






Vision - An Innovative Management System Based on Private DLT

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Abstract. Education is a crucial aspect of most nations. It is the backbone of society, but many regulations and multiple actors make it a complex bureaucratic system, lacking transparency and efficiency. Furthermore, the use of central databases in storing academic records raises concerns about security issues. In this paper, issues of the academic processes in the current system are pointed out, and the solution using private distributed ledger technology is proposed accordingly. A brief comparison with Blockcerts, which is a counterpart using public blockchain to facilitate decentralized certificate verification, is made to emphasize the benefits of the proposed system. Based on distributed ledger technologies, the solution we present aims to create a transparent system to support the institutions' processes and lay a solid foundation for lifelong learning.

Keywords: Blockchain · Private distributed ledger · Academic system

1 Introduction

University bureaucracy is complicated and time-consuming, which lower the quality of student experience in higher education. Specifically, in the enrolment process, students have to deal with multiple stakeholders in order to get enough documents and submit them to the right organizations. Figure 1 demonstrates the current enrolment process of international students. Similarly, the process when a student wants to change education provider is also cumbersome. There are, again, various steps to be taken before the student can be enrolled in a new university. However, the process likely ends in frustration when the credits are not recognized correctly or even the student is rejected. Moreover, central databases make the current system prone to long-standing problems, including falsified documents and single point of failure of academic records. While the former has been on debate for a long time, verifying academic qualifications is not simple, given that forged degrees are becoming much more sophisticated. The latter is caused due to the risk of the central database storing academic records being compromised, thus, lead to the loss or leakage of academic records. Furthermore, using central databases also hinders information continuity and consistency.

Distributed ledger technology (DLT)'s prominent immutability, transparency, and traceability make it a comprehensive solution to the stated problems. The main idea of applying DLT in managing academic records and university-related bureaucracies is to eliminate a single point of data storage and make data transparent to authorized entities. This means student enrolment and academic credits transfer processes will become much simpler and faster. Additionally, data transparency offered by DLT is a key to connect learning records produced by various education providers. Therefore, a sustainable foundation is set for lifelong learning to evolve. Blockchain is an emerging distributed ledger technology that was introduced in 2008 and become a promising technology that will make noticeable impacts on the world [1]. It has been researched in various sectors, even some of the blockchain-based applications (BBAs) have started making the differences [2]. The application of blockchain in education has been suggested since around the year 2016 when MIT Lab was researching their Blockcerts project [3]. It has been elaborated in multiple papers [4, 5], but the topic is still in its infancy, yet the number of researches on this topic has been dramatically increasing in recent years [2, 6, 7]. Various researches have been conducted to study integrating blockchain into the education field, suggesting a variety of enhancements that could be brought to the current systems [6, 7]. According to [6] and [7], majority of them discuss about certificate management and learning outcomes management [8–15], some discuss about evaluating learners' capability [16, 17], some suggest securing collaborative learning environment [18–20], and numbers of other problems in education sector [21, 22]. Most of those research papers suggest using public blockchains, including Bitcoin and Ethereum, while there is a limited number of papers that proposed private blockchain as the solution.

2 Issues in Student Enrolment and Transfer Processes

2.1 Long Waiting Time

Traditional academic transferring processes are claimed to be time-consuming by Badr et al. [8], Ghaffar and Hussain [24] and Jirgensons and Kapenieks [11] due to the involvement of multiple stakeholders and manifold document handling processes. This significant delay in time is also a cause for hindering learning from becoming lifelong [11].

2.2 Security Risk

Daraghmi considers that academic records are common targets of information theft as they include students' personal information [10]. Ocheja et al. claim in both [18] and [19] that the current process of records sharing is lack protection for learners' confidential data. The traditional system is also considered to be easy to be attacked [17]; thus, prone to the risk of a single point of failure [12].

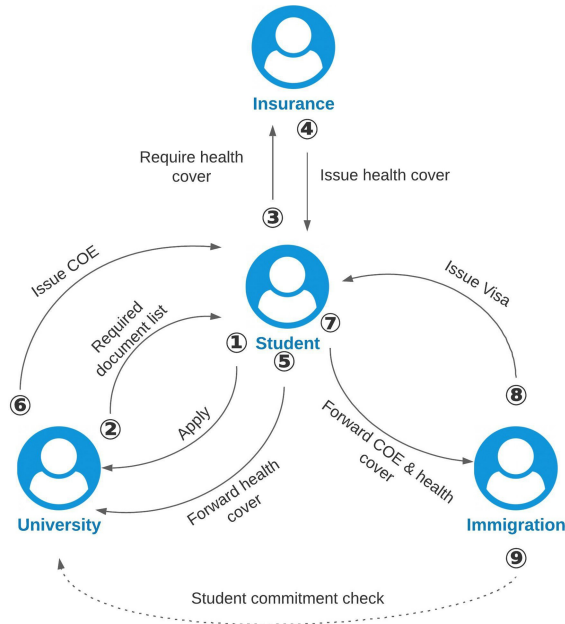


Fig. 1. Current process of enrolment

2.3 Lack of Interoperability

Srivastava et al. [23], Turkanović et al. [15] and Kontzinos et al. [25] claim that different standards in storing academic records lead to the absence of information continuity when records are transferred. Furthermore, [23] and [15] also point out that the barrier of language and script in different countries is another challenge to keeping the seamless stream of learning records. Therefore, lifelong learning is significantly held back.

2.4 Fraudulent Activities

Fake academic documents, nowadays, can be easily forged at a startling speed due to the weak security mechanism of the current system [26] and duplication of records caused by its lack of interoperability [23]. Fake degrees increase legitimate university’s expense to compete with “degree mills”, conduct investigations and mounting litigation against fake entities to protect their intellectual property rights and protect their reputation against the potential harms caused by those fake qualifications [27]. This problem is also enforced by numbers and examples given by Kazakzeh et al. [28]. From the employer perspective, it may cost them an average of 40,000 US dollars per bad hire [29].

3 Private Distributed Ledger

The private distributed ledger is used because it facilitates the partnership between government and public organizations where optimization of resources utilization is guaranteed [14]. Besides, better scalability, security and privacy are also the main reasons private blockchain is preferred in this use case. In addition, the low computational cost is another advantage of using a private blockchain, which, on the other hand, is the main problem when applying public blockchain in any use cases. In this vision paper, Hyperledger Fabric¹ is the private blockchain considered as the solution so that we can take advantage of its additional features of modularity, configurability and versatility.

3.1 More Scalability

Bitcoin [30], and Ethereum [31] are the most popular public blockchains which have been used in improving educational processes. However, they are known for their problems in scaling due to their limited throughput and costly transactions [8]. Hyperledger Fabric, on the other hand, is a permissioned blockchain which, in default, maintains smaller chains, has a shorter processing time, and scalable to handle more amount of transactions thanks to the ability to leverage non-cryptocurrency consensus protocols. According to the comparison in [8], Hyperledger performs much better than other popular platforms, including Bitcoin, Ethereum, Cardano and Multichain in terms of transactions per second with 2500 transactions in a second. However, [32] has introduced a plug-and-play mechanism to boost the performance of Hyperledger Fabric to a promisingly maximum of 20000 transactions per second.

3.2 Better Security and Privacy

Permissioned blockchain (or private DLT), in their default, are operated on a restricted private network where nodes are known to each other, thus, more trust in the network. Furthermore, the network can be configured so that data can only be accessed or verified by authorised nodes. Thus, it is a good fit for protecting confidentiality and privacy of data on the system [8]. In addition, non-cryptocurrency operation in a private distributed ledger lowers the risks of the system being attacked. Unlike other platforms which propose data encryption or Zero Knowledge Proofs as the mechanism for preserving data confidentiality and privacy with different trade-offs, Hyperledger Fabric, in default, provides the channel architecture and private data feature as solutions.

3.3 Less Computational Cost

As permissioned blockchains do not depend on any costly blocks mining processes, there is no native cryptocurrency needed; thus, less expensive consensus

¹ <https://hyperledger-fabric.readthedocs.io/en/release-2.2/>.

protocols can be used. The computational cost is kept low due to the elimination of cryptocurrency consensus protocols and cryptographic mining processes. Furthermore, end-users are not required to run their own nodes to be part of the blockchain network. In this vision, the Hyperledger Fabric network serves in the web application's backend to which the users communicate to take advantage of the services. Therefore, the system will not cost users anything computational resources, and the use of resources is also reduced from a service provider perspective as no additional nodes are created upon end-users interaction [8].

4 Proposed System Using Private DLT

4.1 Simple Processes

Instead of forwarding required documents from one entity to another, which is time-consuming, the proposed system allows stakeholders to interact directly with each other. By facilitating direct interactions between stakeholders in the university's bureaucracy, students are free from involving in any processes after providing their details to the document issuers; thus, complexity and time are lessened. As shown in Fig. 2, what students need to do is request a document, and the rest of the process is automated by related entities.

After receiving and processing applicants' information, bureaucratic entities issue relevant documents and store them on their ledgers in the Fabric channel where other channel members can have access to those documents. Sequentially, the next stakeholder can continue the process as soon as the document they require is issued and stored on the channel ledgers. Thus, the complexity and long waiting time are significantly reduced.

4.2 A Trusted Network

The system also proposes a collaboration space facilitated by a network with enhanced security and trust. Application of DLT in storing documents and records decentrally eliminates the central database's single point of failure risk. In addition to that, the current problems in sharing academic records can be solved thanks to the immutability and transparency features of blockchain, which make data and transactions viewable by any approved entities, however, unable to be modified after committing. In the proposed system, academic records are viewable and accessible by any external entities of the university as long as they are trusted, thus, included in the channel. Therefore, universities in the system are able to share and exchange academic records effortlessly.

4.3 Support Lifelong Learning

Thanks to the use of blockchain, data is owned by the learners, who also control access to it [33], thus, students are placed in the center of the proposed system, which allows them to make their own decisions on their career path [6].

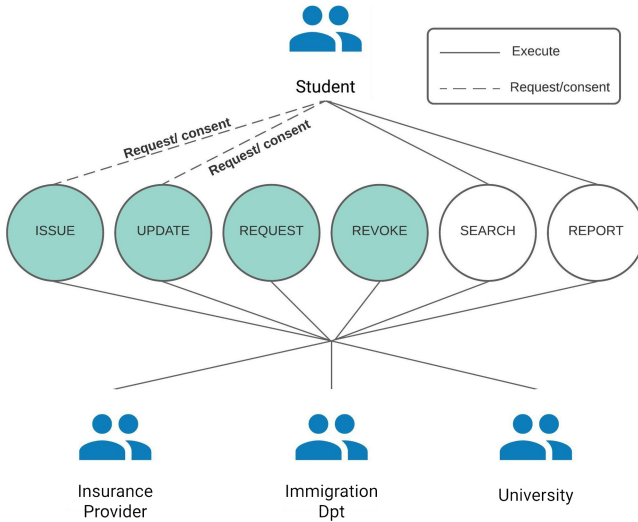


Fig. 2. Proposed DLT solution.

Mikroyannidis et al. [33], in their proposal of a learner-centered approach for lifelong learning, have proposed multiple benefits brought by blockchain to ePortfolios, a crucial component of lifelong learning. Furthermore, simplifying and securing enrolment and academic records sharing processes sets sustainable steps for lifelong learning to become the norm and probably beyond that. When these processes are no longer cumbersome and enhanced with a robust data sharing procedure, learners will be more comfortable and confident to acquire new knowledge and skills from diverse institutions.

5 Comparison to Blockcerts

Although some concerns had been raised on data privacy when data is transparent on the blockchain. By taking advantage of Hyperledger Fabric’s channel and private data collection features, which are developed for the purpose of conserving privacy on the blockchain network, a university in the proposed system can choose particular entities in the network to share their data in a channel privately; or they can even further choose a subset of entities in the channel to share data with each other using private data collection secretly. As Blockcerts² is a system based on Ethereum and Bitcoin, public blockchains, the features for accommodating private information is not available. Also, the consensus rules are also unchangeable on those permissionless blockchain networks. Therefore, there are limited capabilities provided by Blockcerts, which leads to the incompatibility of the system with the variety of business needs. Blockcerts

² <https://www.blockcerts.org/>.

only offers the service of qualifications issuance and verification. On the other hand, Hyperledger Fabric is used in order to take advantage of its versatility and modularity. Also, multiple configurations in the Fabric network are pluggable, which makes it a modular and configurable platform facilitating innovation, versatility, and optimization for a variety of applications while still ensure a high level of security. Therefore, the proposed system promisingly provides a comprehensive management system for education providers, government entities, and other related agencies to facilitate collaboration to optimize any processes with interoperability, transparency, and security.

Hyperledger Fabric platform is suggested to perform better, comparing to other popular platforms, including Bitcoin and Ethereum, in terms of transaction per second (TPS), which is a vital attribute to determine the performance of a platform and whether it can scale up to large applications. Specifically, Badr et al. [8], in their comparison, showed that Hyperledger Fabric (2500 TPS) could process 100 times more than the number of transactions that Ethereum (from 15 to 25 TPS) can process within 1 s, while the difference is more than 300 times comparing to Bitcoin (from 3.3 to 7 TPS).

Blockcerts certificates have been found to be vulnerable to impersonation attacks [34]. In details, fake certificates can be forged if an issuer profile is fabricated with an altered certificate resulting in indistinguishability between fake and legitimate certificates [34]. While [34] suggested using public key infrastructure (PKI) or decentralized identity system to mitigate this vulnerability, Hyperledger Fabric, in its default, has been implemented with these features thanks to the Membership Service Provider (MSP) mechanism. Hence, Hyperledger Fabric is ensured with robust identity management, which prevents malicious activities of malevolent entities in the network. Furthermore, in the Hyperledger Fabric network, participants are expectedly known to each other and collaborate under a certain governance model. Thus, the likelihood of intentional malicious codes injected through smart contracts is eliminated (Table 1).

Table 1. Comparison between Blockcerts and proposed system using Hyperledger Fabric

	Blockcerts	Proposed system
Data privacy		✓
Security		✓
Modularity		✓
Versatility		✓
High throughput		✓

6 System Architecture

The system's high-level architecture is illustrated in Fig. 3. External information exchanges occur in the external channel, while each entity's internal information sharing occurs in their own internal ones, separate from the former. By having this blockchain-of-blockchains alike architecture, data sharing is immutable, transparent and traceable, thus, interoperable across different organizations within the system. Therefore, this will be a viable platform for lifelong learning to thrive.

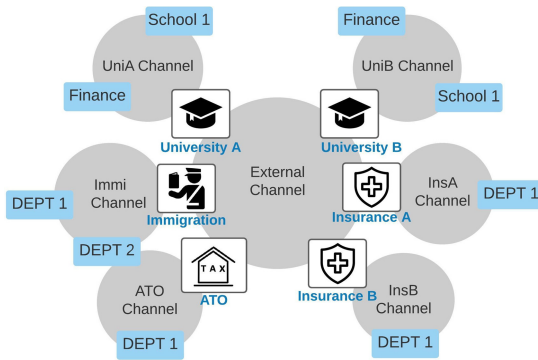


Fig. 3. High level architecture of proposed system.

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