

Blockchain architecture

Blockchain architecture simply understands the processes and starts with (1) the user sends a transaction, followed by (2) receives the transaction, (3) performs authentication and information processing, (4))the transaction is validated and block generated and (5)the transaction is completed. The above process is drawn and described by the author as (Figure 7) below:

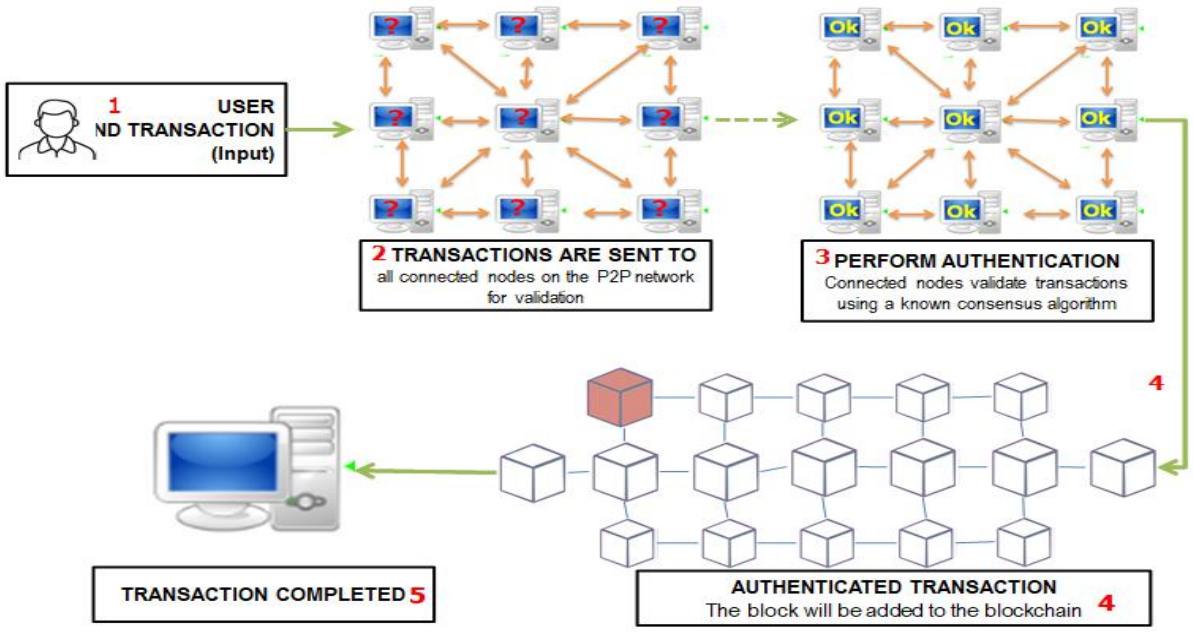

Figure 7: Blockchain architecture with 5 steps

Source: Author's drawing (2024)

a. User submits transaction

At this stage, a new transaction is established and sent by the user on the blockchain network. Thus, a new block is created and the transaction is stored and then distributed to all connected nodes in the network. All nodes in the network have a copy of the complete blockchain which helps protect data during verification. When a block containing a user transaction is verified that the block has not been tampered with and the verification process is successful, nodes now add the block to the blockchain

b. The transaction is sent and authenticated

At this stage, the transaction is sent to all connected nodes on the peer to peer (P2P) network, and P2P is a distributed application architecture that partitions tasks and work between peers. Peers include participating devices with equal privileges. All form a network of peer nodes to authenticate incoming transactions, nodes are authentically connected to each other in transactions using a consensus algorithm.

During the process block data is added to the blockchain and is done by nodes reaching consensus and deciding which block is valid to be forwarded to the next step of adding to the blockchain. The authentication process verifies the transaction and ensures the sender of the transaction is an authentic part of the system.

c. Blockchain consensus algorithm

Each block added to the blockchain goes through a review process to get approval from all the other nodes registered on the network, and the added node is an authorized node. According to Evans. (2016), this process is performed using a consensus algorithm. The consensus algorithms used are PoW, PBFT and POS (Wu et al., 2020). Thus, when identifying and verifying who is

adding data to the block to the chain, it is necessary to use a private and public key, called a "digital signature" and as Yang et al. (2019) already if. When a user makes a transaction, it is signed with the user's private key (Yang et al., 2019). The algorithmic authentication process is shown in Figure 8; The following figure 9 is intended to verify whether the transaction was actually requested by the sender or not.

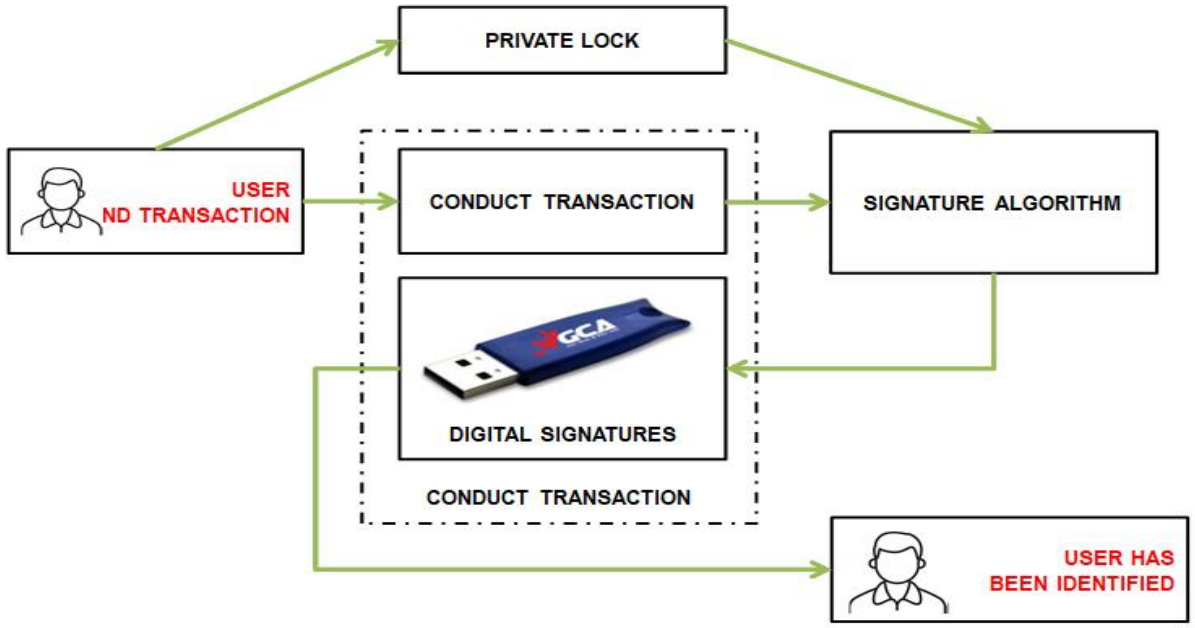

Figure 8: Process of sending transaction request to verifier

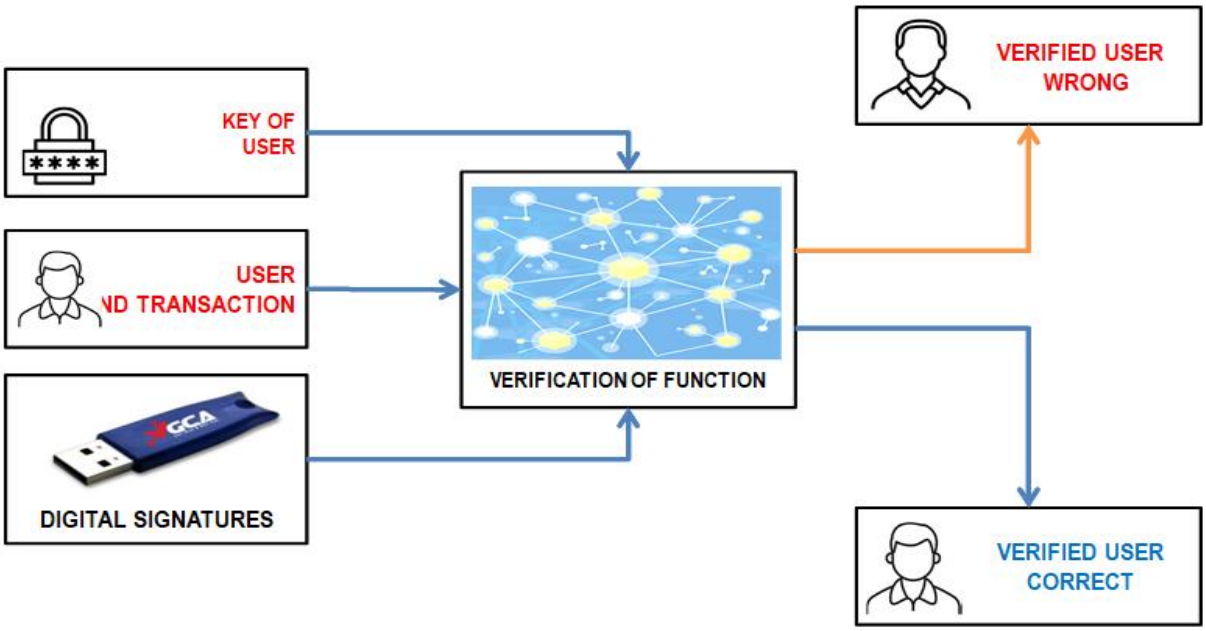

Figure 9: Confirm transaction request

Source: The author redraws the basis of blockchain theory

d. Transaction is confirmed

After the validation process is completed using the Consensus Algorithm used as PoW, PBFT and POS, the new data block will be added to the blockchain.

e. Transaction completed

After the validation process and the new data block is added to the blockchain, the transaction will be completed.

Privacy rights in Blockchain

According to Salman et al (2018); Wu et al. (2020) and Yang et al. (2019), Blockchain provides security to the network through the use of cryptography. Each individual block of a blockchain is connected to a block before and after it. With this mechanism, it will be very difficult for illegal network intrusions (hackers) to change any records. To change, all records or blocks associated with the record that the intruder wants to modify, change, or manipulate must be changed. This is practically impossible to do in a huge network with links beyond the country, where there are a number of blocks in a blockchain. (Figure 10)
As (figure 10) can be seen, any blockchain starts with a root block that serves as a foundation to which other blocks are added sequentially.

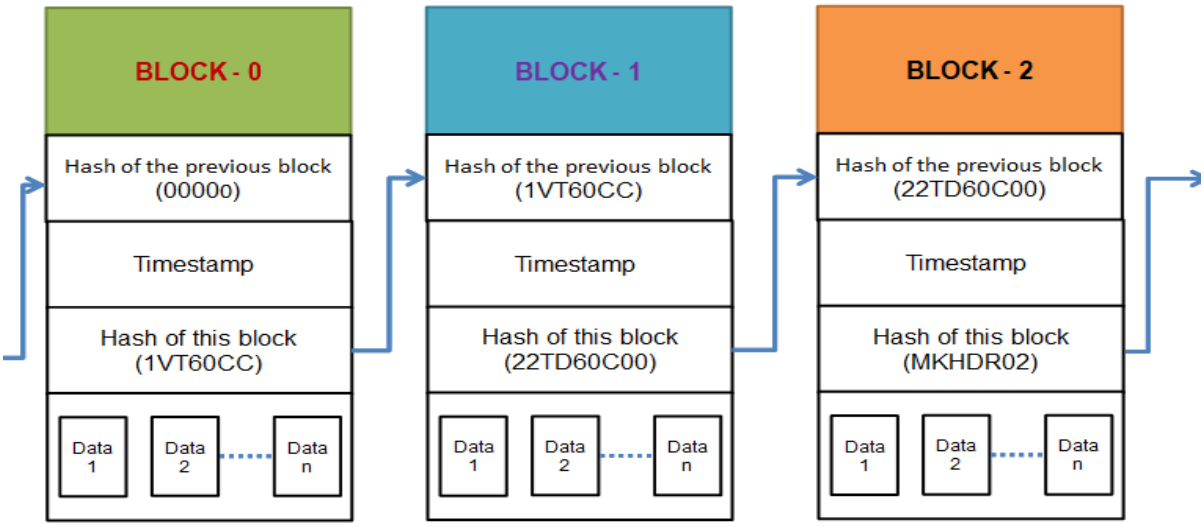

Figure 10: Structure of a blockchain

Source: The author redraws the basis of blockchain theory

As shown in figure 10. At block 0 with the Hash of this block is (1VT60CC), then in the next block 1, the Hash of block 0 becomes the Hash of block - 1 and at block 1 with the Hash of this block (block 1) is (22TD60C00) then the next block (block 2) becomes the Hash of block 2 (22TD60C00) and the Hash of block 2 creates the Hash of this block as (MKHDR02). Thus, each block on the blockchain will include the hash of the previous block, timestamp, nonce data and transactions. With the Hash at each block is also responsible for linking this block to the previous block by preserving the Hash of the previous block. Therefore, the blockchain becomes immutable and very difficult to change.

6. Discussion

With the content the author has presented above. It can be seen that blockchain technology uses cryptographic functions to provide security for nodes connected on the blockchain network, using algorithms such as PoW, PBFT, POS and SHA256 encryption on values. stored on blocks, creating security for the blockchain with integrity, ensuring data. All of this has made blockchain technology

a decentralized platform that ensures the safety of information and data through information encryption. This makes blockchain technology a good choice to protect information, meet data security requirements, and avoid illegal intrusions with malicious purposes.

Operating according to the 5-step architecture of blockchain, applied to the process of performing clinical examination with testing, imaging diagnosis and functional exploration. At each step of the process of performing operations with the application of blockchain technology in each step of the medical treatment process, we see that the data manipulation and processing process must be carried out according to the 5-step architecture. step of blockchain. And the initial clinical information in the electronic medical record is authenticated and functionally verified by algorithms and digital signatures. If the user authenticates correctly, the transaction is now authenticated and the block will be added to the blockchain, resulting in a completed transaction. Thus, (H1) Initial clinical information in electronic medical records is always guaranteed to be confidential. With the completed transaction results of the process and the hypothesis (H1), it will become the input of the next process such as hypothesis H2, including test information and data of this process entered into the system. . After the authentication process, function verification by algorithm and digital signature. The user results of this examination phase are verified as correct, at this point the transaction is validated and the block will be added to the blockchain giving the transaction results as complete, meaning the user information of the transaction is correct. , a new block of information will be added to the blockchain resulting in a completed transaction. Thus, (H2) the confidentiality of test information in electronic medical records is guaranteed.

For the next steps of the clinical process including testing, imaging and diagnosis, hypotheses H3; H4; H5; H6 is also implemented according to the 5-step blockchain architecture (figure 6) and the Process of sending transaction requests to verifiers (figure 7) for each step in the process. The authenticated output for each process becomes the data input of the new process. Thereby, it can be seen that the authentication process using algorithms, the digital signature of each process is repeated many times in the same data block. When the data block is added to the chain, it must also follow the consensus rules, algorithmic processing (PoW, PBFT, POS) and complete authentication, at which point the new data is created and added to the blockchain chain.

In summary: When applying blockchain in information management of electronic medical records with (H1) Initial clinical information, (H2) Laboratory information, (H3) Image and diagnostic information, (H4) Functional exploration information, (H5) Payment information, (H6) Drug and treatment information recorded in electronic medical records are always guaranteed to be highly confidential and secure.

7. Conclusion and recommendations

Conclusion

Blockchain technology provides security through the use of cryptography. Each individual block in a blockchain is connected to a block before and after it. Each block on the blockchain will include the hash of the previous block, timestamp, nonce data and transactions. With the Hash at each block is also responsible for linking this block to the previous block by preserving the Hash of the previous block. Therefore, the blockchain becomes immutable and very difficult to change.
This makes the security of Blockchain technology very high, making it difficult for illegal intrusions to change information or obtain information from any record. Because to change record content,

intruders need to change all records or all blocks linked to the record that the illegal intruder wants to change.

Thus, when you want to change the content in a block, you must change the content of all records in all linked blocks and need to be authenticated by the authentication process with algorithms, digital signatures, and conditions. This would not be possible in a huge network with so many blocks in the blockchain.

With the 5-step architecture of blockchain, it starts with (1) the user sends a transaction, followed by (2) receives the transaction, (3) performs authentication and information processing, (4) the transaction is processed. validate and create blocks and (5)complete the transaction. This process is repeated with each step in the medical examination and treatment process, specifically as stated in section 2.3, the clinical examination process includes tests, images, and functional exploration. Hash at each block is also responsible for responsible for linking this block to the previous block by preserving the Hash of the previous block. And each block when added to the blockchain goes through a review process to get approval from all the other registered nodes and the added node is an authorized node. This implementation will be done using the consensus algorithms PoW, PBFT and POS.

The process of identifying and verifying who is adding data to the block to the chain, will have to use a private and public key, called a "digital signature", that is, when a user makes a transaction, update Data and information in the health record will have to be signed with the user's private key and the authentication process using an algorithm that recognizes the correct user, then the data and information will be completely updated. log into the block.

In conclusion, blockchain technology is advanced technology and ensures a high level of security for data and health record information, specifically (H1) Initial clinical information; (H2) Test information; (H3) Image information and image diagnosis; (H4) Functional probe information; (H5) Payment information and (H6) Medication and treatment information in electronic medical records and health records are always kept confidential and secure.

With information and data of medical records stored sequentially during the treatment process, especially new diseases or complications of diseases during treatment, it will be a very valuable database for medicine. With the patient's consent, that data will serve scientific research, helping to advance health care and public health in the future.

Recommendations

1. Businesses or medical units deploying Blockchain technology applications in their operations. Attention should be paid to organizing the training process for users, in order to improve user knowledge at each stage of operation, hoping to meet usage requirements throughout the process. Because blockchain technology can be considered quite new and advanced, although currently blockchain 5.0 (blockchain 1.0 in 2009). Therefore, the implementation of Blockchain technology applications in the operations of businesses and medical facilities also needs to pay attention to the IT level of users. And each user also needs a personal key (can be understood as a personal digital signature). If a user forgets the private key, no one will get it back and the user will be logged out of the system.

2. The installation investment to put blockchain technology into full operation in a business or medical organization is very high in cost, and users at all stages do not meet the requirements for skills and knowledge to operate. processing at each stage. This will cause data and information errors in the blocks and adjusting data and information will not be as simple as adjusting information in previous internal LAN operations.

3. When applying blockchain technology to the operations of a business or medical facility, the unit should not run LAN network operations and blockchain technology network operations in parallel, meaning the current network system must be completely eliminated. and put 100% blockchain technology into use in operations. This is really difficult for medical organizations and businesses right now. Therefore, units are required to consider carefully the suitability according to the actual internal strength of the unit.

4. Conclusion: Blockchain is considered a reliable solution for connecting and managing devices, data, and information. Therefore, many businesses, units, and medical organizations have used blockchain to manage operations, store medical records, and health records for patients to ensure safety and security. When all data is created during medical examination and treatment processes, each process goes through verification, algorithmic authentication and cryptographic confirmation, the correct confirmation result will have the encryption block added. blockchain network. This is truly a perfect administration and management process for businesses and medical units to use. Giving patients peace of mind, perfection and confidence in medical records, electronic health records cannot be changed, lost control or hacked. This data is encrypted and only when authorized, authenticated, and verified by the user will access to medical records, medical records, or health records be granted. Thereby, electronic health records when applying Blockchain technology are guaranteed to be protected from loss.

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