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A Blockchain-Based Approach for Healthcare Data Interoperability

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Abstract

The healthcare industry faces significant challenges in patient identification and data interoperability due to the use of different electronic medical records (EMRs) and variations in patient information storage. Blockchain technology, a decentralized database that uses cryptography protocols for security and persistency, offers a potential solution to these issues. This research proposes the use of Ethereum smart contracts, a decentralized blockchain solution, to build integrated patient profiles and address interoperability issues in healthcare. The proposed system aims to improve patient data privacy and security, as well as provide a more efficient way of accessing and sharing patient information across different healthcare providers. Through a combination of literature review and case studies, this research demonstrates the feasibility and potential benefits of using blockchain technology for decentralized patient profile building in healthcare. The results of this study have the potential to enhance patient care and improve the overall efficiency of the healthcare system.

Keywords: *Blockchain Technology, Healthcare, Interoperability, Patient Profile*

1. Introduction

Blockchain is a composite word of block and chain and which was introduced in 2008 and applied in 2009 by Bitcoin [1] . In term of technology, blockchain is a digital transaction that works in the decentralized database in which the blocks are interconnected in the form of a chain. In many applications computer such as bitcoin, finance systems, management's risk,

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internet-of-things (IoT) to public and social services where the blockchain technology is implemented [2]. The number of chain increasing due to new block added. Each block uses a cryptographic hash value of the previous block and a timestamp. Blockchain used cryptography protocols which provide security and transparency to prevent a third party [3]. The blockchain technology can mostly save the cost and more efficient because of having key features like decentralization, persistency, anonymity, and auditability [4]. Ethereum smart contracts based blockchain technology that enables participants to create and deploy the decentralized application. Due to the decentralized environment, blockchain technology is enabled by mixing in some modern technologies like cryptographic hash, digital signature and distributed consensus mechanism[5] [6]. Health data can live in numerous systems and distributing data requires many points of teamwork between entities. Patient identification from heterogeneous medical records stored at different EMRs is a big challenge [7].

The one of a kind necessities the healthcare sector is confronting are as validation, interoperability, information sharing and the exchange of medicinal reports [8]. A variety of data formats and differences in patient information storage adds to data Interoperability issues. Interoperability is an ability of the system to understand the exchanged data and information between the interconnected systems [9]. Blockchain has various possibilities for the healthcare sector. The blockchain technology stores these authorization rules, along with the patient public key. Blockchain technology enabled patient-record interoperability, like clinical data transaction volume, privacy and security, patient appointment, and incentives [10]. The aims of this work to integrate the blockchain technology in healthcare. Health organizations are at different levels of maturity when it comes to the quality of their data, governance mechanisms and the use of standards. Some health care organizations must use FHIR (Fast Healthcare Interoperability Resources), while others use the CDA (Clinical Document Architecture) standard to exchange data [11]. Still, Healthcare centers [12] are using the HL7 (Health Level-7) standard reduce interoperability and to share other data [13] [14]. Enter the blockchain technology that eliminates this challenge when accessing the data through the APIs [15]. In addition, blockchain addresses recent challenges related to the synchronization of patient data with numerous and disparate health information systems, while ensuring the security and privacy of patient data through a distributed framework to manage patient identity.

In this paragraph of the paper discuss sections for the quick review about, related work and different existing blockchain application for healthcare are discus in Section 2, then to talk about the techniques and work flow in Sections 3 and 4, then the paper is concluded in Section-7.

2. Related Work

This portion describes related works that offer structures to implement for healthcare dependent on Blockchain. The investigation looked to analyze acts that tended to the EHR coordination or interoperability subject and offered models utilizing Blockchain for such a theme. Although that Blockchain was introduced in 2008, architecture proposing Blockchain usage for EHRs were just found over the most recent few years. In this way, the chose related work displays comparative ideas to those suggested for EHRs [16], now try to compare all developed and implemented works with such a proposed model. Blockchain are working in a decentralized atmosphere, which is allowed by participating in numerous core technologies [17] such as cryptographic hash, digital signature (based on asymmetric cryptography) and distributed consensus appliance. Blockchain technologies already has been adopted in various applications of several domains due to used cryptography protocols which provide security and transparency to avoid a third party [18]. Blockchain Technology provides a decentralized

solution for integrated patient records to achieve interoperability [10]. Blockchain technology has popularity the desirability in the IT arena due to security, decentralization, persistency, anonymity, and auditability distinct capabilities [19].

Ethereum is a platform that use to create blockchain networks [20].The Ethereum offers common-purpose computer protocols called smart contracts, it's a computational program, it is run on the EVM (Ethereum-Virtual-Machine) [21]. In the healthcare, organizations interoperability is frequently concentrated about data conversation among commercial objects e.g. multiple hospital systems interchange the health information [22]. Health organizations are at different levels of maturity when it comes to the quality of their data, governance mechanisms [23] and the use of standards. Some health care organizations must use FHIR [24], while others use the CDA [25] standard to exchange data. Still, others share data using the HL7 standard [26], Interoperability has numerous importance for healthcare. Like, fit interactive systems can develop effective performance, save time to spend on administrative work like physically data entry which received by faxes [27]. Interoperability has the ability to decrease the duplicate chances in clinical systems like laboratory reports [28] , cost of the system and improve the maturity of patient care by dropping the disclosure to radioactivity actions[29], Moreover, there are many problems to interoperability that persistency, the conversation among multiple institutions and needs important partnership among the units intricate [30].

2.1. Existing Blockchain Application for Healthcare

In this section will be discussed about some specific applications that already exist [8]. blockchain technology introduced various possibilities for the healthcare sector [31]. From experimentations and literature reviewing its prove that the blockchain empowered medicinal services applications figure-1 [8].

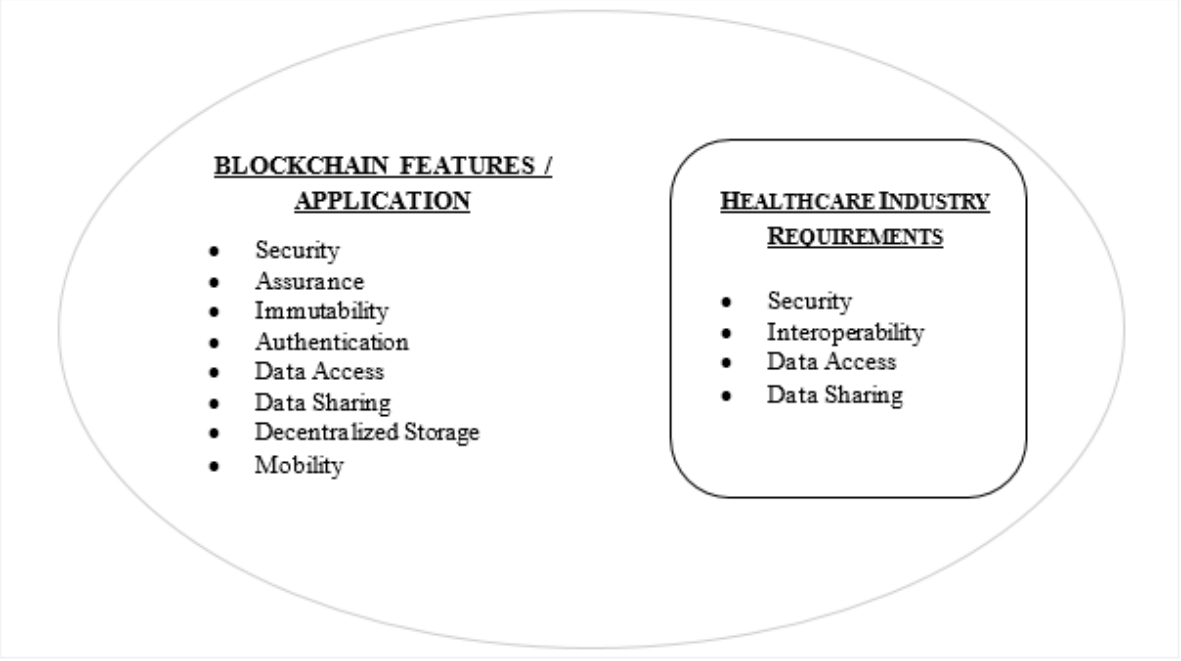

Figure 1 Blockchain fulfilling healthcare Needs

2.2. Medrec

Medrec system is used to manage the decentralized record of EMRs, established by Azaria, Ekblaw, Vieira, and Lippman using blockchain technology. The framework permits patients' [32] regular access to their health data over numerous medical suppliers and treatment areas. In particular, blockchain innovation is utilized to encourage verification, privacy, responsibility, and information sharing using a modular design that coordinates with suppliers' current, localhost. This arrangement enables the patients and medicinal experts to have interoperability. As recently talked about, blockchain needs a sequence of diggers to support encourage the blockchain communications process? MedRec boosts medical partners to partake as the excavators by giving them access to total, anonymized information as mining bonuses as a by-product of supporting and verifying the system by PoW (Proof of Work). MedRec is a working model that spotlights more on breaking down the methodology and execution of the system, preceding any field tests [33]. But MedRec system was implemented in a little scale model mean just for in the same healthcare foundation in Israel, which is utilizing Ethereum based Blockchain system [34].

2.3. Decentralized Application for Smart Health (DASH)

Decentralized Application for Smart Health (DASH) is a Blockchain-based system that is developed for the healthcare field [35]. It gives an online interface in which patients can get to his medical record and furthermore submit solution demands, notwithstanding dealing with the consents to its EHRs. The reviewing work suggests programming applications that integrate with DASH system, so as to defeat the issues and difficulties looked during the improvement of the DASH model.

2.4. OmniPHR

OmniPHR is a system which created by Roehrs, Costa, and Righi to support in managing of Patient-health-record (PHR). Consequently, providing patients a brought together perspective on their health records save over various healthcare systems. Moreover, the OmniPHR system is intended to discuss the issue of healthcare suppliers approaching upto-date the patient information, notwithstanding when the records are saved in other area or refreshed by another healthcare supplier. The fundamental issue that OmniPHR tries to discuss is the distinction among EHR and PHR. EHR are records that are held to an assortment of legislative models which helped to discuss the issue of unchanging record keeping over the state and nation lines[36] . This enables the records to keep awake to-date and as exact as could be allowed. The fundamental thought for information’s are to held and refreshed by the therapeutic experts themselves with no patient communication, which varies from PHR, in which the patients are taken care of by him selves. OmniPHR makes a system that would address such an issue enabling patients to have a progressively thorough and complete image of their records while keeping up the degree of exactness wanted by the therapeutic network [37].

3. The Proposed Method

The blockchain technologies are existing in open source. This code optimizes and deploy on healthcare workplace. There are few steps would follow are described as under.

3.1. Ethereum

Ethereum is the biggest blockchain that sported the smart contract, the capital market value of 18 billion [38]. It is an open-source programming platform, based on blockchain technology that helped the software engineers to create and deploy the decentralized applications (DApps) [39]. Ethereum and bitcoin both are based on blockchain however Ethereum is not quite the same as Bitcoin in that it brings smart contracts into blockchain [40]. Blockchain are considered for DApps recently due to ethereum that sports a smart contract. The analyst researched to move out of their physical contracts to smart digital contracts where a few issues like cancellation, transparency, security, and so forth would be automatically addressed. The result of this exertion brought about the production of Ethereum - a mainstream platform for making appropriated Blockchain applications that help smart contracts. DApps normally apply to applications that operate upon the Peer-to-Peer (P2P) networking of computers instead of a solitary unified computer [41]. Ethereum speaks to a blockchain with an inherent Turing-complete programming language. It gives a dynamic layer empowering anybody to make their very own guidelines for possession, organizations of exchanges, and state progress capacities [31]. This job is finished by including smart contracts, which is a complete collection of cryptography habits that are performed just if specific requirements are satisfied [42], which is run on the Ethereum-Virtual-Machine (EVM). There are some widespread client's code available on GitHub that work with the ethereum blockchain are mentioned in the table-1 [43].

Table 1: Languages for Ethereum Clients

ETHEREUM CLIENTS	LANGUAGE
Geth	Go
cpp-ethereum	C++
Trinity, Py-EVM, and Pyethapp	Python
Ethereum-JS, Web3-JS	JavaScript

3.2. Smart Contract

Smart-contract is an advance and cryptographic protocol that automatically executed of the contract [40]. It provides autonomy, trust, safety, and efficiency features and also high security to Ethereum based blockchain. A Smart contracts are bits of code that execute on the blockchain, without the need for a server [20]. Smart contacts supervised the Ethereum based Blockchain (DApps) computer's network and provides facilities, where to transfer coins, shares [44], property and any important information in a transparent form where no need of a third party [45]. Programmer create a contracts in high-level programming languages, e.g., Solidity [46] and compiled code on EVM [47], [48]. A Solidity is the flagship Ethereum high level language that is used to write contracts. It is use to connect the Ethereum network to work as a complete node.

4. Work Flow

Blockchain has the broad capability to improve and maintained data storing and patient personal records. This technology used for the guarantee to the healthcare worth sequence is self-maintained as fit. It's essential to identify that the numerous fields are discovering the

perfect solution of the technology for healthcare. They are producing modernized results that trust on Blockchain technologies in the environment. Ideally, the finest manner to realize that how a blockchain technology affects the Healthcare layout beneficial. The mechanism of Blockchain technology for patient-identification interoperability in healthcare organizations are explained as one picture has worth one thousand words. The following figure-2 clearly describes the workflow of blockchain technology patient-record interoperability in healthcare organizations [49], [50]. It will read out and search for a more complete literature review to identify a clear and proper solution for the problem of interoperability in a healthcare organization. More ever there will be searching for technology to make system confidentially better for healthcare. [51]

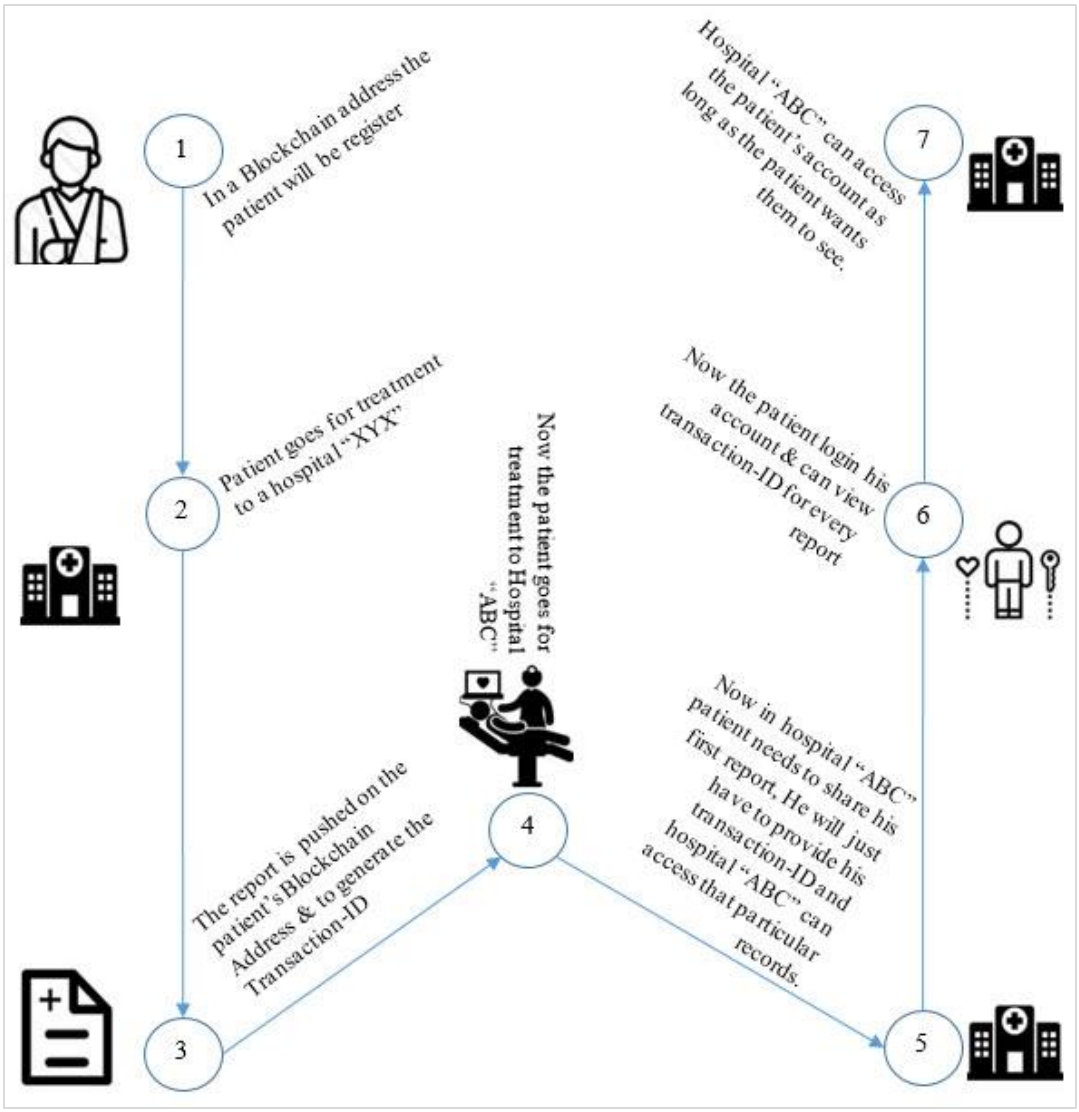

Figure 2 Blockchain Method Patient-Record Interoperability

There are many steps are follow when patient visit to hospitals from registration up to payments all of these are covered by blockchain and to be responsible for improved security. Also, have a full governor on the data fluid from start to finish. Healthcare organization needs a technology which has features that to manage and full fill the patient requirements. Like as a patient visit to different canter, shifting the data properly and sure. There is a Blockchain technology that can exchange and protected data in a safe way [52], [53]. The blockchain is technology that

provides a modern way for the data storage where data are replicated among the nodes which are connected in a network.

5. System Implementation Techniques

The system has two steps should be follow by each one, in first to complete the registration and in second to perform the patient their task in few steps.

5.1. Registration

In Blockchain Interoperability in Healthcare (BIH) system to registrar Hospitals, Patient, and Physician. Hospitals are register once in blockchain and the physician register in blockchain system with concerned hospital. When patient visit to any blockchain registered hospital for his/her treatment to be register in blockchain system. Smart contract assigns a hash key value to each of them which is called address key of node.

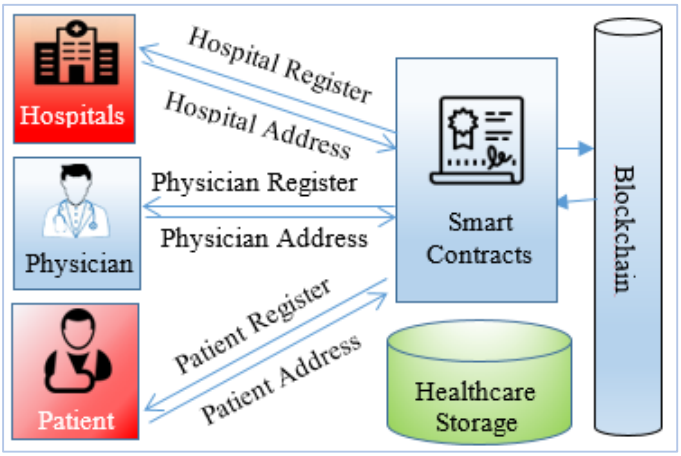

Figure 3 Proposed System registration process

5.2.System Scenario

The figure-4 describes the setup scenario process for BIH system. The patient goes to hospital “B” for treatment where patient registers to blockchain and patient transition_ID generate. Here in the hospital "B" the physician examines the patient and a new report is created with timestamp and digital signature and is pushed to patient’s blockchain address and generated transaction_ID. The patient's medical record is stored in blockchain system. Next time the patient “ABC” goes to blockchain's registered Hospital “A” for further treatment. In hospital “A” there is require the patient first record. Now the patient gives the transaction_ID and hospital “A” can access his records. Here in hospital “A” again create new repost and pushed on the patient “ABC” blockchain address, to generate the transaction_ID. Similarly, the patient “ABC” wants to go to hospital “N” for treatment so to repeat the previous process. Now the patient login his account, can see his own every report transparently and has authorized his record. If a patient wants to access his account than the hospital “A” or “N” can access his account to watch every records.

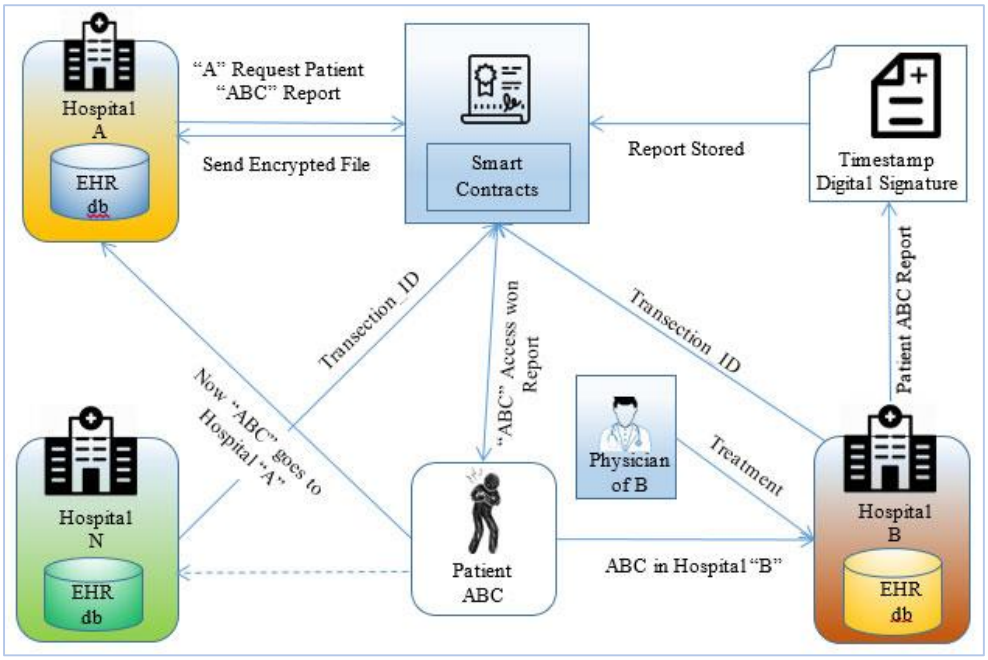

Figure 4 System scenario of developed application

6. Results and Discussions

A modified reference model was proposed after a large number of users examined the proposed framework. The experimental assessment was successful, and several results for different parameters were noted. The preceding subsections contain reports on the system condition findings and test results. The system performed as anticipated, and each healthcare method's measured values for the recommended fix are all positive. The proposed and conventional procedures underwent effective experimental examination, and several discoveries for various parameters were noted. In earlier sub-groups of a performance evaluation, the results of the design and performance suitable for analysis are provided. The system operated as expected, and all performance standards for each piece of healthcare data in the proposed framework were met.

```
1. Input patient-tokensID
2.   for each token in all-tokens do
3.     if token has the same patient-tokensID then
4.      add token into patient-tokens
5.     end if
6.   end for
7. if patient-tokens have more than | token then
8.   valid_token = token in patient-tokens with the earliest traded
   time
9.   invalid_tokens = patient-tokens except valid_token
10.  double_spenders = patient of invalid_tokens
11.  post valid_token, invalid_tokens, double_reject to all nodes
12. end if
```

Equation 1 algorithm of patient tokens

The efficiency of the suggested method is also close to 86%, and will continue for further enhancement. Every so often, the proposed mechanism assesses the confidence of all other networks. In fig-6 show the comparison between the suggested model and current models where proposed models have lower product low ratios than the current. By applying solidity

smart contract as shown on the suggested model and their results are increased to 86% accurate as shown in fig-5.

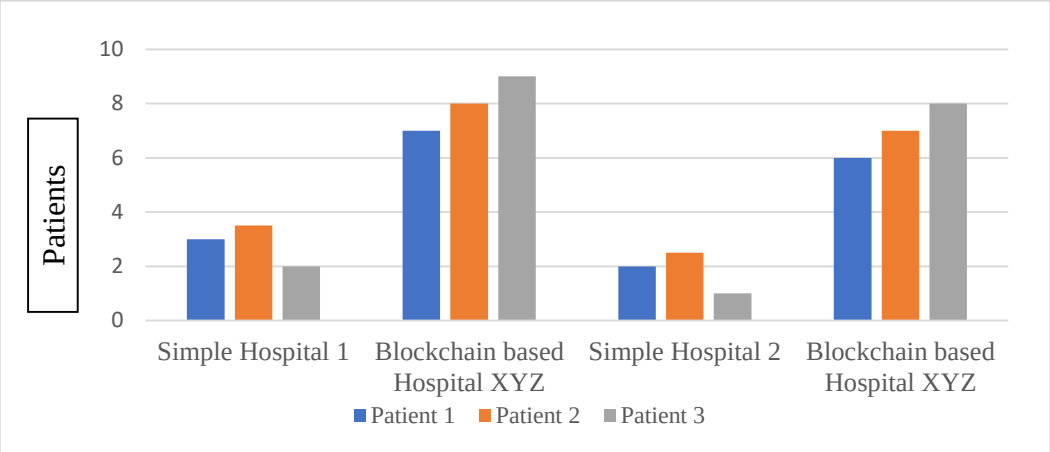

Figure 5 Patient Records Access Hospital System

7. Conclusion and Future Work

Blockchain is vastly recommended to integrate into a decentralized setup and peer-to-peer environment due to cryptography protocols and digital signature. Blockchain has significant features: decentralization, persistency, anonymity, and auditability. Therefore, it gets popularity and is integrated into different fields of the computer industry. Ethereum Smart Contracts based Blockchain technology integrate into the healthcare sector to attain data interoperability issue for patient identification from heterogeneous medical records. Due to smart contracts, the patient records are highly secured and run with the perfect digitally to make them transparent, immutable and auditable. So then, plan to take an in-depth investigation on interoperability issues of healthcare space in the future.

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