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Design and Build Academic Website with Digital Certificate Storage Using Blockchain Technology

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Abstract

A certificate is a form of the award that is obtained by someone after completing a competency test or certain learning. Certificates must be generated and stored in a safe and secure manner to prevent alteration of content or even falsification. Blockchain technology is a technology that allows secure storage processes at low costs. Security is guaranteed because everyone can take part in storing data with a distributed ledger. Based on the results of research and system design, it can be concluded that the process of making blockchain technology as a medium for issuing certificates and their validation can be made using Ethereum's program, namely Geth, and storing data using smart contracts issued on the blockchain network. The results of the reliability testing of the system show that the system has successfully processed 200 transactions in approximately 8 seconds. For scalability testing, it is estimated that 10 million blocks require a storage capacity of 22.6 GB to become a node or miner on this blockchain network.

Keywords: E-Learning, E-Certificate, Blockchain Technology

1. Introduction

A certificate, according to the Big Indonesian Dictionary (KBBI), is a written or printed sign or statement (statement) from an authorized person that can be used as proof of ownership or an event. The certificate itself is often used as evidence that someone has mastered an ability professionally or as proof of ownership of a valuable object [1].

Digital certificates are now very commonly used along with the development of the academic world. Currently, there are many online academic systems or online learning platforms that offer various classes, both paid and free. Digital certificates will make it easier for class participants to access certificates without the need to physically store them at risk of

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paper damage and loss. Digital certificates do have various advantages, but they are also inseparable from the various risks and challenges that need to be faced. One example of the most basic challenges is data storage which is still using a centralized system [2].

One technology that has been proven to help solve problems such as data accuracy, transaction security, and others is blockchain. Blockchain is a ledger system that is transparent and distributed to each node so that the truth of the data cannot be denied; this system can add security and reduce the risk of corrupt data. Blockchain is the right solution to reduce the risk of digital certificate forgery, and secure digital certificate data with a ledger containing digital certificate data spread to all nodes will make digital certificate data more secure and clear for everyone [3].

The application of blockchain technology was initially carried out by Nakamoto by implementing blockchain technology in electronic money. This combination of electronic money and blockchain is called cryptocurrency. Nakamoto created the first cryptocurrency called Bitcoin. Bitcoin is also the one that popularized blockchain technology, and more and more other cryptocurrencies are popping up. The implementation of blockchain in electronic currency drives several studies to implement blockchain technology in various other fields such as biomedical and health, education, and the banking industry.

Several types of research have been conducted to examine the application of blockchain technology in various fields. Rifa Hanifatunnisa created an e-voting recording application using blockchain technology. The results of the research are in the form of a blockchain system that can be used to store voting results, and the system is designed to run with a fairly good level of accuracy. Data storage of voting results with blockchain technology can increase data security and transparency [4].

Conducted a study to examine how the application of blockchain technology to the Internet of Things (IoT). Based on the results of the research conducted, blockchain technology has good potential to be applied to IoT technology. The use of blockchain in IoT can facilitate access and increase the reliability of the IoT system. The peer-to-peer network that is part of the blockchain can be used to connect IoT devices [5].

Blockchain is a technology that stores data in the form of a distributed ledger and allows for real-time transactions with a peer-to-peer network. Blockchain technology has been widely applied in certain fields and is most widely applied to the financial sector. Many new cryptocurrencies are emerging and implementing blockchain technology in them. There are also several studies that try to apply blockchain technology to fields other than finance. To test the functionality and benefits of blockchain in new fields, research is needed that specifically examines the application of blockchain in these fields. Research on the application of blockchain in fields such as education, health, insurance, transportation, and buying and selling is still rare [6].

This research will be different from previous research because the creation of the blockchain system that will be applied in this research will use Ethereum's blockchain system. Ethereum is an open-source platform for decentralized applications that can be used to create your own blockchain network, complete with functions. The creation of a blockchain system with Ethereum is done using Geth, which is an implementation of Ethereum in the Go programming language [7]. Geth allows users to create blockchain networks without writing any programming code at all. Data storage on the blockchain network is carried out using smart contracts. Smart contracts are rules that can be applied to the blockchain network to regulate data storage or other processes. Smart contracts on the Ethereum blockchain network are written using the Solidity programming language. Smart contracts that have been written can be deployed with the help of Truffle. The blockchain network that has been created is connected using Metamask [8].

This research will examine the application of blockchain technology in education. One of the sectors in the field of education that will be researched is an online learning platform. The main objective of this research is to apply blockchain technology for certificate storage in online learning platforms. This research will test how effective and safe blockchain technology is to use as a storage medium. This research also examines the use of blockchain technology in fields other than digital currency, which has been widely applied today [9]. This research can open up new opportunities to use blockchain technology in various fields such as health,

education, and others. Based on the various goals and benefits to be achieved, this research will develop an academic website for the online learning process whose certificates are stored using blockchain technology [10]. This research will examine the application of blockchain technology in the field of education. One of the sectors in the field of education that will be researched is online learning platforms. The main objective of this research is to apply blockchain technology for certificate storage in online learning platforms [11]. This research will test how effective and safe blockchain technology is to use as a storage medium. This research also examines the use of blockchain technology in fields other than digital currency, which has been widely applied today. This research can open up new opportunities to use blockchain technology in various fields such as health, education, and others. Based on the various goals and benefits to be achieved, this research will develop an academic website for the online learning process whose certificates are stored using blockchain technology [12].

2. Research Method

2.1 Problem analysis

Certification is often used to reference how deep a person's abilities are. Certification can be found in various forms, such as certification of special abilities, foreign language certification, and various other types of certification. A person must successfully pass certain exams in a study to be able to get a certificate. An institution can open an academic class and issue a certificate as a sign of graduation to students or class participants. A certificate will usually be recognized in the world of work if the institution that issued the certificate is well known. Technological developments have entered the field of education. Nowadays, it is very common to find various websites that offer certified online academic classes that are quite recognized in the world of work [13].

Digital certificates issued online will be stored on the server of the certificate issuing institution or the website of the online class provider. Users can indeed download and print the certificate, but users will still be more comfortable if the online certificate provider has reliable storage as a backup that can be accessed at any time. Another factor to consider is the risk of certificate forgery. A certificate will be more recognized and appreciated if the risk of certificate forgery is very small or cannot be counterfeited. Forgery of certificates will affect the credibility of the institution that issued the certificate [14].

Blockchain is a technology that allows users to store data securely because the data stored on the blockchain will be permanent and cannot be deleted. Data changes in the blockchain are almost impossible unless there are rules embedded in the system that can accept blockchain changes under certain conditions. This method will obviously be suitable when applied to the custodian of ownership of securities such as digital certificates. This research will require considerable resources because computer devices will be used as nodes as well as miners on the blockchain. The research will also use considerable CPU resources because it will carry out proof of work consensus. The storage capacity of computer devices will also be needed to store the blockchain in the form of a database in accordance with the Ethereum format. The required capacity will continue to grow according to the number of blocks [15].

2.2 System Design

In this research, a website will be created equipped with blockchain technology as a class data storage feature and digital certificates owned by users. The website page that will be created is an online class where users can choose which class to take. Users who register for a class must complete a series of materials and tests in that class to be able to get a digital certificate [16]. To be able to take a class, users must first have an Ethereum account or wallet. The flow chart of the system can be seen in Figure 1.

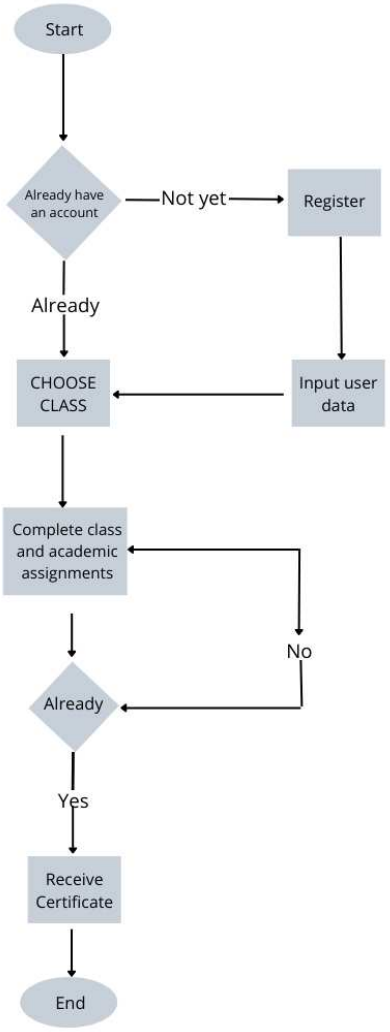

Figure 1. System Flowchart

Figure 1 discusses what users need to have an Ethereum wallet because the certificate will be recorded in the smart contract based on the user's public key and also as the user's payment medium. As class participants, the public key will be used as the address of the certificate owner, while the private key will be used for digital signature creation for the process of signing the certificate issuance transaction, which will be managed by Metamask. When the user has completed the class, then the user can receive and issue certificates on the blockchain [17].

In this study, nodes and miners can be combined so that each node can be a miner as well. This research will also use a peer-to-peer network using the help of Geth as a peer-to-peer blockchain network application so that nodes and minerals are connected to each other while in one network. Miners and nodes in this study will serve as blockchain stores and verify the new blockchain that will be added. Miners in this system will use the proof of work consensus method in which the miners guess and look for the hash value according to the

level of difficulty requested. After the consensus has been completed, any node or miner who successfully completed it first has the right to add a new block to the blockchain. The updated node will broadcast the latest blockchain to all existing nodes so that all data on the node will be synchronized and updated. Miners who succeed in consensus and add blocks will get prizes in the form of transaction fees and mining prizes in the form of cryptocurrency [18].

The stored digital certificate will be in the form of a certificate object which will later be saved into a smart contract written in Solidity. The certificate class will have several attributes that will indicate the certificate owner and the certificate issue date. The certificate will be saved in a folder with the index as the value for certificate identification. The certificate storage process will be written in the Solidity function, which can later be used via JavaScript in the application [19].Miners and nodes in this study will be designed using Geth so that there is no need to write code starting from zero to create nodes or miners. Geth will also set up a peer-to-peer network that holds blockchain data and users only need to set what network Geth will work on as well as manage the genesis block. In this study, the blockchain system designed will use the data storage pattern on Geth and the user only needs to specify the blockchain data storage folder. Connected nodes will synchronize automatically to retrieve the most recent blockchain data. There is an initial process to create your own blockchain, which is to create a genesis block. This genesis block is used as a reference between nodes whether they hold the same data [20].

2.3 Interface Creation

The interface will be created using Bootstrap 4. The website that will be made is a website that provides several academic classes taken from Cloud Firestore and can be selected by the user. Website pages that can be accessed by participants or students will have several basic pages such as the home page, class list page, student certificate, certificate check and learning page.

2.4 System Test

The blockchain system that will be applied to the online class will be tested by considering several factors, namely security, reliability, and scalability. The system will be tested in the face of data forgery attacks, block changes, and new invalid transactions. The system will be tested to maintain the authenticity of the contract so that no new contracts can be issued by unauthorized parties. The system must be able to keep the data safe and original. The system will be tested to handle quite large transactions at almost the same time. The test will see how quickly the system responds to large amounts of data flow so that it can be seen how much power the system has. The test will also see how much the system can accommodate data and still maintain system stability. Other important components, namely nodes and miners, will also be tested A.

3. Findings

3.1 System Design Results

The online class application with blockchain technology will consist of two types of systems that regulate the website, namely a server for online class display and content and a blockchain system used as a storage medium for user data. The blockchain system that will be used in this research is designed using Ethereum's program, Geth. Geth will create a blockchain network based on nodes in the blockchain network that has been created. The user needs to write down some parameters so that Geth understands which blockchain network the nodes will connect to. When all commands and parameters have been written, Geth will execute the command to start a node [21].

Nodes that are already running can do mining to add new blocks to the blockchain. Connect one node to another; it can be done through the Geth console or by creating a static-nodes. Son file. After the nodes have successfully connected to each other and are ready to mine, the next step is to connect Metamask with the blockchain network that has been created. When a network is added, Metamask will automatically try to connect to the

blockchain network. The blockchain network and the user's web browser will be connected by Metamask [22].

In this study, smart contracts will be used as a medium for storing user data on the blockchain. User data such as classes that have been purchased and also certificates belonging to users will be stored into attributes in the smart contract so that several attributes and functions will be needed to access the stored data. After all the functions and attributes are written on the smart contract, the next step is to deploy the smart contract on the blockchain network using Truffle. Please note that in order to deploy a smart contract, a certain amount of Ether is required to pay the transaction fee [23].

The blockchain system that has been created can be used in web applications using JavaScript. Firebase Firestore will be implemented and used to store non-critical data. The application will run on a server built with Node.js' lite-server module. The application will run on localhost in order to connect with Metamask. The metal mask on the web browser will connect the application to the blockchain network.

3.2 Interface Design Results

Making the interface is done with a combination of CSS and Bootstrap. The black and white themed interface also has a clean and simple look. Every major part of the application is available through the navigation on the top of the page so that it is easy to access. At the far right of the navigation bar, a description of the currently active user will be displayed. When a user accesses the website, the main page will be loaded by default. The main page will display a carousel that displays class images available in the application. The image below the carousel and so on will show the advantages of the application, such as blockchain-based storage, as well as the introduction of the application to the user.

On the class view page, all classes available in the application will be displayed. The classes showed fetch data from the Firebase Firestore. Each class item will display the class name and class duration. Users can press the "view" button if interested in the class to be directed to the class module page [24].

If the user has not purchased a class, only the first three modules can be seen by the user as a sample. Users can continue learning by purchasing the class. When a user tries to access a locked module, a modal dialogue will appear to make a class purchase. The user can press the buy button and continue the transaction with the help of Metamask to add a class to the user account.

The certificate issuance page will display an example of a certificate and what class the user has worked on. Users can issue their certificate by pressing the issue certificate button at the bottom of the page. All user certificates can be accessed on my certificates page. The certificate displayed will contain data such as the class name and certificate number to check the authenticity of the certificate and also the date the certificate was issued. Users can show their certificates to others through the certificate check feature.

On the certificate check page, the user can enter the certificate number to check the authenticity of the certificate. If the certificate is registered on the blockchain and the number entered is correct, then the certificate will be displayed. If the certificate number entered is invalid and there is no certificate with that number on the blockchain, it will display the info that the certificate is invalid [25].

Users who have not registered with the application to have their name and email address recorded on Cloud Firestore will be given a dialogue to register. A dialogue will appear when the user opens a page in the application.

The security of the system will be tested based on how secure the data stored on the blockchain network is and also how secure the network is against the threat of data falsification. A blockchain system with good security will maintain the integrity of the smart contract so that it cannot be changed by irresponsible parties. In the first test, a certificate will be issued without buying a class. This test can be done using the unit testing method written in the Javascript programming language. In the unit testing code, a call to the certificate issuance function will be simulated in the smart contract. The function will be given a class code

parameter that does not yet have the account that is used as a test account. When a certificate is issued without buying a class, an error will appear, and the transaction will be rejected because it does not meet the conditions written in the smart contract [25].

Deployment of new smart contracts by unauthorized parties needs to be tested to ensure user security. Testing will be carried out by trying to deploy new smart contracts through accounts of parties that do not have previous smart contracts. Based on the test results by deploying new smart contracts through other devices, it was found that the new smart contracts were successfully deployed but did not replace the existing smart contracts. The test results show that the integrity of the smart contract is good because it cannot be changed by irresponsible parties [26].

Testing the reliability of the blockchain system in this study will be carried out by making 200 transactions that occur on the system at the same time. The number of transactions made to test the reliability of the system is not too much because the test is done manually, so you have to make transactions one by one. The main factors that will be considered in testing the reliability of the system are time and system stability [27].

Based on the results of testing the reliability of the system, it can be obtained that the system is good enough in handling transactions in large enough quantities. System scalability testing is carried out by measuring how much storage capacity is needed by users, especially nodes and miners, to be able to play a role in the blockchain system. When there are no transactions to be validated by the miner, the miner will still mine but add an empty block. An empty block is a block that does not store transactions at all. An empty block is 539 bytes in size, while a block that holds ten transactions will be 2265 bytes.

If an average of each block stores ten transactions, it can be calculated to estimate how much storage capacity is needed to become a node on the blockchain network of this research. If you multiply it by how many blocks you will add, you will know how much storage capacity is required. Estimates are made by assuming that the miner will add blocks only when there are transactions so that there are no empty blocks. Miner performance optimization can be done by creating Javascript code that will be executed by miners. If using the usual method, the estimated storage required will be very difficult to obtain because there are too many changes in the capacity of each block [28].

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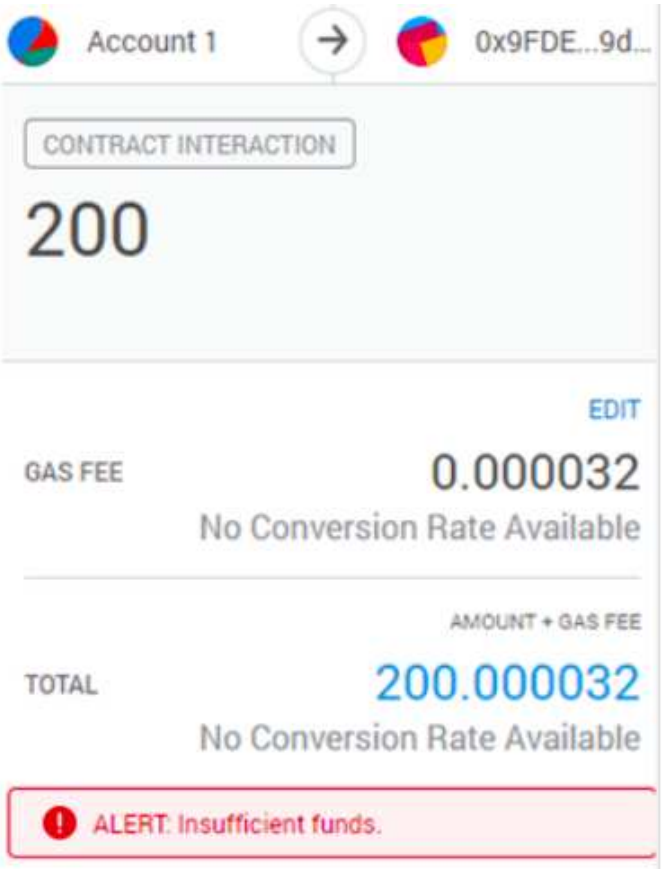

Figure 2. The estimated storage capacity required node

Figure 2 of this paper discusses about the number of blocks below 1 million, a relatively small storage capacity is required. When it hits one million blocks, it will require a storage capacity of 2.2 Gigabytes which is still relatively small for today's technology. If it reaches 10 million blocks, it will require a storage capacity of 22.6 Gigabytes to become a node or miner on this blockchain network. Based on research and testing, the scalability level of the blockchain network created using Ethereum's Geth is still very good. The stability and performance of the system have also been tested, considering that the Ethereum network has been implemented in the real world [29].

4. Conclusion

The results of research and system testing carried out on the blockchain system for online learning classes have the conclusion that a blockchain network can be created using Ethereum's program, namely Geth, and data storage using smart contracts issued on the blockchain network.

The local blockchain network created in this study is able to carry out the functions required for a publishing platform on an online learning system. The use of Geth on the blockchain network created has a fairly good level of security, reliability, and scalability [30].

This research can still be developed and researched further. One of the novelties in this research is to explore various applications of blockchain technology for various fields. For example, to increase reliability by using a boot node hosted on a web service. System testing can also be improved by performing automated tests so that more transactions and data are tested.

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