

# Applying Blockchain Technology for Improvement of the Educational Process in Terms of Data Processing<sup>1</sup>

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**Abstract.** The paper considers some new methods of using blockchain technology as a tool of improving educational process management. Two e-learning problems are described. The first one is low ratings of completing MOOCs. The second one is the need for more detailed and accurate reports. Blockchain technology and its applications in education is considered. Blockchain's ability of documenting events is reviewed particularly. Two cases of using blockchain in this way are performed. The first one is making educational reports more detailed and easier to design. Another one is using blockchain for creating any student model in adaptive education to make electronic educational courses more effective and to increase ratings of completing MOOCs. A blockchain's option of documenting timestamps and users' addresses automatically is specially mentioned. Both cases are described mathematically and united in one model. Using Ethereum blockchain for the evaluation because of its smart-contract's mechanism is justified. Sequence diagram showing application workflow, is presented. Input data from the real e-learning course are processed with using statistics to get the most frequently used system events. Application tools for working with the Ethereum blockchain are presented. The process of developing, deploying and mining smart-contract is shown. Output report is presented. Implementation is described, the ways of future learn are reported.

**Keywords:** blockchain, · adaptive learning, · report, · smart-contract, · education, · Ethereum.

## 1 Introduction

Today online education becomes more and more massive [1-3]. There are a lot of students, therefore, a lot of data. To analyze and control educational process, we need a lot of parameters to handle. Every learning management system has a module for generating and analyzing reports. But as MOOCs become more popular, new methods of manage and control educational process are required.

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Another problem is low rating of completing courses. One of solutions is adaptive learning. When learning is adaptive, every student has his own learning path with his own preferences and features. Adaptive learning can make electrical education more effective [4].

Blockchain technology is a popular research topic. It is a distributed database which based on peer-to-peer network. Every transaction in the net must be confirmed with all the nodes. Every new confirmed transaction needs to be recorded to every node of the network. All the confirmed data is packed in special blocks; every block has a reference to previous block; so, there is a chain of blocks as all data storage.

Blockchain technology has some advantages of use in many areas like medicine, realty and education [5, 6].

Initially, blockchain was created for operation with cryptocurrency, but later it became independent platform for open and reliable data change in some peer-to-peer network. Bitcoin blockchain is for cryptocurrency operations only, while Ethereum blockchain allows various transactions using smart contracts mechanism. A smart contract is a program, which describes some operations in the Ethereum blockchain, Operations become automated transactions between the nodes in the network. It allows to use blockchain in electrical education.

EduCTX project was developed from the Ethereum platform. EduCTX provides internal tokens, which acts like virtual educational currency. Every student has his own electrical ectx-wallet, which appends while learning process [7]. “Learning as earning” is another concept. It means building a chain, using all the education results as building blocks. This chain forms student’s digital portfolio [8].

Nicosia University uses blockchain for certificates’ digital signature. Also, it runs blockchain courses and accepts bitcoin as a payment currency [9]. Finally, blockchain is used in the education reputation system. Reputation acts as a currency [10].

Now there are some studies about certificates’ verification applying blockchain. Confirmation records are automatically stored in the blockchain [11, 12].

One of the most useful blockchain features is its ability to register and store all the events in the system. All these events are available for future processing.

The paper considers two cases of applying blockchain in the e-learning.

## 2 Method

### 2.1 Grade reports

The first case is generating reports. Today there are only determined options for saving and reporting events in existing LMS [13]. Let’s consider a functional block in the LMS, which makes reports. Input data is heterogeneous and consists mostly of four parts. Let the course have  $N$  students and  $M$  tasks.  $A = \{a_i\}$  is an array of integer students’ identifiers, where  $i = 1, 2, \dots, N$ .  $T = \{t_{i,j}\}$  is a matrix of integer timestamps. Every  $t_{i,j}$  means that student  $a_i$  solves task number  $j$ ,

where  $j = 1, 2, \dots, M$ . If student  $a_i$  didn't solve task number  $j$  yet,  $t_{i,j} = 0$ . Then,  $K = \{k_{i,j}\}$  means a matrix of grades. Every element  $k_{i,j}$  is a student  $a_i$  integer grade for the task number  $j$ , or NULL if the student didn't solve the task yet.

So, grade report is a matrix:

$$U = \{u_{i,j}\}, \quad (1)$$

where every element is a dataset obtained from the function:

$$u_{i,j} = f(a_i, k_i, j, t_{i,j}) \quad (2)$$

Function means program code, which are necessary to create for processing all the parameters.

When using blockchain, students form peer-to-peer network, so all their interactions are recorded into blockchain. Time parameters and users' identifiers are registered automatically by blockchain; therefore, grade report is matrix:

$$U' = \{u'_{i,j}\}, \quad (3)$$

where every element is a dataset obtained from the function:

$$u'_{i,j} = f(k_{i,j}) \quad (4)$$

Any report in every LMS can be considered similarly. Every report uses time parameters and users' identifiers. Blockchain makes reports more detailed and universal and doesn't require any data scheme.

## 2.2 Adaptive learning

Another case of using blockchain in education is student modelling in adaptive learning. The student model is the central concept of adaptive learning [14, 15]. It allows the system to choose proper learning path for every student. It denotes a set of characteristics that have different values for different students. Depending on these values, each student belongs to a particular group with different educational path. The characteristics of students are collected and processed both before the start or during the educational process. Such parameters as academic performance, time for solving tasks, asking for reference material, etc. are processed. Regardless of chosen model, to build it it's necessary to get some data about the behavior of the student. Some parameters are time related; anyway, student's identifier is required.

If  $D$  is mentioned before input data for processing in the student modelling, then output dataset for the student model is a result of function:

$$f(D) = f(A, T, K), \quad (5)$$

where  $A$  stands for an array of students' identifiers, like in the previous case;  $T$  stands for an array of all students' actions' timestamps, like in the previous case;

$K$  stands for all the other parameters, required for modelling including grades, actions, uploaded files, comments, viewed pages etc.

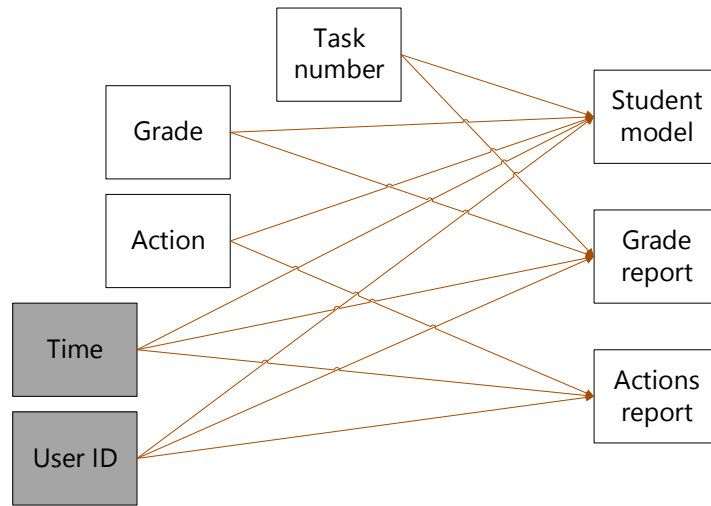
When using blockchain, every timestamp and user identifier are registered automatically, similarly to the previous case, so student model is a function:

$$f'(D) = f'(K). \quad (6)$$

So, blockchain using allows partially automate student modelling and makes input data more detailed. Also, no matter what type of adaptive model us used. Similar to previous case, no special data scheme is required. Blockchain is a universal tool for heterogeneous data registering and storing. Therefore, different models can be designed and implemented.

### 2.3 Both cases in one model

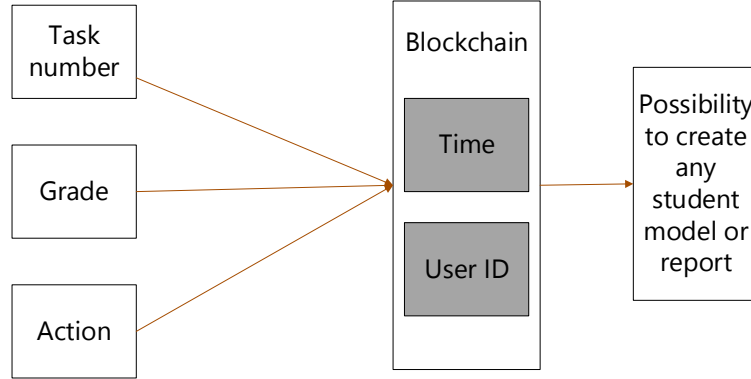
Both cases can be described in one model (see Fig. 1, Fig. 2).



**Fig. 1.** Registering events in existing LMS

It also can be presented mathematically. The first case describes existing LMS:

$$U = f(A, T, K), \quad (7)$$



**Fig. 2.** Registering events in blockchain-based system

where  $U$  means output dataset to form report or student's model,  $A$  means an array of users' identifiers,  $T$  means an array of all user actions' timestamps, main data  $K$  contains all the other user actions' parameters of learning process including grades, actions, uploaded files, comments, viewed pages etc.

Blockchain-based system simplifies the process:

$$U' = f(K) \quad (8)$$

Now, system has to register only  $K$  to generate  $U'$ , because arrays  $A$  and  $T$  are registered by blockchain automatically.

It is important to say, that in both cases no special data scheme or structure is required. Any parameter can be added or selected for processing during system runtime.

The blockchain supports several properties that are considered in both cases:

1. Traceability. It can be easily tracked how an assessment was formed using a detailed report of all student's actions
2. Security. Data cannot be distorted.
3. Reliability. It can be found out that the assessment was obtained precisely by the methods provided for in the curriculum.

### 3 Evaluation

Both models were implemented in a developer’s version of the Ethereum blockchain using the smart contract mechanism. As it was said before, Ethereum is blockchain application platform, which allows to develop blockchain-based applications.

Input data was obtained from the educational center of Design in ITMO University. The system is based on the Moodle platform. At the moment, there are running more than 20 courses. Webmaster offered three log files with results of studying “Design and layout using CorelDraw”. Since the course started, there were about 270 students studied and their activities were recorded into three logs. The files contained following data:

- First and last login of all users in the system, including date and time.
- All students’ grades. The students had to complete 11 home tasks and the final test. Home tasks had to be loaded in the form of a file and were accompanied by a grade and teacher’s comment. The grades were presented in a five-point scale, as well as a percentage of the maximum possible value. The final test consisted of 30 questions. Test grades were presented as a number of correctly answered questions, as well as a percentage of the maximum possible value.
- All students’ actions with date and time. The actions contained data on the following events: a student enrolling in a course, a student uploading a file, giving grades, test attempts, viewing a course section, as well as some system events like assigning a role to a user.

Every file had its own structure. So, a lot of heterogeneous data was available for processing with blockchain. There were more than 200 records with grades and about 40,000 actions.

This data was analyzed for types of events with their parameters and frequency. It is not necessary to model all the events from the input data. This paper needs only the most common types of students’ actions:

- task solving with grade and number of attempts;
- page viewing;
- file uploading with teacher’s and student’s comments.

Smart contract was created with Solidity language and Remix online compiler. It contained event descriptions with a set of parameters for every event type.

There was a handler method for every event. Methods initiated events and recorded them into blockchain with event timestamp and author’s address.

The contract was deployed and mined in the “dev” Ethereum network, available through “geth” console.

Event data was available through the “geth” console too (see Fig. 3, Fig. 4).

Dataset was exported into text file. It allows us to create any student’s model and any educational report (see Fig. 5).

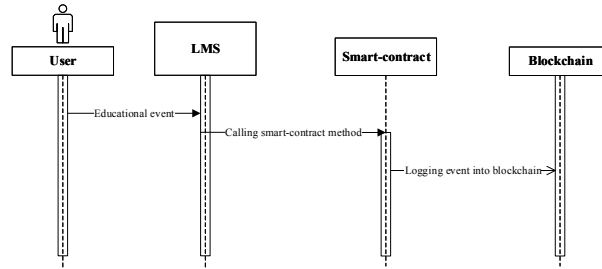


Fig. 3. Recording event into blockchain

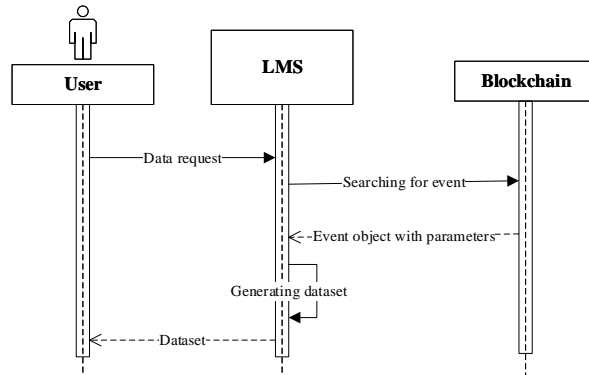


Fig. 4. Extracting data from blockchain

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{"rating": "67", "owner": "0xff2999f3335ea3549d3106cd1d03e1b5bdb3991e", "task": "1", "time": "1563404542"}
{"action": "upload file", "owner": "0xff2999f3335ea3549d3106cd1d03e1b5bdb3991e", "time": "1563404549"}
{"rating": "93", "owner": "0xf83d4e53a82e3cdbc95c74d843d76dd46e963766", "task": "1", "time": "1563404806"}
{"action": "page view", "owner": "0xf83d4e53a82e3cdbc95c74d843d76dd46e963766", "time": "1563404817"}
    
```

Fig. 5. Event report

The output is a log exported into a .txt file. Here is a excerpt from the log with four entries of two types. The first type is task assessment. It contains the "grade" parameter with a student grade as a percentage of the maximum value and the "task" parameter with an integer task number.

The second type is a student's action. It contains the "action" field for the event's name.

Both types of records also have two parameters. "Time" is an integer that the blockchain registers. This is the time of adding the new block, which contains the transaction with this event. The "owner" parameter is the address of the node in the blockchain that triggered the event. This is a hexadecimal number. It serves as the user identifier in this dataset.

The difference between input and output data can be presented in the table.

**Table 1.** The difference between input and output datasets

Property	Initial data	Processed data
Number of logs	3	1
Log files format	.xls	.txt
Data structure	Every log has a table structure, it's impossible to add new data format	Log is a list of records with different set of parameters, any new data format can be added
Events' sequence	No unified sequence for all events, every log needs to be considered separately	Events are in one sequence
Traceability	Need to form every student's path from different logs	Easy to trace every students' learning path
Security	Reports are stored in one place	Records are stored in distributed network
Reliability	Reports are stored in the editable database	Every event has its owner in the network, so, actions cannot be changed

## 4 Conclusion and future work

As it was shown, smart contract logged heterogeneous data of learning events and students' actions to the blockchain without using special data structures. The blockchain stored data in a unified registry and stores event timestamp and event author's address by itself.

As a result of the study we can say, that blockchain technology is a possibly good tool for electronic massive education. The next research task is to measure advantages of blockchain's implementation. The next practical task is to expand the system to the full version, including user interface, and also estimate the cost of using this model.



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