Blockchain Technology in the Educational Environment

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Blockchain popularity is growing every day and its potential is seen in various domains. One field of application is the educational system, where the blockchain technology could be used in several areas like admission, student records, exams and assessments, certifications etc. A distributed ledger is used to store securely all the transactions related to the educational activities. The aim of this paper is to review the applications of blockchain technology in education, with the focus on higher education. Furthermore, the architecture of a system to be used in Bucharest University of Economic Studies is proposed.

Keywords: *Blockchain, Higher education, Ledger, Security, Sensitive Data, e-Learning, m-Learning.*
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1 Introduction

In the last years, digitalization has become very important for many domains, including education and public administration. One technology that can be built in the educational applications is blockchain, a form of distributed ledger technology. The blockchain can be seen as a ledger, a collection of records, distributed over a network, related to various transactions. The main advantage of this system is that is difficult, sometimes impossible, to change the content. Within the educational processes there are various transactions with data that have to be kept safely for long periods of time: students' records, courses' content, contracts (studies, accommodation, etc.), syllabus etc. The implementation of a digital educational solution based on blockchain could be on objective for higher education institutions, including the Bucharest University of Economic Studies. There are several projects, like the Digital Credentials Consortium (https://digitalcredentials.mit.edu/), led by MIT, that aims to create a shared infrastructure for verifying academic credentials [13], or Southern New Hampshire University (https://www.snhu.edu/) or University of Melbourne (https://unimelb.edu.au), that use blockchain to issue students' related records.

The aim of this paper is to present a proposed solution that involves the use of blockchain technologies within the university information management system.

The paper is structured as follows. The next section presents the main concepts related to blockchain technologies. The next section presents the concepts related to blockchain technologies. Related works deals with the latest research related to blockchain use in educational projects. Section 4 presents the potential for blockchain implementation in our university. Finally, we propose a solution for the next steps of our research. The paper ends with conclusions and future work.

2 Blockchain technologies

Blockchain is one of the most promising technologies. With its help, everything around us can be visible due to the transparency it provides. At the moment there is a lot of confusion between blockchain and cryptocurrencies, as was done in the past between the Internet and e-mail. Blockchain is not crypto. Cryptocurrencies being just a small application provided by blockchain. People are afraid of blockchain precisely because they make the analogy with cryptocurrencies, counterfeit currencies, as some call them, but blockchain means more, it means decentralization, distributivity and immutability, which promises security. The moment people see the security of this system, the market will explode.

Specifically, blockchain is a technology not a product. Blockchain is a database that can be seen as a ledger, which records all the information in the network in the form of blocks. Figure 1 presents the structure of a block.

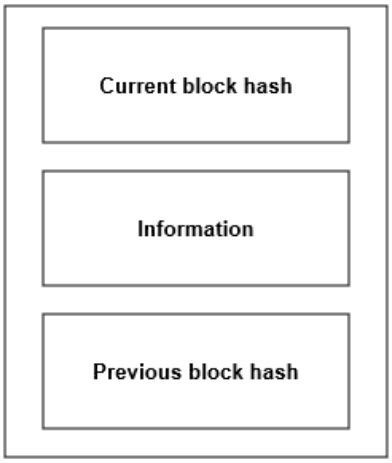

Fig. 1. The simplified structure of a block

Each network node keeps a copy of this database, which allows complete and fast access to data for all members of the network. There is no central database from which nodes can access only certain information, which translates to transparency and security [3], [12].

As is well known, decentralization means the lack of a central unit to coordinate the activity of another entity. In the blockchain, each node of a network has all the information that the other nodes in the network have and does not respond to a higher node. Figure 2 depicts the chain structure of blocks. However, it responds according to a consensus mechanism established between the nodes of the chain. This means that there is no one node to make decisions and others to respect them. It follows the reverse principle, you enter and remain in the chain if you respect the rules of the network as a whole, not of the network leader.

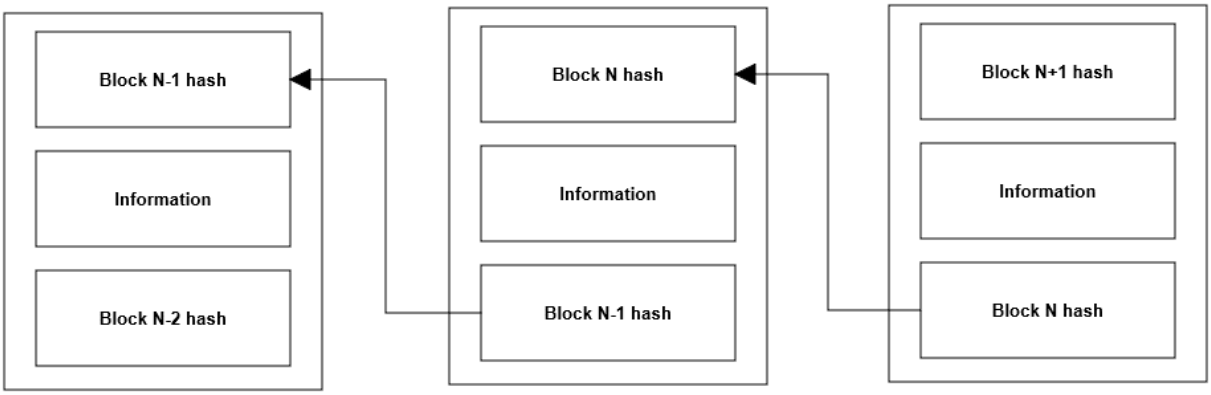

Fig. 2. A sample chain of blocks

Immutability is a concept that assumes that once data is entered into the system, it cannot be changed. If there is a person who has fraudulently tried to change the history of the system, all the other nodes check the information they have with the one transmitted by that node, and if they do not correspond, for the altered blocks a unanimous decision is made which generally depends on consensus, but they are generally

excluded from the network. This is possible due to the hash mechanism through which the blocks are linked. The hash of a block is unique because it is built on the information it contains, and it changes with each change. It can be seen as a book, this being the network, and the pages of the blocks from which it is formed. This makes it easy to see if some pages are broken, damaged or altered [3], [5].
In terms of **distributivity**, it can be seen as a continuous process of back-up, each node of the network, more precisely each block contains information about all the other blocks. If one of the nodes fails, there is no problem of data loss and moreover they are visible everywhere.
Blockchain technology solves the problem of Byzantine generals [14]. At that time there was the problem of sending messages between generals from one campaign to another, but while a messenger was in charge of sending the message, he could be killed, and an enemy could have taken his place. Moreover, the messenger himself could have hidden intentions or could be easily corruptible. With a technology like blockchain the problem is easily solved because no messenger is needed, each node has the information needed to solve its transactions and more, the information is reliable because it cannot be altered over time. Moreover, there are no higher-ranking nodes that can plot against the entire system.
Security is provided by encryption mechanisms, namely hash functions. Such a function involves asymmetric data encryption. We can know the output but we do not know the connection between them so we can determine the input. If the output is minimally changed and the hash function changes, then it is no longer valid. The probability that the same output will result for different inputs is very small [2], [3].
In case of a **public blockchain**, anyone can join the network, write and read information without authorization, the network is not owned by anyone. This is the first type of blockchain to appear on the market. was born with cryptocurrencies, Bitcoin being the first of them. The novelty was related to the need for people to make transactions quickly.
A **private blockchain** is owned by someone: an organization, a person or more generally an entity. Unlike the public blockchain, in this case a prior authorization is required to read and/or write the information in a node. Joining a node is done only if the owner agrees.
This type of blockchain appeared when people realized the power of technology and saw beyond the great gains of Bitcoin to some lucky ones. They studied Bitcoin and extracted blockchain, in other words they found the treasure behind a currency very often discussed and criticized [3].
One important application within a blockchain are the smart contracts. They include executable code that can execute and enforce the terms of an agreement [15].

3 Related Work

There are a lot of research papers which addresses this issue of using blockchain technology in educational environment. In [1], the geographical distribution of the publications in this field is presented, Figure 3.

Fig. 3. Geographical distribution of the research papers of blockchain in Higher education [1]

It is important to observe that in al continents the research in this field is very important and in USA, Spain and India are the greatest number of research papers.

In [4] are 14 chapters that approaches the different areas of using the blockchain technology in the educational environment. In this book are presented approaches from how can be used the blockchain for the lifelong learning to how can be implemented an open innovative dedicated E-learning platform for students and also for teachers.

According to [2] and [11] more universities have started to use blockchain technology for their platforms in evaluating the students or like a support academic degree management. It is very important to understand that the blockchain technology brings more quality in the new platforms and applications that can be used in the educational environment.

In [6] are presented the future promises of blockchain technology in Educational environment. The blockchain technology is used in this moment and in the future this utilization will grow in storing the credentials, degrees and badges for students in various types of training programs.

In [7] are presented existing solution of blockchain in education. For each solution is presented the type of blockchain that is used and also the authors that developed that platform or solution.

According to [8], most blockchain implementations in education are used for diploma management as well as for evaluating learning outcomes. In this way it is desired to reduce the risk of fraud of the diploma system because the using of blockchain will lead to the saving of information from diplomas in an immutable way, thus not allowing their falsification, like the solution presented in Figure 4.

Fig. 4. Architecture of the blockchain solution in educational environment [8]

Also, in [8] are presented all the steps for the development and implementation of one solution based on blockchain used for verification and validation of the academic certificates.

4 Potential Areas of Education Where Blockchain Can Be Used

4.1 Contract management

A higher education institution manages several types of contracts:

- *work*; this involves various categories of employees: faculty, administrative staff, associated staff;
- *studies*; with students (bachelor, master, doctoral and post-doctoral studies);
- *service and maintenance*; like any institution, there are numerous services that have to be acquired, like electricity, Internet, library access, heating, cleaning, etc.
- *supply of goods*; the educational process requires various types of products in order to work: IT equipment, office supplies, etc.

All of these contracts have to be recorded in order to be tracked [9].

Usually, a contract implies several parties, like the student of the employee and one or more of member of the management staff (director, dean, rector etc.).

This area is suitable for the use of smart contracts.

4.2 Students' records

The information related to students comprise the several categories:

- personal information, usually added at admission and updated during the studies;
- educational information like courses taken, marks, sanctions etc.
- administrative information related to accommodation, library, social activities etc.

This information is recorded and it has to be accurate and any modification needs to be logged.

4.3 Course publishing

For the instruction phase of the learning process the blockchain can be used only for the distribution of the materials [10]. The blockchain technology allows to back-up all the materials in more nodes and in this way when the teacher share a new course, it can be replicated in more nodes, Figure 5.

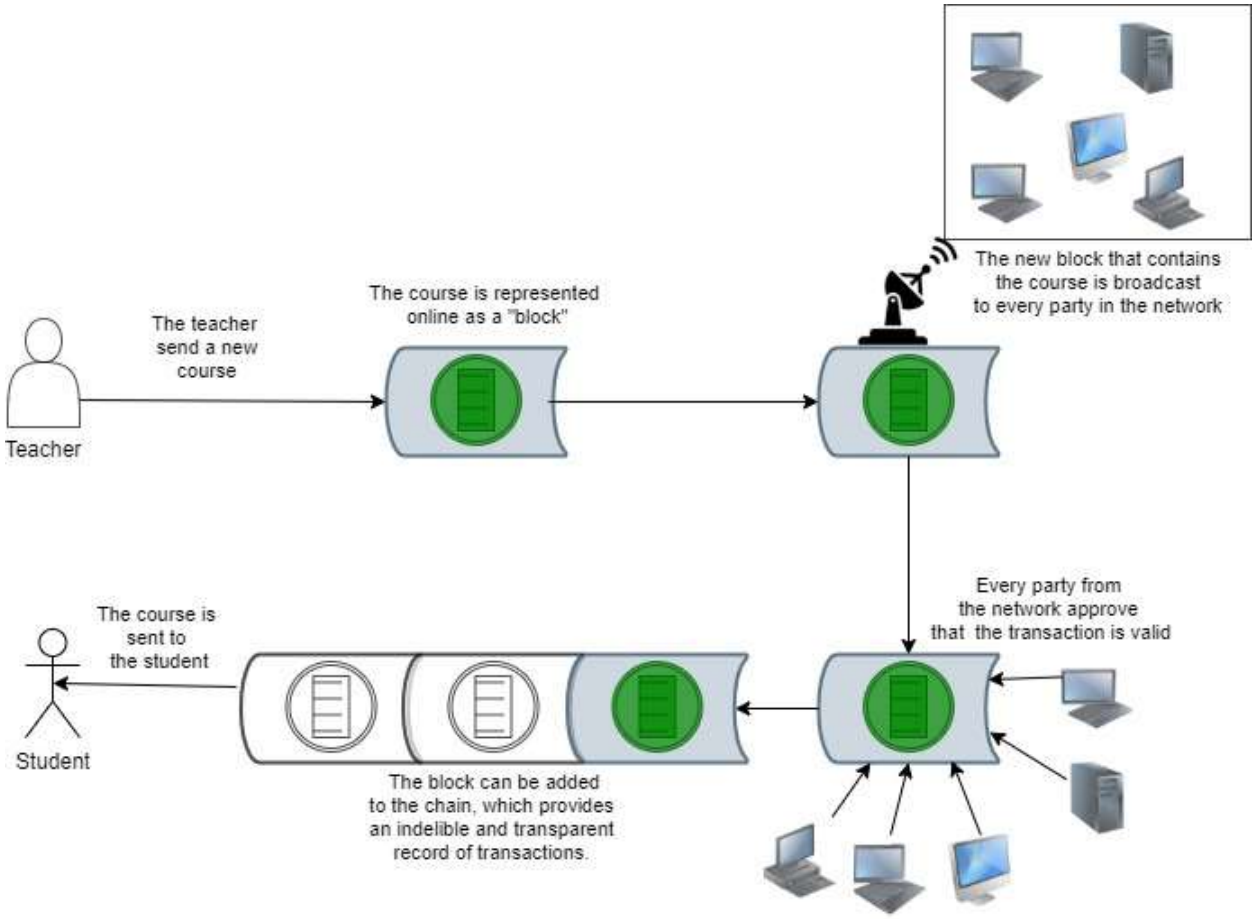

Fig. 5. Adding a new course on blockchain

This process of adding a new course is represented by following steps:

1. **Publishing** – the teacher publishes a new course;
2. **Block creating** – the course it will be represented online as a block;
3. **Broadcasting** – The new block that contains the course is broadcast to every party in the network;
4. **Validating** – Every party from the network approve that the transaction is valid;
5. **Chaining** – The block can be added to the chain which provides an indelible and transparent record of transaction. In this way the block became permanent and unalterable.
6. **Delivery** – the course is sent to the student.

The same process is repeated for each course that the teacher sends to the students.

4.4 Academic Certificates

The processes related to academic certificates issuance are suited for blockchain use. As shown in the *Introduction*, there are several projects in this direction within the educational context.

4.5 Other activities

There are also other activities where the properties of a blockchain are useful. One example is the recording of academic staff activity in terms of research results' dissemination like conference and symposium presentations, journal and books publishing etc.

5 The Proposed Architecture

Our university has several systems for educational activities: admission, students' records, syllabus, schedule etc. Starting from these existing implementations, we propose several components for our solution. Not all components require blockchain integration

and some of the applications could be left as they are, other have to be rewritten and other are new. The existing data (student records, syllabus etc.) will be imported or will be used as it is.

Figure 6 presents the main components of the proposed solution.

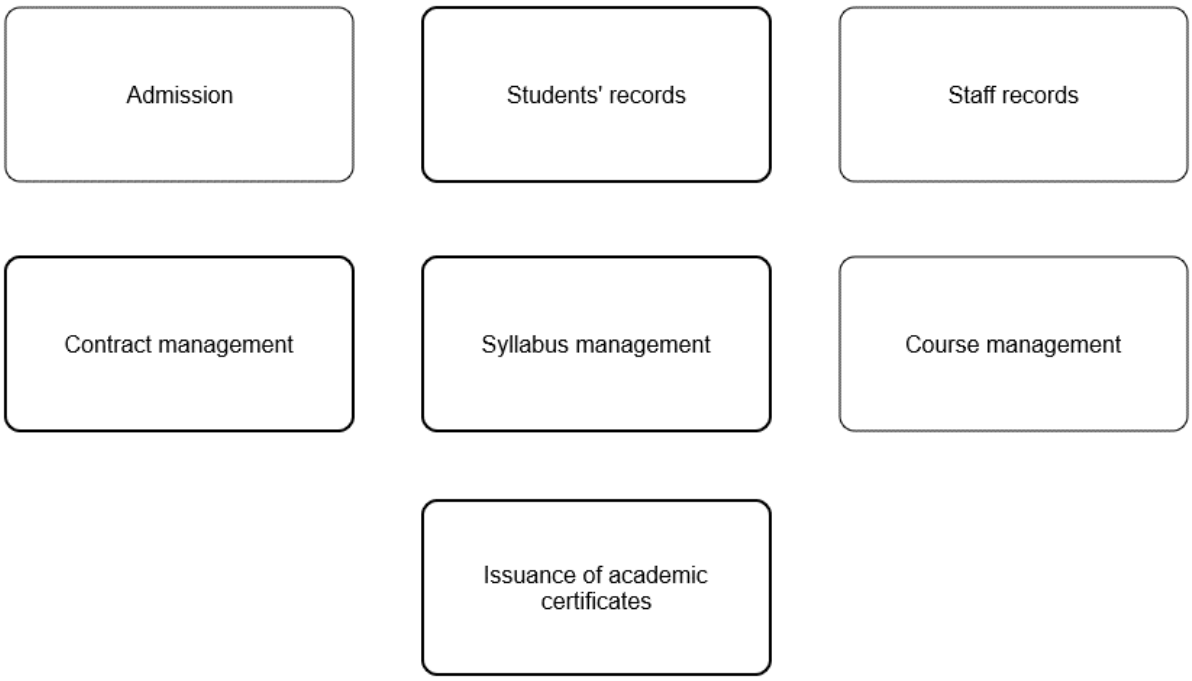

Fig. 6. System components

The system comprises on the following modules: Admission, Students' records
Staff records, Contract management, Syllabus management, Issuance of academic certificates and Courses management.

Admission is used for candidates' applications. The candidates can fill the forms, but the data is validated by the staff.

Students' records module uses personal data from admission, and it is used to record all of the students' activities: courses taken, grades, requests and other specific data.

Staff records module manages the academic and administrative personnel data. In addition to personal data, academic staff data will be related to syllabus, students' activities, courses management and other specific activities.

Syllabus management is very important for the educational activities. All operations related to syllabus are recorded and actual or former students or third parties are able obtain all required information related to any subject of study.

Courses management is also important for the educational processes. The students will access the course content and they could compare the new additions. They could also relate the content with the exam topics. Another perspective is the institutional accreditation, where the course content is analyzed in this process.

Issuance of academic certificates deals with all kind of certificates: graduate diplomas, certificates of participation, administrative proofs etc. The issuing process is automated and the content is validated even through blockchain mechanisms. For certain types of certificates, the process has to be correlated with external systems.

Contract management includes all the tasks related to various types of contracts.

The system has to be integrated with other required applications, such as for human resources.

The system will benefit from the use of smart contracts at different levels.

6 Conclusions and Future Work

As previous authors and successful projects have shown, blockchain technology could be used in educational computer-based systems. In this paper we presented a proposed architecture for a system adapted to the Bucharest University of Economic Studies needs.

There are many aspects that have to be analyzed, like: information structure, transactions, type of blockchain, infrastructure etc.

Next steps will focus on detail design and flow and relationships identification, among technical aspects.

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