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Blockchain analytics in healthcare: An Overview

João Cunha[a]*, Ricardo Duarte[a], Tiago Guimarães[a], César Quintas[b], Manuel Filipe Santos[a]

[a]*Algoritmi Reasarch Center, School of Engineering, University of Minho, Azurém Campus, Guimarães, 4800-05, Portugal*
[b]*Centro Hospitalar Universitário do Porto, Porto, 4099-001, Portugal*

Abstract

We can't consider blockchain only as a change, but as a fast phenomenon that is already on the move. It is a new wave of disturbances that has come to redesign the interactions that involve any form of exchange of values. It brings a new perspective on security, resilience, and effectiveness of systems. It initially became popular with the emergence of cryptocurrencies. Currently, it is more than just a base for this type of coins, since its materialization it has already made inroads in different areas and industries, which we can highlight the area of health and healthcare. It was originally designed to hold transaction data, however, there is growing interest in providing analytics capabilities. The stored data can be used to respond to organizational needs such as: providing provenance histories, predictive planning, fraud identification, regulatory compliance, etc.

In this article, in section 2, an overview of blockchain technology will be presented. An introduction to the topic Business Analytics will be carried out in section 3, so that it can later be related to the topic under study. The Blockchain Analytics concept will be presented in general in section 4. In the following section we will present several applicability of this technology in the health sector and, finally, a small conclusion and the future work that we intend to follow will be presented.

Keywords: Blockchain; Blockchain Analytics; Blockchain Analytics in Healthcare, Business Analytics

* Corresponding author. Tel.: +351-967-446-013.
E-mail address: joao--carlos1996@hotmail.com

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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]–[4].The management and availability of confidential and sensitive data, such as healthcare 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. 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].

2. 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 [6]. It brings a new perspective regarding security, resilience, and efficiency of systems [7]. For emphasis, blockchain is compared by some authors to the invention of the internet and its impact on the entire industry [8].

It initially became popular with the emergence of Bitcoin, a decentralised cryptocurrency. Today, blockchain is more than just a basis for a cryptocurrency. In fact, since it first materialised, it has already made inroads in different areas and industries [5], [7]–[9], excelling in the financial sector, healthcare, Internet of Things (IoT), supply chains, cognitive computing, cloud technologies and several other areas [7], [10], [11].

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 [9]. 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) [6] 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.

This system is a public, distributed database that stores data in encrypted form, that anyone can use, as long as they have an internet connection. Unlike traditional databases that are managed by entities, blockchain is not managed by anyone [11]. With an entire network looking after it, tampering with the system by falsifying documents, transactions and other information becomes almost impossible to happen [8], [11]. In addition, all participants in the system have a personal key or signature that is used when a transaction is created. This key makes it possible to know why the user created a transaction and to whom that transaction was sent. It is possible to trace the ownership of a given transaction at any point [8]. The information stored in the blockchain is permanent and held through a network of nodes, making the information decentralised and distributed. Each node on the network can store a local copy of the blockchain system, which is periodically updated in order to maintain consistency between all nodes. If a node fraudulently changes its version, that new version of the blockchain is rejected by all other nodes. New entries can only be accepted if they are valid, which means that they need to adhere to a predefined protocol [9], [11]. There is a problem in a centralised system, that problem being having a single point of failure. However, in a decentralised system there are multiple coordinated points that outweigh the single point of failure. In a distributed environment, all nodes perform the task collectively.

In blockchain, block is the collection of valid transactions that any node can initiate and transmit to all nodes present in the network. The nodes presented in the network validate the transaction using the old transactions. When validated, the next step is adding it to the existing blockchain. It is important to note that each block inherits the hash of the previous block, meaning that this type of system uses the hash of previous blocks to create the new block hash, which makes the blockchain tamper proof. Whenever a transaction is changed, the entire hash of the subsequent block needs to be changed. The larger the blocks the greater the processing of large amounts of transactions at one time [11].

Blockchain technology can be used and categorised in different ways, public or private, also known as unauthorised or authorised [8]. There is yet another term to categorise this technology, called consortium blockchain [11]–[13]. 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 [8], [11]–[13]. Finally, the consortium blockchain is presented. This is built by multiple organizations and is partially decentralized. Instead of giving power to a single entity, that power is divided by a group of people or individuals, called consortia. Only this defined group can verify and add transactions, which need to be acknowledged by consensus nodes, where only a small part of the nodes are selected to determine consensus [11]–[13].

3. Business Analytics

Business Analytics (BA), at its core, is about leveraging the value of data. Eric Schmitt articulated a famous perspective on data. He said that from the dawn of civilization until 2003, 5 exabytes of information were created. However, that amount of information is now generated every 2 days and that is only going to increase. There is a growing perception that data is a valuable resource and should be managed as an asset [14].

A BA component, in an initial phase, aims to transform data into information, so that it is later possible to generate knowledge. Currently, organizations tend to deal increasingly with large amounts of data. The absence of a BA component responsible for the data integration and consolidation process results in organizations losing the potential that the data have [15]. BA components also incorporate data visualization tools capable of providing fast and intuitive data analysis, which helps in the process of transforming data into useful information. Easy access to useful information means having full support for the organization's decision-making process. This leads to improvements in business performance and, consequently, to gain competitive advantage over other organizations operating in the same business sector. The benefits of BA implementation extend to all business sectors [15], [16].

To understand and clarify the concept of BA, some definitions from the perspective of different authors will be presented. From the perspective of Turban et al. (2008) [17], BA is a component that provides analysis models and procedures to analyse information from Data Warehouse. In this way, it is possible to obtain a competitive advantage over other organizations in the same business sector. According to Schniederjans et al. (2014) [18], BA is the process that begins with the collection of organizational data, to which the main types of existing analyses are applied sequentially. In this way, it is possible to obtain a result that supports and demonstrates both business decision-making and organizational performance. For Trkman et al. (2010) [19], BA is not a technology, but a group of approaches, organizational procedures and tools used together in order to obtain information, analyse it, and predict results to solve problems.

The definition of BA depends on the literature consulted, and yet we may say that the definitions presented reach an agreement regarding its definition. They start from the assumption that the collected data are transformed into useful information, capable of supporting the organizational decision-making process and create competitive advantages.

4. 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 [20]. 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 [21].

The volume of data generated in this internet age, Internet of Things (IoT), is growing significantly, which puts blockchain systems at their limits of both transaction and storage capabilities. Consequently, when new data information arrives, it is important that the blockchain can understand the data input and its relevance to the business in order to determine whether the data is deleted or accepted for storage. Currently no blockchain system has the capability to self-learn about the relevance of incoming data. This requires blockchain systems to be active and intelligent to make it able to classify data, which helps reduce redundant data storage and calculations for later stages. Originally, the blockchain was designed to be a repertoire for transactions, but for there to be analytics run directly on the blockchain an execution engine will be required. A possible solution to bridge this problem is to make the data present in the blockchain easily accessible for parallel processing in systems such as "MapReduce" or "Spark" [22]. An input reader could be implemented, being, both mentioned systems, able to efficiently scan data from the blockchain. Moreover, execution nodes can be physically co-located with blockchain nodes, which makes the need for data transfer way smaller, improving the analytical performance [20]. Overall, blockchain provides a decentralized, reliable, and immutable method of sharing and recording data, which can be used to improve an organizations analytical performance [21].

5. Blockchain applied to healthcare

Blockchain, is considered as a general-purpose technology with presence and relevance in several areas, among which we can highlight Healthcare [23]. 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 [24], [25]. 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 [23].

Some authors present some applicabilities of blockchain technology in healthcare [23]–[25]:

- **Electronic Medical Records.** One of the most popular use cases of blockchain in healthcare is for the management of electronic medical records (EMR). EMRs, on many occasions are used interchangeably with electronic health records (EHR) or personal health records (PHR), for the creation, storage, and management of the patient's medical data. By implementing a blockchain, it is possible to put the patient at the centre of managing their own health data, where they know how it is shared, processed, or used. With the properties of decentralization, immutability, data provenance, reliability, robustness, smart contracts, security, and privacy, blockchain makes a viable and suitable technology for storage and management of patients' electronic medical records.
- **Biomedical Research and Education.** Another use case for blockchain is in biomedical research and education. In clinical trials, it helps eliminate data falsification and underreporting or exclusion of undesirable clinical research findings. It makes it easier for patients to grant permission for their data to be used, due to the

anonymization that is inherently encoded in the data. The immutability property certifies the integrity of the data collected, and its transparent and public nature facilitates replication of research from blockchain-based data.

- **Drug/Pharmaceutical Supply Chain.** Another case where this technology can be implemented is in healthcare supply chain management, in particular in the pharmaceutical industry. The delivery of counterfeit or substandard drugs can have negative consequences for the patient, however, it is a frequently occurring problem. The properties of decentralization, transparency, openness, immutability, data provenance, timestamping and auditability are useful in ensuring that the problem of counterfeit and distributed medicines can be contained. All transactions related to prescription medicines, from their production, distribution and delivery to the final consumer are recorded, and all stakeholders are connected. In this way, any malicious alteration or modification of the medicine by any of the parties is detected. With this approach, it becomes impossible to produce and distribute counterfeit medicines. Poor quality medicines are traced back to the producer and even stolen medicines can be traced if they are registered at the time of production.
- **Equipment tracking.** Another implementation opportunity is in the tracking of medical equipment from manufacturer to decommissioning. The savings that healthcare institutions achieve are significant. By using a blockchain approach several benefits are offered over traditional tracking products. The ones that stand out the most are the immutability and inviolable qualities, which prevent the alteration or elimination of the location history.
- **Health Data Analytics (HDA).** The implementation of blockchain technology also offers a unique opportunity to harness the power of other emerging technologies, such as deep learning and machine learning, to perform predictive analytics on health data and research advance in the area of precision medicine.

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 [26].

6. Conclusions

In the 1990s, with the adoption of the internet, the way people negotiated and did business changed. By removing the friction of creating and distributing information, it paved the way for new markets, more opportunities, and possibilities. Similarly, blockchain is here today to take the internet to a whole new level, by eliminating friction from three key areas: Control, Trust and Value [6]. If blockchain achieves the potential that is being described and observed, it will make available to the digital world a new level of objectivity and trust that is unmatched. In other words, it will provide a global and decentralized information infrastructure in which no one is in full control so no one can distort or lie about past or current events [10]. The application fields for blockchain are multiple, especially in areas that have historically relied on third parties to establish a degree of trust [27].

Using Blockchain technology provides some health benefits. Of which I highlight the integrity, security, immutability, verifiability, and resistance to tampering of sensitive medical data. The benefits presented facilitate the data management process, not only for the patient, but for the various actors present in this area, ensuring accountability for improper consultations with private or confidential patient data. The literature review presented addresses the issues for the development of a solution that combines not only the obligation to guarantee the immutability and veracity of clinical data, but also a controlled and safe consultation of them. Developing a solution that contributes to increasing the reliability and veracity of the data, which provides informed and timely information in order to be able to support clinicians and managers in their daily actions is the next step to be taken.

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