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Development and implementation of the cloud platform for tokenization of personal data of students

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Abstract.
The modern world is going through an important transitional period from the stage of informatization of important aspects of human activity to the stage of their digitization. Digital transformation means deep rethinking and reformatting of various spheres based on digital solutions and technologies. This process requires not only the maintenance of existing conditions for the development of advanced digital platforms and technologies, but also the creation of new opportunities for the birth of innovative solutions. In the context of the digital transformation of the educational sphere, a study was conducted on the use of blockchain technologies for the tokenization of educational resources and the analysis of the potential of their application in education. In the context of the digital transformation of the educational sphere, a study was conducted on the use of blockchain technologies for the tokenization of educational resources, thus the purpose of this study is to increase the confidentiality of educational data, their integrity and accessibility, as well as to ensure reliable exchange of this data between all interested parties due to design, development and implementation of software components of a cloud platform for tokenization of students' personal data based on blockchain technology. The object of the study includes systems for the transmission and processing of educational data, which ensure the exchange of data between all interested parties in the educational process. The subject of the research is the methods and means of designing and developing software components necessary for the creation and maintenance of platforms for the tokenization of students' personal data. These components include software for encryption, authentication, authorization, and mechanisms for fault tolerance and data recovery. This paper proposes a model of a cloud-based decentralized system for tokenization of students' personal data. The integration of blockchain technology into the education sector has great potential to strengthen trust and improve the quality of education services, as well as to create a new ecosystem of educational assets that are accessible and verified at the global level. The implementation of blockchain technology in the field of education requires the development of specialized software for issuing and verifying digital diplomas based on blockchain. The introduction of a cloud platform for tokenization of students' personal data promises a

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significant improvement in the processing and storage of educational documents, contributing to greater trust and transparency in the field of education.

Keywords:
blockchain
personal data of students
cloud data storage
smart contracts
Ethereum
architectural model of cloud data tokenization platform

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Introduction. Blockchain technology offers a decentralized structure that allows transactions between two parties without the need for a third party [1]. Blockchain's inherent properties, such as decentralization, transparency, and security, have made it highly attractive in many sectors, including finance [2], supply chain management [3-5], the Internet of Things, healthcare [6], and education [7]. In the field of education, blockchain is innovating in several areas, including academic research, reputation systems, e-portfolios, intellectual property management, integration of continuing education with learning analytics platforms, and verification of credits, credentials, and certificates [8-9].

There are many scientific reviews [10-12] dedicated to the application of blockchain in education, which highlight a wide range of solutions that solve key problems in this field. For example, some papers considered the role of blockchain in the management of academic certificates and accreditation information [13-17], although the initial analysis was based mainly on theoretical propositions rather than practical implementations. Other reviews identified new projects using blockchain in education and explored various potential applications.

Based on previous systematic reviews of blockchain-based educational applications, this paper proposes a cloud-based platform for tokenizing student personal data. This approach allows for a more detailed understanding of the impact of blockchain and its implementation in educational institutions, demonstrating the ability of technology to introduce innovations and improve educational processes and systems.

The purpose of the work is to increase the confidentiality of educational data, its integrity and availability, as well as to ensure the reliable exchange of this data between all interested parties due to the design, development and implementation of software components of a cloud platform for tokenization of personal data of students based on blockchain technology.

Main part. Analyzing the classification of blockchain applications according to [18], a three-level approach can be distinguished: Blockchain 1.0 focuses on currency

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transactions, Blockchain 2.0 expands to smart contracts and financial instruments, while Blockchain 3.0 goes beyond financial transactions, adapting to various sectors, including education.

This technology opens up new opportunities for reforming the system of issuing and storing educational documents, providing the advantages of reliability, transparency and efficiency. The use of blockchain allows you to reduce the risks associated with the forgery of documents and ensure the safe storage of educational assets without the need for third-party intervention.

An examination of the current system of issuing and storing diplomas reveals its shortcomings, such as the complexity of the process, high costs and vulnerability to physical and legal risks. A solution is proposed, which consists in tokenization of educational assets using blockchain, which will allow digitizing the process of issuing and storing diplomas, ensuring their authenticity and reliable storage in a decentralized registry [19]. This will not only simplify access to educational documents and their verification, but also ensure their preservation even in the event of termination of educational institutions.

According to the proposed method of tokenization of educational materials, universities issuing digital versions of diplomas use a common decentralized registry for their storage. Digital diplomas signed with a unique private key are provided directly to employers, providing the ability to verify the authenticity of the diploma through comparison with a blockchain hash. This helps to solve the problem of falsification of documents and the preservation of important data.

To take advantage of the unique technological capabilities of the blockchain for the student data tokenization system, a cloud platform based on the Ethereum blockchain system with smart contracts is proposed. A private blockchain is also called a "permission blockchain" that restricts access to certain users. The system architecture includes two modules:

1) binding module: the system administrator of the educational institution will create a contact point for the

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student after the digital token of the student's diploma is ready, and enter the relevant primary information into the smart contract for future indexing;

2) request module: students grant employers permission to access their data by adding employers to a "whitelist" in the smart contract.

The data collected using this framework is transferred to the API module, which not only stores the data in the database module, but also generates a connection to the blockchain module, linking it to the database. In addition, it records the transaction ID in a separate database system.

A transaction on the blockchain is initiated by activating the Chaincode CreateIntervention function. This function records the transaction ID, the IDs of the student's educational institutions and digital wallets, and the path to the database module that stores the student's personal data information.

When an employer needs to examine a student's educational data (diploma data and transcripts), they must authenticate in the application. After authentication, it can get the necessary transaction ID (Encounter ID) from the database module. The identifier is processed by recording an access event and returning a transaction that includes a reference in the form of a database string to the required student data records.

Students accessing their records follow a process similar to that of an employer. Students must authenticate and connect to their personal records database through an external application. Then they find the identifier of a specific data request operation in the database. This ID is used to call Chaincode's GetInterventionByID function, which retrieves a transaction containing a reference to the required student records database row.

The system performance evaluation included several tests to verify the Hyperledger network configuration and the functionality of the entire system as a whole. To test the proposed framework, a customized test infrastructure was created on a remote Amazon Lightsail-based virtual server equipped with 4 GB of RAM, 2 processor cores, and a 3000 MHz processor running Ubuntu 20.04.2 LTS. The network was

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structured as a simple setup that included three entities, each with one node, making a total of three nodes where all transactions took place. The RAFT consensus protocol was chosen because of its ease of implementation and full support in the Hyperledger Fabric documentation. For database needs, CouchDB was used due to its ability to perform complex queries, and Amazon RDS MySQL was used to manage SQL connections related to transactions. The developed smart contract had two main functions, one to create new transactions and insert data, and the other to retrieve JSON data using a specific identifier.

Initially, the block size was set to a maximum of 99 MB, but for testing it is better to use smaller blocks of 512 KB, containing up to ten transactions each. A Python script was used to create a significant test load, and the Postman tool was used to evaluate the API's ability to handle HTTP POST requests. Hyperledger Caliper was installed as a tool to test and evaluate the performance of the Hyperledger Fabric network, focusing on metrics such as throughput, latency, and scalability.

The results showed a stable average delay and throughput at different block sizes without significant fluctuations (fig.1-2). This consistency is likely due to the setup of the test environment, in which all nodes were located on the same computer, which minimized network propagation delays.

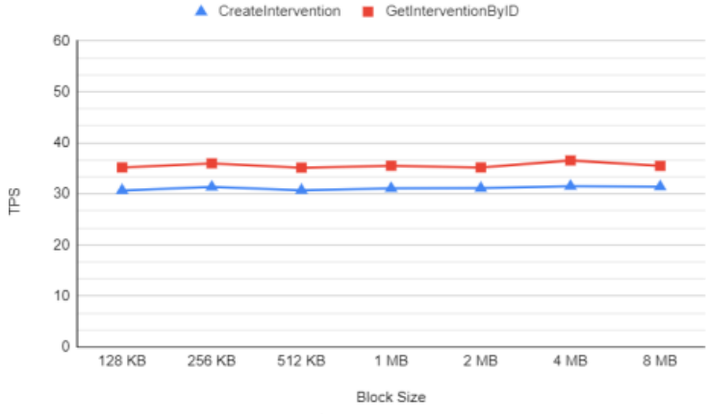

Figure 1

Results of throughput estimation (measured in TPS) when varying the block size (using 10 transactions per block)

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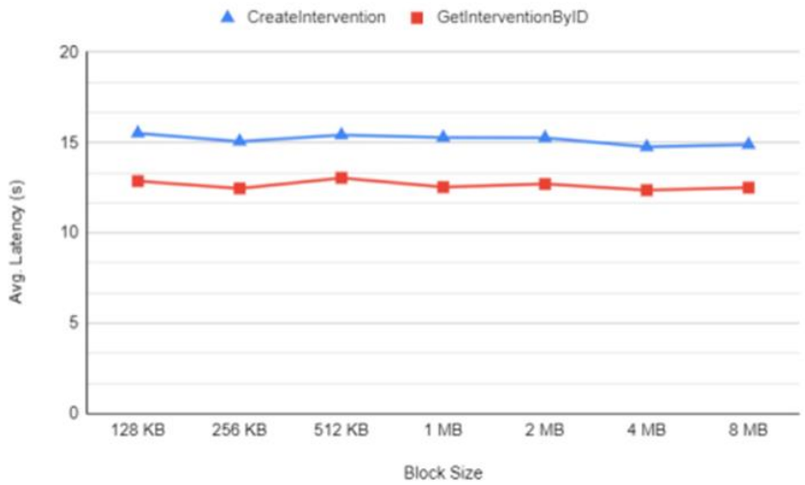

Figure 2

Latency results (measured in seconds) when changing the block size (using 10 transactions per block)

In fig. 3 and 4 show how throughput increases as the number of transactions in a block increases, which is consistent with expected results and similar estimates of Hyperledger Fabric. However, the latency reached a stable level after reaching 50 transactions in a block, showing no significant change after that point.

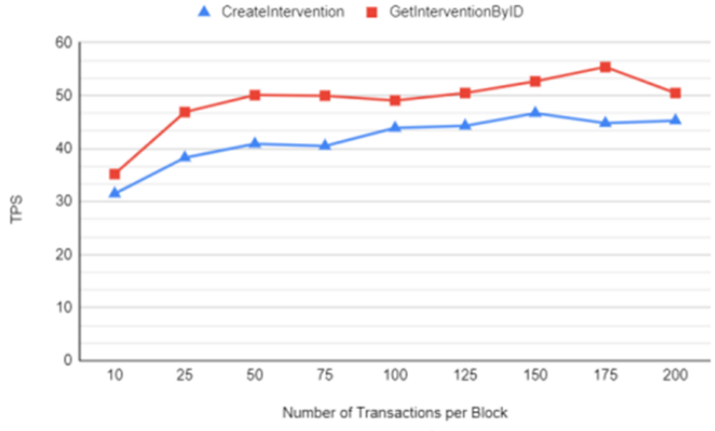

Figure 3

Hyperledger throughput (measured in TPS) results, Fabric network and chain functions used when varying the number of transactions in a block (using a 2MB block size)

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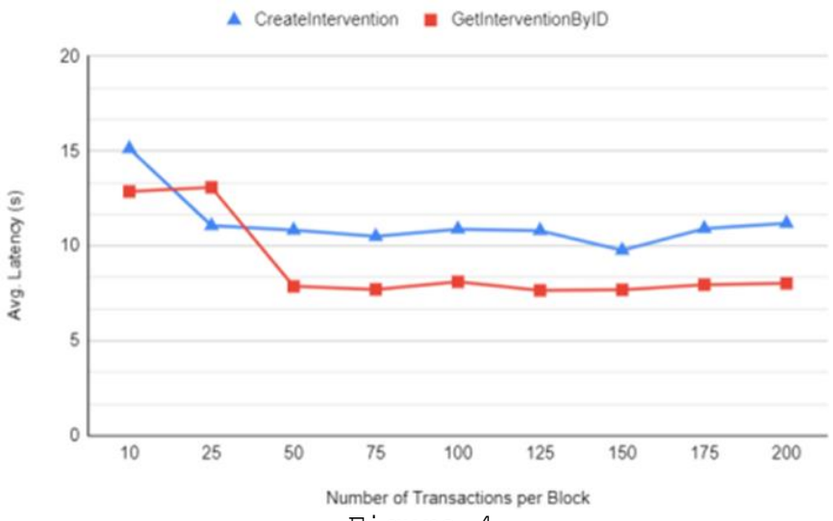

Figure 4

Latency results (measured in seconds) when varying the number of transactions in a block (using a 2MB block size)

In addition, an estimate of the additional storage required for the system was made by monitoring the disk space usage after the transaction batches. As a result of testing, it was found that each batch of 2000 transactions led to an increase in disk space by an average of 11%. These results highlight the trade-off between improved privacy, integrity, and immutability offered by blockchain and increased storage requirements, which is an important consideration for education systems considering blockchain adoption. As a result, it was decided to save only individual cloud addresses in Ethereum, which entails a small fee for cloud storage.

Conclusions. It is important to note that blockchain is not a one-size-fits-all solution for education, but this research demonstrates the viability and reliability of using blockchain's unique attributes. The obtained results indicate that the integration of blockchain with a platform for tokenization of personal data of students is not only feasible, but also offers significant advantages, including secure storage of transactions, and an immutable transaction log for network participants. The design of this system also allows for the separation of personal and student data, ensuring data traceability and anonymity.

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While the integration of blockchain and educational data management systems is still in its infancy, the undeniable benefits of a distributed, immutable transaction log are clear. As blockchain technology continues to advance through lower costs and easier deployment, and as new off-the-shelf data storage methods are developed, blockchain-integrated IoT systems are likely to become the norm for student personal data sharing solutions. The key conclusions are:

1. The results of the study confirm the feasibility of using blockchain for tokenization of students' personal data.

2. Privacy can be effectively maintained by combining cloud storage with blockchain technology to meet privacy standards.

3. As the network grows to include more and more objects (organizations, nodes, users), maintaining performance to ensure quality of service for all participants is critical. Addressing potential scalability issues, such as increased latency with more transactions and larger block sizes, may require the implementation of a segmentation protocol for valid blockchains.

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