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Blockchain Analytics - Real-time Log Management in Healthcare

Tiago Guimarães[a]*, Ricardo Duarte[a], Bruno Pinheiro[a], Daniel Faria[a], Paulo Gomes[a], Manuel Filipe Santos[a]

[a]*Algoritmi Reasarch Center, School of Engineering, University of Minho, Azurém Campus, Guimarães, 4800-05, Portugal*

Abstract

With the growing dependence on information technologies in healthcare organizations, it is crucial to ensure data security since its sensitiveness. To guarantee this requirement, a system was developed consisting of a private blockchain network designed to support the recording of hospital logs and an interface to facilitate data analysis. This article covers the development of a private blockchain solution. For its development were used Hyperledger technologies and Sockets.io. Apart from that, web technologies that were used to interface real-time logs. The objective of the developed solution is to allow the visualization of logs in real time, where analysis methods have applied.

Keywords: : Blockcahin; Blockchain Analytics; Helthcare; Hyperledger Fabric; Log Management

1. Introduction

Health is one of the most concerning issues in human society. From very early on, mankind began to be concerned with diseases, since these factors have been present throughout evolution. The concept of health reflects the social, economic, political, and cultural circumstances in which an individual is inserted, directly influencing his/her quality of life [1]. In this sense, the need to improve the quality of health care arises. For this purpose, it is necessary to ensure accurate and concrete information so that the decision-making process is useful and provides value to the patient [2][3][4]. The management and availability of confidential and sensitive data, such as healthcare

* Corresponding author. Tel.: +351-918-608-484.
E-mail address: tsg@dsi.uminho.pt

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data, requires special attention and a set of specific rules to ensure its authenticity, privacy, and security. Several healthcare systems present this problem in that they do not guarantee the immutability of the data [5] and therefore representing a threat to the privacy and security of the patients [6]. Blockchain technology offers a solution to this problem, as it guarantees a chronological order of data as well as its authenticity, privacy, and security [5].

The present work is divided into several sections, initiating with a brief introduction. Section 2 is presented the context in which the article is inserted, and then presented the Materials and Methods used to develop the Blockchain solution. Section 4 presents the blockchain solution developed. Finally, it's presented a brief discussion of the results obtained and the final conclusions.

2. Background

2.1. Blockchain

Blockchain is not just a change, but a fast-moving phenomenon that is already in motion. It is the new wave of disruption that has come to redesign commercial, social, political and every other form of value exchange interaction [7]. It brings a new perspective regarding security, resilience, and efficiency of systems [8]. For emphasis, blockchain is compared by some authors to the invention of the internet and its impact on the entire industry [9].

Some authors present a description for blockchain technology. It can be described as a distributed, transactional database technology that provides immutable, validated, and consistent transactions between many network participants [10]. Other authors describe blockchain as a secure, distributed database that can function without an administrator or a central authority, using a distributed and peer-to-peer network to hold a continuous and growing list of records, called blocks, to form a digital ledger. In this environment the network itself validates the transaction, secures the history, and allows assets to be transferred directly between parties in an environment of trust, without the involvement of third parties. It is important to note that the transactions performed are public with read permissions. However, it is not possible to make changes once it is stored [5][11]. For Singhal et al. (2018) [7] Blockchain is a system of records to transact any kind of value in a peer-to-peer manner where there is no need for a trusted intermediary, such as banks, brokers, or other services, to serve as a third party. The transacted data is immutable and irreversible and, any change would result in a new transaction that would be validated by all constituent nodes, where each node has its own copy of the blockchain.

Blockchain technology can be used and categorised in different ways, public or private, also known as unauthorised or authorised [9]. In public blockchain, given its transparency and openness there is no barrier to who can use and participate in the process. It has ledgers visible for anyone on the internet to check and add a block of transactions to the blockchain as long as they follow the rules previously defined. In contrast, private blockchains are considered a centralized network as it is controlled by an organization. They are closed and only accessible by a few, those chosen by the organization that have authorization and permissions to engage with the blockchain. They can check and add transaction blocks, but all internet participants, in general, are allowed to view them [9][11]-[13].

In this case of study, the preference for private blockchains becomes evident, as they are a better choice to guarantee the privacy and safety of patients.

2.2. Blockchain in Healthcare

Blockchain, is considered as a general-purpose technology with presence and relevance in several areas, among which we can highlight Healthcare [14]. Healthcare is fundamental and represents an area where there are several opportunities for applying this concept, due to the wide variety of problems that can be solved through the features and properties offered by blockchain [15][16]. An important feature of blockchain that is clearly beneficial for healthcare applications is decentralization, which allows distributed implementation of applications without relying on a centralized authority. The fact that the information present in the blockchain is replicated between all nodes in the network creates a transparency and openness that allows healthcare stakeholders, in particular patients, to know how their data is being used as well as by whom and when. Given its nature it can protect data from potential loss, corruption or security attacks and its immutability property makes it impossible to alter or modify any record that has been attached to the chain, ensuring the integrity and validity of patient records. By using cryptographic

algorithms to encrypt the stored data, it is assured that only users with legitimate access permissions can decrypt it, which improves its security and privacy. Furthermore, given that patient identities within the blockchain are pseudonyms, since cryptographic keys are being used, their data can be shared among stakeholders without their identity being revealed [14].

However, there are challenges that must be considered when adopting blockchain technology in healthcare. The first challenge is related to transparency and confidentiality. In this system everyone can see everything, so there is high transparency and low confidentiality. Transparency of information during a transaction is usually considered a limitation. In addition, even if a user is anonymous, when using hash values, they can be identified by inspecting and analysing the transaction information publicly available on the network. This is a critical issue for healthcare applications because patient-related data is highly sensitive. The second challenge is speed and scalability. Transaction times can be long, depending on the protocol used and a speed constraint can limit the scalability of blockchain-based applications. This is an important issue in developing real-time and scalable blockchain-based healthcare applications. The third and final challenge is the 51% attack threat. This attack happens when there are more malicious nodes than honest ones in the network, so the consensus is corrupted. This issue is critical for healthcare applications, that must be demanding in terms of security [17].

2.3. Blockchain Analytics

Blockchain was originally designed to hold transaction data. However, there is a growing interest in providing analytical capabilities in these types of database systems [18]. Currently, data scientists spend around 80% of their time collecting, preparing, cleaning, and organizing data for analysis. In blockchain, the data has already been identified, collected, prepared, and organized, which provides a rich storehouse of information for analysis. The stored data can be used to address organizational needs, which often translate into well-defined aggregated queries and descriptive analytics. Some examples of such queries include trend analysis, time series and time space, top N queries, and aggregations. The creation of analytics starts with providing a dashboard or a data visualization, called descriptive analytics, which can evolve into more advanced analytics. Machine learning models can be built when there exists sufficient historical data. By using this type of model, it is possible to find implicit patterns in the data that help answer questions about future events or trends in an organization. Analysing healthcare data organizations data can provide useful information to scientific research, commercial applications, and services. For this reason, blockchain analytics is an imperative factor to improve organizational efficiency and innovation since it can play an important role in medical evolution and public health care. Overall, blockchain provides a decentralized, reliable, and immutable method of sharing and recording data, which can be used to improve an organizations analytical performance [19].

3. Materials and Method

In this chapter, some frameworks that support blockchain development and tools for blockchain benchmarking will be presented as well as a few key features of the latter that will be described and analysed.

3.1. Hyperledger Fabric

Hyperledger Fabric is a distributed ledger platform for smart contracts that uses well-known and well-proven technologies and has a modular architecture that allows for pluggable implementations of different functions. Validating peers execute a replicated state machine that accepts three types of transactions as operations using a Byzantine Fault Tolerance consensus protocol. The fabric includes a security framework for authentication and authorization since it implements a permissioned ledger. Enrolment and transaction authorization are supported by public-key certificates, and chain code security is ensured by in-band encryption [20]. It takes a novel approach to consensus that allows for scalability while maintaining privacy [21].

In this project it was built a private Blockchain network based on permissions using the Hyperledger Fabric technology with the purpose of storage of the hospital logs in a safe and immutable way for further analysis and consult of the data when it needed.

3.2. Hyperledger Explorer

Hyperledger Explorer is a tool that provides an interface to view transactions within a Hyperledger Fabric blockchain, and it can be run locally or in Docker containers [22]. Its main features include its user-friendly web interface, metrics referring to blocks and transactions, search tools, filters for blocks and transactions, dynamic discovery of new channels and real-time notifications of new blocks. As well as any other relevant information stored in the ledger [22][23].

3.3. Hyperledger Caliper

Hyperledger Caliper is a tool for measuring the efficiency of private blockchains. It helps users to compare various blockchains in similar environments [24]. It's a blockchain benchmarking tool that allows users to assess a blockchain implementation's success against a collection of predefined use cases, could be generate reports with a variety of performance metrics [25][26]. This one was designed for extensibility, allowing it to work with today's most popular monitoring and infrastructure solutions [26]. Throughput, latency, performance rate, and CPU / Memory resource utilization are all metrics that the tool can monitor. This is accomplished by listening for transaction timestamps and measuring metrics from them [24].

In this project this benchmarking platform is used to measure the performance of the blockchain.

3.4. Prometheus

SoundCloud created Prometheus, an open-source device monitoring and alerting toolkit. Many businesses and organizations have embraced him since its launch in 2012, and the project has a thriving developer and user community. It is now a self-contained open-source project that is run without the involvement of any organization [27]. Prometheus has a query language and a basic but powerful data model that allows you to analyse how your applications and infrastructure are performing [28]. Prometheus has several features, which we highlight [27]: a multi-dimensional data model with time series data identified by metric name and key/value pairs; PromQL, a flexible query language to leverage this dimensionality; no need for distributed storage; single server nodes are self-contained; time series data is collected using a pull model over HTTP; an intermediate gateway is used to push time series; service discovery or static configuration are used to find targets; support for various graphing and dashboarding modes; in this project the Prometheus system needs the Caliper well installed so that it can be executed. In this project the Prometheus system needs the caliper well installed so that it can be executed.

4. Project Introduction

In this project it was built a private Blockchain network based on permissions using the Hyperledger Fabric technology with the purpose of storage of hospital logs in a safe and immutable way for further analysis and consult of the data when it needed. In order to make this possible it was created a Chaincode using Go, which is running in the blockchain network that with the rest of the configured settings that were also made allows the proper function of the proper function of the network and the register of the hospital logs. To complement the blockchain network it was developed a web interface with the intention of analysis and comprehend the data stored.

4.1. Solution Architecture

This solution works in accordance with the ledger of the Hyperledger Fabric with the help of the Chaincode created for the purpose and the CouchDB that storage the data as it is in that specific moment. Additionally, it was developed a web interface, with the data stored on the networked, updated in real-time by using socket.io. The following image represents the architecture developed to achieve the final solution.

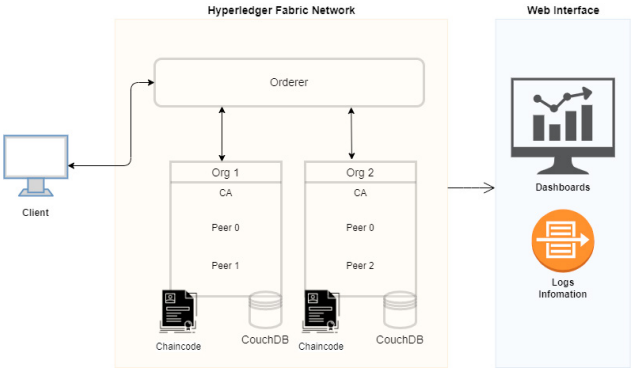

Figure 1 - Solution Architecture

4.2. Web Interface

The web interface consists in two different areas: for consult and analysis of the data stored in the blockchain.

In the consult area, it is possible to check every log that is registered in the blockchain in real time, so it's easier to see the movements that are happening at that moment and find some kind of anomaly or something that shouldn't be happening. Furthermore, it is still possible to know how many users have logged in that day in the platform, and what has been the most access application in the system. In the analyses' area, it is possible to search for any log that exists in the blockchain and see every attribute of it as well as access to some graphics that are very helpful in the logs' analysis. The graphs referred to show the number of logs recorded over time, on a monthly scale, as well as the total number of logs and the comparison between each application inherent to the system. In the following image, it is possible to observe some visuals present in the two mentioned areas.

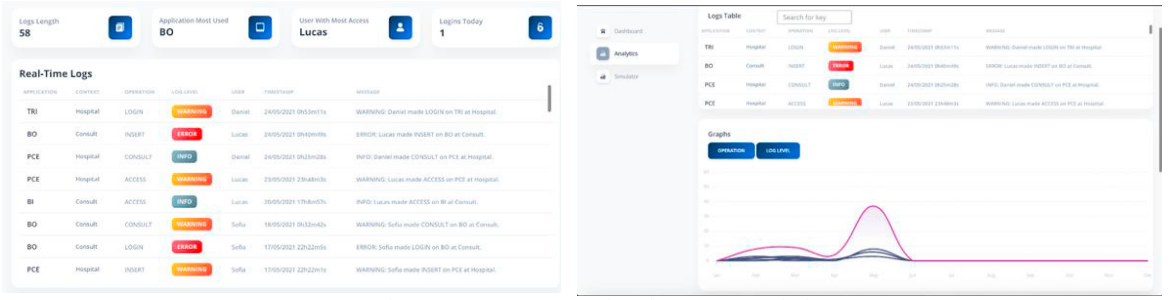

Figure 2 - Log Data Consult and Log Data Analysis

5. Result Discussion and Conclusion

The constant evolution of data management solutions has enabled growth not only in efficiency and reliability, but also in confidentiality and privacy of patient data. When developing a platform to support a healthcare institution, it is essential to ensure the veracity and value of the data used. Over the long run, understanding the data and being able to use it correctly will lead to faster decisions with less human or medical error. For vital areas, such as healthcare, being able to understand data while respecting patient privacy will lead to a more sustainable and truthful practice. The implementation of Blockchain technology, provides some health benefits such as integrity, security, immutability, verifiability, and resistance to breaches of sensitive medical data. The enumerated benefits facilitate the data management process for the most diverse actors present in the area, and also ensure accountability for improper consultations of private data or patient confidences. In this context, it becomes an adequate solution with the potential to improve this sensitive and critical area, such as the health area.

Through the Blockchain application developed, it is possible to maintain a database with the current data, where analysis methods are applied to the logs registered in the blockchain network. With this process, an important step was taken to maintain a fully functional network. However, it is not enough just to store the data, it is essential to perform analysis on them to find patterns and anomalies that avoid both human and network errors. In addition, with

increasing documentation, evolution, and contributions, and by supporting smart contracts created in general-purpose programming languages, the learning curve for its implementation is reduced when compared to other solutions.

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