QUALITATIVE ANALYSIS OF NODES AND NOT-NODES STAKEHOLDERS' READINESS FOR BLOCKCHAIN TECHNOLOGY ADOPTION IN HEALTHCARE

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ABSTRACT

Despite the benefits of the advent of Digital Transformation, and the consequent transition to the electronic medical record, there are few critical issues related to data governance, such as data transparency, traceability, immutability, privacy, and security.

Blockchain is an innovative technology with the potential to address such issues.

The stakeholders involved in the digitalization process have a key role in the implementation of a blockchain-based solution. In particular, their readiness, intended as availability and ability to adopt new technologies, is pivotal for the success of the project. Indeed, stakeholders can be themselves nodes of the blockchain, as they have the fundamental role of keeping and exchanging the information necessary for its operations. Their readiness, then, is a factor that directly affects the correct implementation of blockchain.

However, to the best of our knowledge, there are no studies in the literature analyzing the differences between stakeholders that are nodes of the BT network and those that are not-nodes, not only in terms of type but also in readiness.

This work aims at identifying the stakeholders interested in these projects, determine which of these represent nodes of the network and which not-nodes, and identify the different dimensions of readiness that characterize them.

Keywords*: Blockchain, Electronic Medical Records, Healthcare Organizations,*

1. INTRODUCTION

Digital technologies represent a main tool to achieve a better healthcare quality (EUR-Lex, 2020). The results of "Digital Transformation: Shaping the future of European healthcare" research, performed by the Deloitte Center for Health Solutions (2020), highlighted that data is the core element of this digital transition, which revolutionized economy, society, and health.

Although there are significant differences among the requirements and objectives of the different digital health systems, there are three main criticalities characterizing most of them.

First, the health structures often use not-homogeneous application architectures, even within their operating units, and the data extracted from different devices are heterogeneous. The resulting fragmentation generates inefficient coordination of care, difficulty of interoperability, and potential lack of essential information in case of emergency (Yaeger *et al*., 2019; Zhang *et al*., 2018). Secondly, patient information is generally contained in electronic health records, mainly organized within centralized systems and, for that reason, vulnerable to a single point of failure and information loss,

due to natural disasters or information thefts following cyber-attacks (Yaqoob *et al*., 2021). Finally, current data management systems cannot ensure transparency, reliable traceability, immutability, audit, privacy, and security when managing Electronic Medical Record (EMR) (Yue *et al*., 2016).

Blockchain Technology (BT) has the potential to address those issues (Chen *et al*., 2019; Gordon, 2019; McGhin *et al*., 2019; Farouk *et al.*, 2019). It is an extremely innovative technology, able to aid the simplification of health data management operations: on the one hand, it allows unprecedented efficiency and reliability in data management (Islam *et al*., 2016; Chukwu, 2020; Syed *et al*., 2019; Esposito *et al*., 2018), on the other, it offers a wide range of important integrated functions, such as data access flexibility, security, privacy, decentralized storage, transparency, immutability, authentication, disintermediation, verifiability, programmability, interconnection (Omar *et al*., 2018; Hasselgren *et al*., 2020).

BT is, indeed, a decentralized digital ledger that offers the opportunity to record and share information (Hussien *et al*., 2019). This data is held on the network through a series of nodes. Any entity connected to the blockchain can be classified as a node.

Despite the several benefits of BT, it is worth noting that the introduction of new and emerging technologies in any sector can give rise to problems and challenges (Khan *et al*., 2021).

The literature unison confirms that blockchain requires a strong synergy among the stakeholders (Lee *et al*., 2012). When implementing a BT project, it is essential to assess the stakeholders' readiness, i.e., the availability and capacity of the various stakeholders concerning the adoption of the new technology, both individually and collectively (Savage *et al*., 2010). Specifically, the literature shows that four dimensions of stakeholders' readiness play a pivotal role: motivational readiness, engagement readiness, technological readiness, and structural readiness (Balasubramanian *et al*., 2021).

However, to the best of our knowledge, the literature has neglected one important difference among stakeholders: all nodes can be stakeholders, but not all stakeholders are, in fact, nodes. This means that not each readiness dimension may be as important for every stakeholder and hence that not necessarily all the stakeholders should score high whatever the readiness dimension is analysed. To fill this gap, the research questions underlying this work are the following:

1. Who are the stakeholders involved in the implementation of blockchain-based solutions for the EMR governance? Among them, who are the nodes of the blockchain network?
2. What is the difference in terms of readiness dimensions between stakeholders-nodes and stakeholders-not-nodes in BT-based projects applied to EMR?
3. How does nodes-stakeholders' readiness and not-nodes stakeholders' readiness affect the implementation of BT-based projects applied to EMR?

The paper is structured as follows. Section two presents a brief description of background, and section three explains the research methodology. The results of this work are presented in section four, section five discusses the implications and presents conclusions and suggestions for further studies.

2. BACKGROUND

The fundamental basis of BT is represented by the nodes that constitute its network and that orchestrate all the information necessary for its operation. Nodes are a critical component of the infrastructure of a blockchain because they act as further validation for the ledger (Hussien *et al*., 2019). If the nodes involved in blockchain are already known to the network, then the blockchain is referred to as permissioned, such as Hyperledger Fabric (Androulaki, 2018). When a system is open to the public, any individual or organizational node can be a member of the network; hence, this blockchain is referred to as public, such as Ethereum (Founder *et al*., 2018) and Bitcoin (Nakamoto, 2008; Hussien *et al*., 2019).

In the literature, the nodes of the projects implemented with BT are usually referred to as stakeholders or as interested and involved actors at various levels. The distinction between node and stakeholder is neither clear nor thoroughly defined; very often, it is not even considered that, if it is true that all the nodes of the BT network are stakeholders, not all stakeholders are nodes.

Typical node participants in the EMR management context include medical providers, claims processors, laboratories, billing departments, patients, and regulators. Each node wants to provide that data is secure, trusted, and efficiently processed within a comprehensive, single, complete medical history (Burke, 2018).

In the healthcare sector, focusing on Electronic Health Record, stakeholders can be classified into three groups (Beinke *et al*., 2019). Primary stakeholders are deeply involved in providing health care: physicians, caregiver and nurses, therapists, pharmacists, clinics and hospitals, laboratories, care service and nursing homes, and patients. Insurances, family and relatives, and employers, are secondary stakeholders. The tertiary stakeholder group includes society, healthcare industry, research institutes, and public authorities.

Previous studies in the healthcare field have highlighted a plurality of stakeholders relevant for implementing BT-based solutions. For instance, patients (Patel, 2019; Siyal *et al*., 2019, Yoon, 2019, Khatoon, 2020; Tandon *et al*., 2020) and Governments (Bell *et al*., 2019; Dhagana *et al*., 2019) have sometimes been included as stakeholders. Moreover, business entities (Radanovic and Likic, 2018), regulatory bodies (Nugent *et al*., 2016), and service providers (Kuo *et al*., 2017) have been included as actors with a stake in the BT system development.

Hence, while recognizing the diversity in terms of type and interests between the involved actors, the literature identifies a wide spectrum of actors as stakeholders, without taking into account if they are nodes or not-nodes of the blockchain network. For example, in a patient-centric project aimed at improving clinical record management, both the patient – i.e., the owner of clinical data – and hospitals – i.e., data managers – are undoubtedly stakeholders and nodes of the blockchain network. Conversely, the Government, even if recognized as a stakeholder aiming at both ensuring the privacy of its citizens and improving the efficiency of the process, is not necessarily a node in the network.

Moreover, readiness could be defined as the willingness of an actor or organization involved in the solution to cope with a situation and perform a sequence of actions (Handayani *et al*., 2021). Readiness relies on careful planning, eligibility, and accessible and sustained staff training (Khoja *et al*., 2017). In the healthcare sector, readiness refers to the readiness of health organizations to anticipate changes brought about by information and communication technology programs (Khoja *et al*., 2017). Furthermore,

it is essential to evaluate the availability of new solution adoption to save time and money and to be able to prepare better technology's architecture (Handayani *et al*., 2021). With the readiness factor, blockchain-based solution developers can determine how the system or application will be created, developed, or updated to suit the capabilities and characteristics of its users (Khatun *et al*., 2015). The achievement level of each of the different dimensions of readiness (motivational, engagement, technological and structural) is an essential element that impacts the BT implementation (Balasubramanian *et al*., 2021; Li *et al*., 2012).

Motivational readiness shows stakeholders' willingness to act to achieve a desire or goal (Kruglanski *et al*., 2014) and it is necessary to appropriately address the changes concerning an existing service or circumstance (for instance, in clinical data management, the need to overcome problems related to the quality of service or privacy) (Balasubramanian *et al*., 2021).

Engagement readiness measures the extent to which people are exposed to the blockchain concept and actively debates on the perceived benefits and negative effects (Mauco *et al*., 2019). Engagement readiness refers to the knowledge of new solutions and the explicit recognition of their benefits and potential challenges (Balasubramanian *et al*., 2021). For BT, this includes knowing how to achieve results, the potential risks to current systems, the potential benefits, the difficulties associated with development costs, and the risks of failure.

Technological readiness is the individual or organizational predisposition to embrace new technologies. Factors contributing to this type of engagement include, for example, the availability and compatibility of existing hardware, software, networks, applications, and other information and communication technology (ICT) resources that facilitate the new technology (Balasubramanian *et al*., 2021; Khatun *et al*., 2015; Mauco *et al*., 2019).

Structural readiness refers to the availability of not-technical resources - financial and human - to be invested in adopting new processes or technologies (Snyder-Halpern, 2001, Balasubramanian *et al*., 2021). Indeed, implementing BT requires valuable resources, such as time, money, and people.

The relationship between readiness and types of stakeholders involved in the implementation of BT-based projects – if nodes or not-nodes – is important to properly assess to what extent the single stakeholder is ready for adopting new technology. However, the scientific debate does not provide indications. More specifically, we encountered only three studies about blockchain readiness assessment (Ozturan *et al*., 2019; Vlachos *et al*., 2019; Balasubramanian *et al*., 2021), and only one of them (Balasubramanian *et al*., 2021) involved healthcare. Furthermore, at the best of our knowledge, no work on readiness assessment has been published that considers the difference between the stakeholders in terms of node or not-node of the blockchain network.

At the practical level, the lack of this information results in the absence of tools to support healthcare organizations interested in creating data management solutions through the implementation of BT. Furthermore, systems that support the sharing of information among different organizations involve a high variety of stakeholders with often conflicting interests. Failure to divide the actors involved into nodes and not-nodes stakeholders could make the readiness assessment process inaccurate and act as an obstacle to BT adoption.

3. METHODOLOGY

Since blockchain-based solutions in healthcare are a new phenomenon, we relied on a multiple case study method which is very powerful because of two main reasons. Firstly, case studies are recognized as big opportunities (McClintock *et al*., 1979) in terms of i) taking into account the richness of the context (Eisenhardt and Graebner, 2007), so avoiding instrumentation artefacts of standardized measurement procedures, ii) allowing detailed examination of organizational process, and iii) illuminating specific factors which may allow greater understanding of causality. Secondly, case studies are reckoned better than quantitative studies in terms of theory building (theoretical generalisation and falsification) and theory testing.

To identify the best suitable case studies for our research aim, we used the database provided by the Blockchain & Distributed Ledger Observatory of Politecnico di Milano, which maps the state-of-the-art blockchain projects worldwide.

The main criteria used to select the case studies from the database are the level of maturity of the project and their relationship with the medical record.

The selected case studies are the following:

1. SAFE (2020; Operating)
2. Medicalchain with the Groves Medical Group (2018; Operating)
3. Hypertrust X-Chain (2018; PoC)
4. Toronto Hospital Project (2020; PoC)
5. IBM Canada Project (2019; PoC)

Following a detailed projects analysis and an initial contact with their respective representatives to verify their availability to participate in the interviews, we selected SAFE, MedicalChain, and HyperTrust X-Chain.

SAFE is a platform born from the program "MedTech Acceleration" of Maio Clinic and Arizona State University. Currently used for COVID-19, it was designed to diagnose and monitor sexually transmitted diseases and some common ailments. The platform connects patients, doctors, and test providers through HealthCheck, an advanced smartphone and desktop application, which allows verification of vaccination status as well. SAFE has relied on Hedera Hashgraph, a distributed ledger technology evolving from blockchain, which offers the same benefits as BT without some of its limits. The app includes voice / video telemedicine, services to allow the review, almost in real-time, of diagnostic tests, and the option to request tests.

Medicalchain is a platform built in 2018, allowing the exchange and use of medical data safely and fast, without compromising patients' privacy, thanks to asymmetric encryption. Healthcare professionals, doctors, hospitals, laboratories, pharmacists, and insurance companies can request permission to access and interact with medical records. The platform is based on the Hyperledger Fabric architecture and, through permissions, allows different access levels, with the patients directly controlling who can access which records and how long. Access can be granted in a limited form to specific files. Doctors can record, as ledger transitions, notes, scans, and lab results, and, likewise, pharmacists can add medications provided.

Eventually, Hypertrust X-Chain of the CAMELOT Consulting Group is a blockchain-based, patient-centered solution, suitable for personalized treatments. The system provides an end-to-end solution to automate, streamline and secure the supply chain for

customized treatments, and inform interested parties about upcoming auctions. Hypertrust X-Chain enables safe, efficient, and transparent workflow management for the entire autologous cell therapy process, with far-reaching benefits for pharmaceutical companies and all other stakeholders in the supply and data chain. The research protocol was drawn up in a semi-structured way, to allow the interviewees to speak freely about their projects and stimulate thoughts and opinions on the topics related to the study.

4. RESULTS

According to Beinke *et al*. (2019) classification, the three case studies allowed us to categorize the main actors involved in blockchain-based projects into three broad categories: primary, secondary, and tertiary stakeholders.

For simplification, we decided to divide the stakeholders into nodes and not-nodes, keeping in mind developing further technical classifications among the nodes already present in the literature (e.g., Burke, 2018).

The case studies confirmed that not all stakeholders are nodes. In fact, all three interviewees identified the three stakeholders' categories, but the substantial difference among the three projects is to be found in the number and type of nodes that make up the BT network. In SAFE, the network's nodes are mainly represented by patients and physicians, in MedicalChain, hospitals are included as well, while in Hypertrust, the network becomes even more extensive, incorporating a series of further actors that concern, for example, the healthcare industry such as drug supply chain (Table 1).

MAIN STAKEHOLDERS (STKH)		CASE STUDIES					
		SAFE		MedicalChain		Hypertrust	
		Not-nodes STKH	Node STKH	Not-nodes STKH	Node STKH	Not-nodes STKH	Node STKH
Primary STKH	Hospitals	✓			✓		✓
	Physicians		✓		✓		✓
	Patients		✓		✓		✓
	Caregivers and nurses			✓		✓	
	Therapists					✓	
	Pharmacists						✓
	Laboratories	✓		✓			✓
	Care services and nursing homes	✓					
Secondary STKH	Insurances	✓				✓	
	Family and relatives			✓			
	Employers	✓					
Tertiary STKH	BT providers	✓				✓	
	Research institutes			✓		✓	
	Public authorities	✓		✓			
	Healthcare industry						✓

Table 1. Not-nodes Stakeholder vs Node Stakeholder

The interviews highlighted the differences between the readiness dimensions relating to stakeholders, both nodes and not-nodes, of each case considered. A more or less strong relationship with stakeholders is always associated with the different dimensions of readiness. In table 2, ✓ represents the relationships among the readiness dimensions and the stakeholders indicated as crucial by the interviewees.

		CASE STUDY																					
		SAFE								**MedicalChain**								**Hypertrust**					
		Not-nodes STKH				Node STKH				Not-nodes STKH				Node STKH				Not-nodes STKH				Node STKH	
STKH \ **READINESS**		MR	ER	SR	TR	MR	ER	SR	TR	MR	ER	SR	TR	MR	ER	SR	TR	MR	ER	SR	TR	MR	ER	SR	TR
Primary	Hospitals													✓			✓					✓			✓
	Physicians					✓		✓						✓		✓						✓		✓	
	Patients					✓	✓							✓	✓							✓			
	Caregivers and nurses									✓		✓						✓		✓					
	Therapists																		✓	✓					
	Pharmacists																							✓	✓
	Laboratories			✓	✓							✓	✓											✓	✓
	Care services and nursing homes			✓	✓																				
Secondary	Insurances			✓																✓					
	Family and relatives									✓															
	Employers		✓																						
Tertiary	BT providers			✓	✓															✓	✓				
	Research institutes											✓	✓							✓	✓				
	Public authorities		✓	✓							✓	✓													
	Healthcare industry																					✓		✓	

Table 2. Readiness (MR: motivational readiness, ER: engagement readiness, SR: structural readiness and TR: technological readiness)

Regarding primary node-stakeholders, the three cases agree in assigning great importance to patients' motivational readiness because the drive for change involves realizing problems about poor service or the violation of patient privacy. SAFE and Medicalchain also find engagement readiness important for patients.

"*Let me directly start with that, we had tried to address user needs and blockchain happens to be part of a possible solution. This project would not have started without real requirements and demand to meet the needs of end-user and the business process needs"* (Hypertrust).

For physicians, both motivational and structural readiness are considered necessary in all cases.

"*It's very frustrating when you are seeing the patient in your clinic and you don't have all of their medical information in front of you, because you are limited by what you have on*

your computer, but your computer doesn't show you when they went to this hospital or this clinic or spoke to this doctor, so we want to create systems where the patients can carry the medical records with them, so, when they come to the appointment, they can just share their medical records with them and the physicians can review it on their computer, they can see everything and they add their consultation" (Medicalchain).

Medicalchain and Hypertrust refer that hospitals' motivational and technological readiness is crucial.

Finally, only for Hypertrust is the structural and technological readiness of pharmacists and laboratories indispensable.

As for the secondary stakeholders, the case studies did not identify any nodes.

Eventually, Hyperstrust indicates as necessary the motivational and structural readiness of the healthcare industry, a tertiary node-stakeholder.

Regarding the primary not-nodes stakeholders, structural and technical readiness proved to be fundamental. On the contrary, the relevance of caregivers' and nurses' motivational readiness, and engagement readiness of therapists has emerged.

Into secondary not-nodes stakeholders' group, insurances' structural readiness is essential according to SAFE and Hypertrust. SAFE also adds the employers' engagement readiness, while Medicalchain reports the significance of the family' and relatives' motivational readiness.

Structural and technological readiness is the crucial willingness of the tertiary not-nodes stakeholders. SAFE and Medicalchain agree on the importance of engagement readiness for public authorities, while, SAFE and Hypertrust agree on technological readiness relevance for the BT-based solution providers, and the importance of structural readiness for both.

The importance of governments' readiness for involvement is related to knowledge, awareness of new initiatives, and a clear recognition of their benefits and potential challenges that may drive regulators to change legal frameworks. Structural readiness refers to the availability of financial and human resources that governments invest in the adoption of new processes or technologies.

"Stakeholder readiness is critical to designing solutions based on new technologies and, in particular, it is necessary to trigger a real cultural change. The regulatory bodies play a fundamental role; for example, in 2016, the Cures Act accelerated medical product development and bring new innovations, reducing waiting times the provision of services, and advances to patients who need them faster and more efficiently. A change in the legal framework can help to promote and enable the development of new solutions" (SAFE).

Regarding BT solution providers, the importance of technological readiness is linked to the availability, ability, and deep-in knowledge of existing hardware, software, networks, applications, and other information and communications technology (ICT) resources and BT. Structural readiness, on the other hand, is linked to the availability of resources that would make it easier to implement BT.

"*Developing innovative solutions requires time, budget and knowledge in various combinations*" (Hypertrust).

Therefore, the case studies have highlighted that the assessment of readiness (with a different specific weight depending on the type of stakeholder and the type of readiness) of both nodes and not-nodes is an essential variable for the implementation of blockchain.

5. DISCUSSION AND CONCLUSIONS

The aim of this study was to fill a gap in the literature related to a clear distinction between nodes and not-nodes stakeholders and the weight they have in the implementation of BT respectively and the importance of their respective readiness.

About the first research question, the stakeholders, nodes and not-nodes of the BT network, in the implementation of BT-based solutions for the EMR governance are shown in table 1; the nodes correspond, mostly, with the group of primary stakeholders.

Moreover, as regard the second and the third research questions, the importance of readiness for the implementation of BT projects was confirmed by our qualitative analysis. Using blockchain to secure data access and sharing is effective and reasonable if all parties involved in the process use it; indeed, BT is not owned by a single independent entity and all stakeholders must be part of the chain with a defined role.

The case studies revealed the existing relationship between each stakeholder, node or not-node, and between each type of readiness. This step is essential because it clarifies what factors need to be considered when implementing such a solution and how stakeholders could facilitate or hinder the building of BT-based projects.

Theoretically, our study showed that the dimension of readiness that has the higher weight for not-nodes stakeholders is structural readiness. The financial and human resource availability and the administrative support are assessment factors for the organizational information technology/systems innovation readiness and are integral to blockchain success. Instead, regarding nodes stakeholders, motivational readiness is most important for the correct implementation of blockchain-based solutions. Indeed, when new applications can be considered helpful by users to improve health, the readiness of users to adopt these applications will increase (Grandison *et al*., 2000). This result is significant, as the stakeholder nodes mostly correspond to the primary stakeholders, including the group with a direct relationship with the blockchain network. Therefore, the perceived utility of using blockchain has a direct impact on the implementation of these solutions.

This research also provides a practical contribution; identifying the stakeholder nodes and not-nodes and the information relating to their readiness dimension can support healthcare organizations that need implementing BT-based data governance solutions.

Eventually, a further aim of this paper is to provide a better understanding of the complex phenomenon of blockchain-based solutions.

The analysis described in this research study is qualitative. We expect that, with the increasing popularity and maturity of BT, novel data will be available for quantitative studies.

For instance, during the selection of the case studies, two other cases were identified which are in the operational stage, as far as we know:

- The UAE'S Health Ministry’s new blockchain platform (Peng, 2020).
- The Department of Health and Human Services' blockchain-powered acquisition system (GCN Staff, 2018).

It could be interesting either to broaden the investigation, analyzing these cases listed above, or to gather more information with other interviews from the cases analyzed in this study.

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