

SECURITY AND TRANSPARENCY OF BLOCKCHAIN SYSTEMS IN HIGHER EDUCATION INSTITUTIONS

Avni RUSTEMI^{1,2}, Vladimir ATANASOVSKI², Aleksandar RISTESKI²

¹*Department of Informatics, Faculty of Natural Sciences and Mathematics, University of Tetova, N. Macedonia*

²*Department of Electrical Engineering and Information Technologies, Ss Cyril and Methodius University in Skopje, N. Macedonia.*

^{*}*Corresponding author: e-mail: avni.rustemi@unite.edu.mk*

Abstract

Blockchain technology is one of the safest technologies, which is finding application in almost every sphere of life, due to the characteristics that it possesses. The beginning of blockchain technology was difficult, as all people thought that we were dealing with fraudulent technology that only aims to deceive people and get money, but such a thing will change over time, and today blockchain technology and in particular cryptocurrencies are an integral part of most people's lives. Everything is transparent, and safe and people are benefiting from this technology, depending on the investments and the cryptocurrency market. Unlike all spheres, in the sphere of education, blockchain technology is encountering many challenges, especially in higher education institutions. There is a lack of interest from researchers, as they do not see this field as profitable, but on the other hand, there is also a lack of developers who deal with blockchain programming. In this paper, we will try to make an overview of the application of blockchain systems in higher education institutions, the importance of the application in particular for the generation and verification of diplomas as a matter of great importance, the challenges that the educational institutions are facing, and above all we will explain the security and transparency that blockchain technology offers. We will also present a simplified framework of how we think of the process of generating and verifying diplomas, as an important part of academic qualifications in a higher education institution. The creation of standardized templates for the generation of diplomas is one of the possibilities for overcoming various misuses. Prevention of the misuse of diplomas is important for the whole society, as it is a phenomenon which, despite the measures taken, is still present today.

Keywords: diploma, falsification, verification, blockchain system, security, transparency.

1. Introduction

Blockchain technology is one of the technologies that recently has been applied in many spheres of life, including health, business, government, and aviation, but in some spheres, there is still an incomplete application of blockchain, which is currently one of the technologies that offer high data processing security. It is based on a distributed and decentralized network and anyone can access it without any prerequisites or without being controlled by anyone. The application of blockchain technology in education especially in higher education institutions is facing more difficulties or even a lack of interest from researchers. Some researchers believe that this is a result of education is not profitable for the majority of researchers who are currently focused on cryptocurrencies and the financial benefits derived from them (Čeke *et al.*, 2020). Blockchain technology is one of the technologies that offer a distributed architecture, so we have a transition from a centralized way of data management to a decentralized, transparent, but on the other hand more secure way of data management (Rahardja *et al.*, 2022). The robustness of blockchain lies in the storage of data in the blocks of the blockchain network and the establishment of unique hash values, which also verifies the immutability

of the data. Each block in the blockchain network is connected to the other block, in reality, the respective hash values are stored in each of the blocks, and no change can be made in the ledger in the blockchain because any change would result in a change in the hash value different from that registered in the blockchain ledger (Ahmad *et al*, 2022). The benefits of the application of blockchain in education are great, even though there has been no interest in the full application of blockchain in all spheres of higher education institutions. It is evident in some cases the use of blockchain for various purposes in higher education institutions, but it is not implemented in the most important spheres where in some cases various misuses are made. However, in addition, to prevent misuse, blockchain systems in higher education institutions would reduce the time for many things, such as the faster verification of many documents, and in that aspect, it would facilitate the work of the administrator and teachers, since through these systems the teachers would be able to keep evidence for each assessment and in the end the system would automatically generate the final grade, without having influences from outside (Mohammad *et al*, 2022). Figure 1 presents the main characteristics of blockchain technology: immutability, transparency, consistency, integrity, decentralization, security, distributed architecture, and consensus mechanism. Everyone has the right to become part of the blockchain network, or rather to become a miner and create their blocks and execute on the blockchain. The blockchain network is decentralized, with no control by specific people. Every transaction is transparent, which can be seen by all those who are inside the network. It is very difficult or almost impossible to decipher the data within the blockchain network, although attempts are still ongoing. When we talk about blockchain systems in higher education institutions, it is worth noting that there are many cases where it should be given importance. It happens that some other person pretends to be the student and appears on behalf of the student. There are other cases when the institution has a person who tries to change the student's data, be it a grade or other information. Therefore, much importance it should be dedicated to the correct identification of the student. While creating a blockchain system, a lot of work should be automatically generated, i.e., try to remove as much intervention in the system from third parties as possible. And what is most important is transparency. Transparent services, there is less chance of the same being misused, as the possibility of their verification is easier (Tang *et al*, 2021).

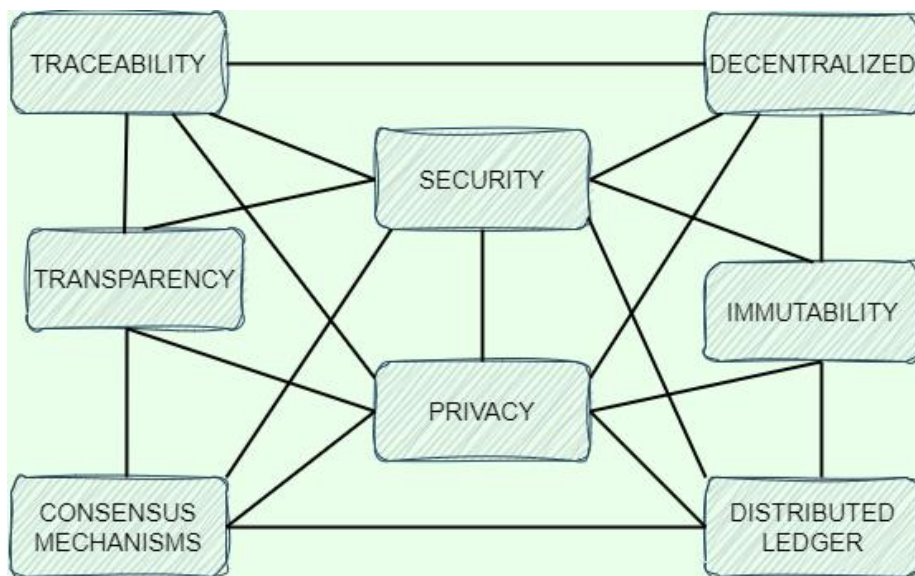


Figure 1. Blockchain characteristics

The use of blockchain technology in higher education institutions will bring several benefits, among which we will mention some of them:

- protected data of students and teachers in all departments of the institution of higher education,
- limited access with certain permissions, where everyone who has access to the system is also responsible for their actions since everything is recorded and leaves traces,
- data transparency, even though the data is public, transparent, and accessible at any time, the system should offer data security and guarantee that the same will not be misused,
- costs are reduced, depending on the nature of the system, used platforms and frameworks, as well as system maintenance,
- assessment of students is done transparently, also the receipt of credits and final grades does not depend on third parties, as the system automatically can generate depending on the preliminary assessments,
- generation, verification, revocation, and regeneration of diplomas is possible through the blockchain system (Sunny *et al.*, 2022).

2. Security, transparency and challenges

The security of blockchain technology, in addition to the distributed network, is the hash value generated for each process executed in the blockchain network. The hash value is unique, therefore even if someone tries to falsify the data that is generated, whether it is the student's diploma, very quickly the same can be verified that it is not original based on the changed hash value. Hash values are also stored in the blocks of the blockchain network, and in each block, in addition to the hash value of the current process, is also stored the hash value of the previous block. If the hash value changes in a block, it will not be the same hash as the value of the next block, which very quickly verified that someone wanted to falsify the data (Dubey *et al.*, 2022). There have always been attempts to falsify diplomas as important documents for the employment of people. The process of their verification has been very difficult, since most of them have been done in physical form, looking for students' files, checking credits, teachers, etc. It is much easier if a higher education institution has digitized services. In digital form, most of these processes are performed faster. However, the majority of higher education institutions, even though most of their services have been digitized, especially private institutions, once again there is a lack of use of blockchain in the services they offer. Transparency is one of the phenomena that prevent forgery. Since the services are transparent, online, and accessible at any time, very easily the same can be verified if they are true or false. Blockchain is one of the technologies that offer transparent services, although it depends on the type of blockchain application, since private services that are categorized as private blockchain, they cannot be accessible to all people. However, the categorization of services is done depending on the policies of the higher education institution, but also on the privacy issues of the students in particular. Services that are categorized as public, are accessible at any time in the blockchain system (Souza-Daw *et al.*, 2021). There are many challenges regarding the application of blockchain in higher education institutions. First, the academic staff, teachers, and other employees must be prepared for the blockchain systems. Higher education institutions should start organizing training for staff, teachers, and students regarding blockchain applications and give instructions on how to easily adapt to this technology. Higher education institutions should start implementing policies that will force certain departments, especially the science departments to start recording resources using blockchain systems (Sunny *et al.*, 2022). Another challenge involving higher education institutions is the wide inclusion of a system for additional services within the higher education institution. Digitization of existing services is a challenge for everyone, as the institution moves from the

offline system or with physical papers to online services, in electronic form. Also due to the large appearance and use of smartphones and other intelligent digital devices, in addition to the blockchain system in higher education institutions, the same must be adapted for smartphone devices so that students can access it at any time and from any place. As a challenge in the blockchain system, there is also the personalization and intellectualization of the services within the system. Therefore, services offered should have more options, not be limited. To offer higher security while surfing through the browser for other research, if the system is threatened by any virus then the same will immediately alert the student or the professor. Blockchain systems should also offer many other intelligent services, which are closely related to the application of blockchain in artificial intelligence (Wei *et al.*, 2022). Figure 2 presents some challenges of applying the blockchain system in higher education institutions.

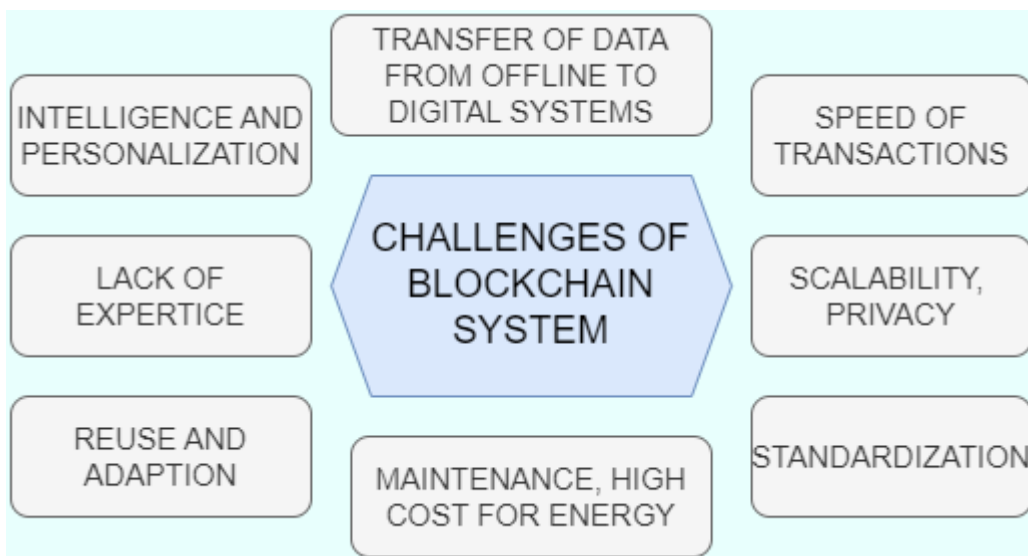


Figure 2. Challenges of blockchain system

3. Educational platforms for higher education institutions

To date, a large number of educational platforms have been applied, some of them even for the verification of diplomas. However, there is no concrete result of how far they have progressed with implementation, respectively if they have shown positive results during implementation. A Blockchainized Certificate Verifying Support System (CVSS) is a blockchain platform, which aims to manage certificates to prevent forgeries and various misuse attempts (Nguyen *et al.*, 2018). Otherwise, the platform includes four important processes regarding diplomas: registration, generation, verification, and revocation. There is no data for the practical implementation of the system, except for the models of how these 4 processes work. Blockcerts is another educational platform that allows students to manage their diplomas and share them in a secure network with the people they want. BlockTechCert (BTCerts) is also an educational platform that aims to verify and revoke diplomas safely. Other platforms that are of the same nature are Block.co and OpenCerts (Hsu *et al.*, 2022). Hyperledger Fabric (Alaksieva *et al.*, 2020) is a blockchain, open-source platform that, unlike other platforms, supports the creation of smart contracts even in common programming languages that developers have learned such as Java, Node.JS, and enables their execution under the same conditions as be programmed in a language compatible with smart contracts such as Solidity or others. Hyperledger Fabric offers a closed

consensus mechanism, which allows network participants flexibility in choosing consensus mechanisms (Hsu *et al.*, 2022). BCert is an educational platform based on the blockchain which also aims to verify certificates and diplomas, adding the certificates to the blockchain network and making them transparent and accessible to all participants in the network. It is implemented using the Ethereum platform, while Solidity, a compatible programming language for the Ethereum platform, similar to the Java programming language, is used for programming the smart contract. For storing encrypted certificates, InterPlanetary File System (IPFS) (Rustemi *et al.*, 2022) is used as a blockchain database. Otherwise, the architecture of the system has as main elements, progressive web applications, frontend and backend, with which encryption/decryption of information is carried out, i.e. through visual objects perceptible to the users of the system. The connection to the smart contract is made using the peer-to-peer network and other protection mechanisms such as Secure Sockets Layer (SSL) (Rustemi *et al.*, 2022). While on the blockchain network, the execution of transactions is carried out using Ethereum Virtual Machines (EVM), which enable transactions to be carried out using virtual networks (Leka *et al.*, 2022). VerDe (Verified Degrees) is also a blockchain platform that deals with the registration and verification of academic qualifications. It is based on the use of the Business Process Model & Notation (BPMN), which demonstrates the use of methods in the most effective way to address the most complex issues, and facilitates the implementation of blockchain-based systems (Nousias *et al.*, 2022). The table below presents several blockchain solutions that have been created about the issue of diplomas, whether for verification, revocation, or even generation of diplomas (Murugesan *et al.*, 2022).

Table 1. Blockchain educational projects

Project	Purpose	Platforms
University of Nicosia	credential verification and online payment through cryptocurrencies	Bitcoin, Go Chain
University of Birmingham	issue Blockcerts problems and challenges	Docker, Maven
Open Certificate	platform for generating certificates	Ethereum
EDUCTX	generation and verification of certificates	Ethereum
EduChain	blockchain platform for online learning	Ethereum
Blockcerts	educational platform that allows students to manage their diplomas	Hyperledger Fabric
Tutellus	evaluates students based on their performance and rewards them	Ethereum

Most of the blockchain solutions that are created in the direction of the verification of diplomas have used the Ethereum platform. Ethereum is more compatible with many frameworks and programming languages for smart contract execution. Each transaction has its own cost, while Ethereum also has a framework that allows researchers to test smart contracts for free, without any additional cost until they are placed in the blockchain

network. Such example we have Remix IDE, which is a rich toolset, that offers a workspace for both researchers and students to test pilot projects.

4. State of the art of blockchain system design

There are many models proposed by different researchers regarding the process of generating, verifying, and revoking diplomas through the blockchain system, depending on the platform they use. However, everyone agrees with the fact that the main elements during this process, or the main actors, are: the students, the institution of higher education, the diploma issuer, and the diploma verifier. During the creation of the blockchain system, great care must be taken to the issue of data privacy, as the same must be done in coordination with the policies of the higher education institution, but also with the students, who must necessarily agree on which services should be public and private. Therefore, during the creation of such a system, in most cases, the blockchain consortium is used, which represents the use of both public and private blockchain (Hsu *et al.*, 2022). Most of the services offered by the blockchain system must be generated automatically. This would avoid the use of the system by third parties, and would further reduce possible forgeries or misuses by system users (Ghazali *et al.*, 2018). However, the automatic generation of services has its challenges, because for every mistake during data insertion, it would generate the wrong diploma, while the wrong generation of a diploma in the blockchain system would mean its deletion from the system and the generation from the beginning because the same cannot be generated with the same hash value. Figure 3 presents a framework for the generation and verification of diplomas (Hsu *et al.*, 2022). This process is more complicated than it appears in Figure 3, where we have presented only a simplified framework of the processes which we will explain in detail. Through the framework, we propose that the generation and verification of diplomas should not be linked to the system used by the institution of higher education. Respectively, the generation or verification should be done by a third party, be it a private company or the institution's programmers, but who will be independent from the institution's leadership, due to possible misuse. Every service in the blockchain system must be executed through a smart contract. To implement a blockchain system for higher education institutions, we need to do a technical analysis of the specifications needed. First, hardware and software parts are needed. As hardware parts are needed fast processors, fast graphics, clusters, nodes. From the software parts, are needed programming languages for smart contracts, the framework where we will execute them, and the environment where we will test them before executing them. Regarding the implementation architecture, we must define decentralized, transparent, and immutable architecture (Isler *et al.*, 2022).

The main requirements for the implementation of the blockchain system for higher education institutions are:

- participants in the system must be identified, their roles, the permissions they will have in the system,
- the design of the system in a detailed form, each actor what activities will perform, a systematic analysis of the system should be done,
- depending on the requirements, the systematic analysis, to define the hardware and software equipment needed both for the creation of the system and its maintenance,
- to define the consensus mechanism,
- to identify the platform that will be used for system implementation, which depends a lot on the consensus mechanism chosen,
- determining the nodes of the blockchain network, as well as classifying them as private or public, depending on the services that will be offered by the smart contract that will be executed in that block,

- designing instances related to parameters, address format, permissions, asset naming,
- connecting to the database and creating data communication channels,
- interfaces for the admin and other users included in the system, to create easier possibilities for using the system,
- complementary features to the blockchain system, such as intelligent services, cognitive recognition services, internet of things and other features of the future. (Isler *et al*, 2022).

These represent the technical requirements of the blockchain system. However, we will present the functionality of the system, respectively the organizational aspect of the proposed system for the generation and verification of diplomas. Blockchain system should:

- offer transparent services for students, academic staff, and all citizens in general,
- offer verification of diplomas at any time,
- process the requests of students to receive the diploma and generate the same in record time,
- be valid and provide security for an indefinite period,
- have interoperability with other blockchain platforms and offer the possibility of data transfer from existing digital systems,
- have the possibility of updating the system depending on the needs, without affecting the data and data privacy,
- be maintained all the time and to offer support to the users at any time,
- reduce the time for the generation of diplomas, the cost of maintenance, even better if the institution can maintain it,
- generate the diploma based on the information inserted earlier, and the possibility of revoking the diploma if there are cases of errors and its regeneration,
- have ways of identifying students, either through QR codes, digital signatures, or even face recognition,
- generate credits automatically after the student has completed the evaluations by the teachers,
- as well as many other intelligent, cognitive features of the future era, to make the institution of higher education more real, in addition to offering data security and autonomy, also attractive to students of different profiles, and to prevent any misuse possible.

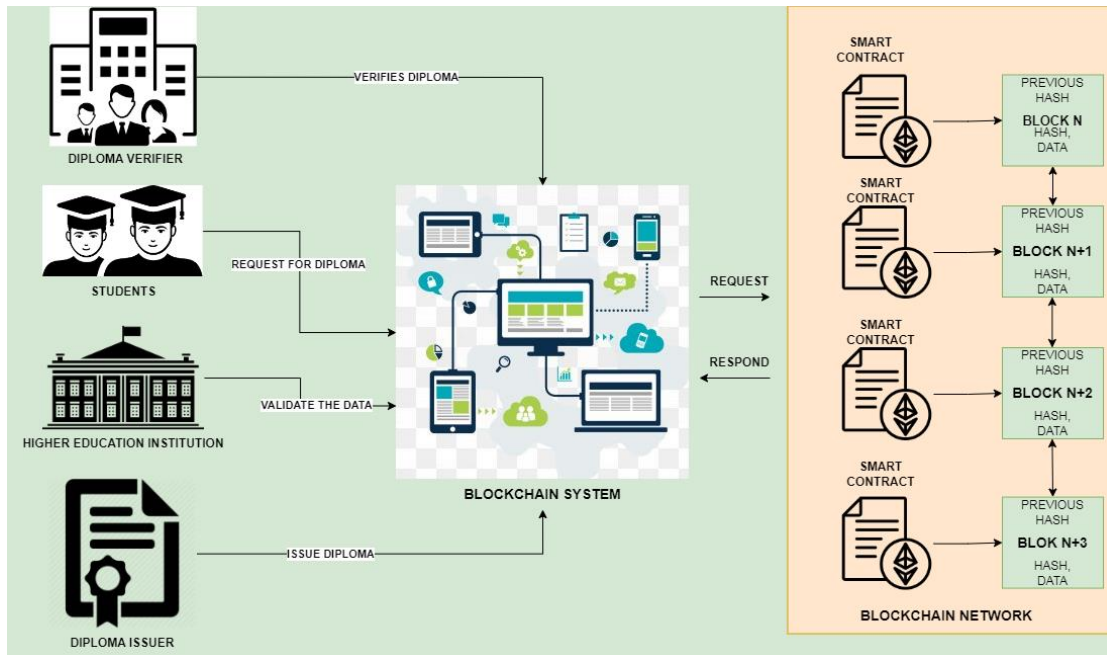


Figure 3. Framework for issue and verification diploma

The framework presented in short points can be clarified as follows. Students apply for the diploma after finishing all obligations to the institution where they completed their studies. After the request is verified by the higher education institution, it processes the request to the diploma generator, which can be a private, licensed company, or even the institution itself if it has the capacity for such a thing. The generation of diplomas is based on the information that is previously entered into the blockchain system, evaluations made by teachers, credits generated, and grades. So, in fact, during the generation of diplomas, you should not at all interfere with the details of the diploma, but only process the same data, to be validated later again by the institution of higher education, to be signed in digital form by the institution but also by the student, and it is given to the student in electronic form. The same procedure is for the verification of diplomas, where the verifier can be any private company or the institution of higher education itself if it has the capacity. The communication between the student, the higher education institution, the verifier, and the issuer is done through the blockchain system, respectively through the frontend and backend parts which are part of the web application programs with which requests are processed and converted into smart contracts, ready for execution on the blockchain network.

5. Conclusion and future work

Blockchain technology enables the processing and maintenance of large amounts of data. The cooperation between blockchain in education and learning systems is very important, to create certain standards for interoperability. Despite the many challenges, blockchain has begun to be applied in many sectors of higher education institutions. Payment processes, evidence of academic staff, students, and professors, and automatic payment processing are successfully managed. What remains the challenge for researchers is the generation and verification of diplomas. There is no concrete data, or research that shows that blockchain is succeeding in this very important process for higher education institutions, but also for society in general. One of the

challenges in this direction is the lack of blockchain programmers. There must be a collaboration between higher education institutions and private IT companies, especially those that deal with blockchain, where students can do internships and become professionals in this field. Also, conferences should be organized only regarding blockchain in higher education institutions, to gather people from all countries of the world and to exchange experiences and opportunities on how to make such a system in a standard form, acceptable by all countries of the world. After we made a description of the blockchain in the institution of higher education, where we gave special emphasis to the security, and transparency of the services that this technology offers, we described some blockchain solutions that have been created in this direction, and we gave a model of how to create an online system for the generation and verification of diplomas. We are concluding this paper with our plans for the future, trying to collect all the practical blockchain solutions we can access, to make a systematic analysis of the codes and algorithms used, and to give our contributions to the analysis of the used codes and algorithms and see the possibility of their reuse in our project, which we want to implement shortly. The implementation of the proposed project undoubtedly requires commitment and, detailed analysis of all literature regarding the practical applications of blockchain platforms for higher education institutions, however, its implementation will facilitate the higher education institution to at least verify diplomas, a very important phenomenon and to prevent forgeries and possible abuses by malicious persons.

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