Registration of Land and Building Certificate Ownership using Blockchain Technology

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***Abstract*—Currently, the certificate ownership system in Indonesia is still done manually. The system has weaknesses and loopholes that can be exploited by irresponsible parties. Some examples of problems that may arise are the loss of physical certificates. To overcome this, a land and building certificate ownership recording system is built using blockchain technology. The development of this system aims to reduce the problems that arose in the manual system. The use of blockchain technology is intended to maintain data integrity. The system utilizes one of the main properties of blockchain technology, the anti-tamper properties that maintain data integrity from parties who try to tamper with stored data. The system is decentralized by involving several peers who run the blockchain network. The technology used to build the blockchain network is Hyperledger Fabric. This is a permissioned blockchain, using a consensus method that does not require large computing resources. The developed system facilitates basic processes in the form of certificate ownership transfer transactions through the functional requirements. The system also improves data transparency by providing various information retrieval features. The developed system is tested with various tests to ensure that the functional and non-functional requirements are met. The system built can be used as a system for recording ownership of land and building certificates, as it is able to record ownership of certificates without problems and facilitates checking and the failsafe methods and can reduce problems in the previous system, for example loss of certificates.**

***Index Terms*—system, blockchain, certificate, technology, data**

I. Introduction

Property, both in the form of land and buildings, is one type of asset that has good prospects in terms of increasing the value of its assets over time. One characteristic of property assets is that under normal circumstances, the value of these assets will continue to rise. This makes property one of the attractive assets that are often used to make investments. In addition, humans have the need for housing as one of the primary needs in human life. This means that everyone has a need for a place to live in the form of property, both land and buildings. This shows that property is one of the most important things in human life.

Due to the importance of property, a system is needed to regulate ownership of property assets. In Indonesia, ownership of a land or building is determined by using a certificate of ownership of the land or building. Under Indonesian law, there are various types of ownership of both land and buildings that can be obtained by a person or a company, each of which has a different certificate. As for determining the ownership, the party holding the certificate of ownership physically is determined as the owner of the land or building.

Ownership of a land or building is determined with a certificate of ownership, and the party holding the certificate is the party who has the right of ownership. Thus, there is a process to transfer ownership rights from one party to another. In Indonesia, the process of transferring ownership is currently still involving manual methods. Based on the Standard Operating Procedures for Regulation and Service of the Central National Land Agency [1], the two parties must go through a bureaucratic process with the Land Deed Making Officer (PPAT) and the National Land Agency (BPN). Currently, all these processes are still done manually starting from creating the deed of sale by the PPAT, then submitting the transfer of ownership to the BPN, and other bureaucratic processes at the BPN, until the submission of the transfer of ownership has been processed and ownership has been transferred to the new party.

To overcome the problems, a digital system for registration of land or building certificate ownership will be created using blockchain technology to ensure the integrity of the ownership registration system. The system that will be created focuses on recording ownership of a land or building certificate, only the ownership of the certificate and information related to the certificate will be recorded. This system will not facilitate the process of making a new certificate. The system can be used as a reference to determine the owner of a land or building certificate. One of the main characteristics of blockchain is the immutability of records stored in a blockchain. This is considered important in a system for recording ownership of certificates on land or buildings to avoid errors from both the owner and the bureaucratic system. The system that will be created will also increase the aspect of transparency, as the process of checking and searching for information related to land and building ownership becomes easier. By using this new system, it is hoped that problems that arise can be reduced.

II. Land and Building Ownership System in Indonesia

In Indonesia, the land and building ownership system is regulated by law. There are several types of ownership with various types of rights according to the type of ownership. Based on Article 16 of Constitution Number 5 of 1960 regarding Basic Regulations on Agrarian Principles [1] [2], the types of ownership are as follows.

- Right of Ownership
  This type of right is the strongest ownership right to land. The party who has this ownership right has full rights to the land, including the buildings on the land. This type of ownership is indicated by a Certificate of Ownership (SHM).
- Cultivation Rights
  This type of right is a special right granted by the government to use land for the purpose of carrying out business activities that include agriculture, animal husbandry and fisheries. This right has a maximum term of 25 years, and for companies that require more time, a maximum of 35 years can be obtained. This right can be extended by applying for an extension to the government.
- Building Rights
  This right gives permission for the owner of the right to build a building on land that is not his own. This right has a maximum period of 30 years and can be extended. This right can be granted by the state on state-owned land and by land owners with property rights in accordance with the agreement. This right can be upgraded to right of ownership by going through the procedures in accordance with the conditions.
- Right of Use
  This right is the right to use and take land from state-owned land or land belonging to other people. This right cannot be transferred to another party except with the permission of the land owner.
- Rental Rights
  This right is a right that is given when someone leases land or buildings on the land by making payments before use or at a certain time in accordance with a predetermined rental agreement.
- Right to Clear Land and Forest Products
  This right can only be owned by Indonesian citizens and is regulated by government regulations. Acquisition of this right does not necessarily give the right of ownership over the land.

III. Blockchain

Blockchain is a distributed ledger or recording technology using a peer-to-peer architecture. A distributed system is a system consisting of more than one node independent from each other, in which each of the nodes is running the system. From an outside perspective, the system is seen as a single system [3]. A distributed system has three main features, which are consistency, availability, and partition tolerance. The

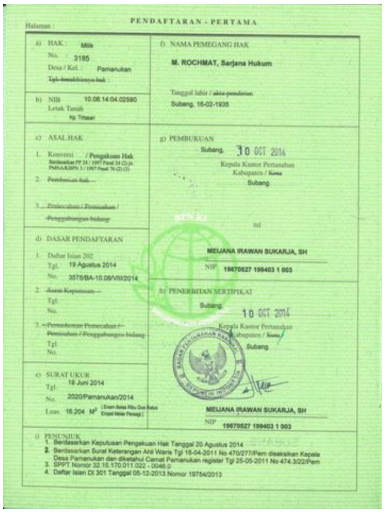

Fig. 1. Example of a certificate of ownership issued by the Indonesian land office

CAP theorem dictates that at most only two out of the three features may be fulfilled by a distributed system [4].

On the blockchain, recording can only be done by adding a record, there is no record deletion. Records on a blockchain can only be added by a consensus on the blockchain network. With this mechanism, blockchain is considered very difficult to change [5]. By using a blockchain, the recording of a transaction record can be carried out without a central entity determining the validity of the transaction, and there is no central entity that stores all records as a single source of truth. This is in accordance with the characteristics of blockchains, which is distributed and runs on a peer-to-peer network.

Blockchain can be seen as a linked list. A block has a pointer to another block in the form of a hash. On a blockchain, the connectivity between blocks is seen from the hash that the pointer to the related block points to. To simplify the description, it can be seen in Figure 2.

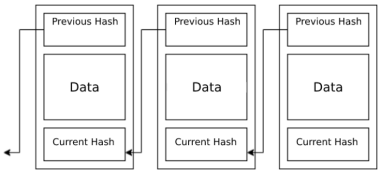

Fig. 2. Illustration of the connection between blocks on a blockchain

With this pointer, the contents of a block that is already in a blockchain cannot be changed by one of the peers, as a change will affect the hash of the block, disconnecting the blockchain. If one of the peers on the blockchain network tries to change the contents of a block, the changes will not be accepted by other peers because of the inconsistencies in the blockchain. The blockchain is distributed, each peer on the blockchain network will know the entire record and be able to check for changes by the peer trying to modify it, and can easily reject the change.

When viewed in more detail, in general a block on a blockchain network has several parts, namely the header and body [6]. In the header, various data related to the identity that defines the block are stored. While in the body of a block two things are stored, namely the number of transactions in the block and the transactions that are done in the block. In general, the structure of blocks on a blockchain can be seen in Figure 3.

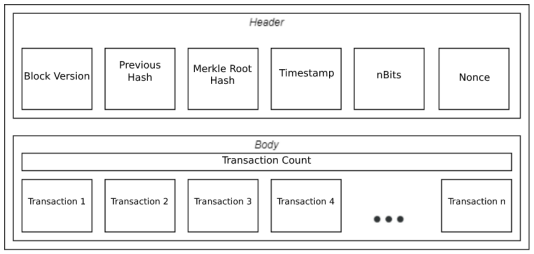

Fig. 3. The general structure of a block

To determine the new valid and correct block that will be appended to the blockchain, an approval method is needed. This approval method is referred to as consensus. In general, the consensus method used on a blockchain network can be divided into two, namely proof-based and byzantine fault tolerance-based [5]. There are various consensus methods that are already used on blockchain networks today.

- Proof of Work
- Proof of Stake
- Proof of Elapsed Time
- Proof of Importance
- Proof of Authority/Identity
- Federated Byzantine Consensus
- Round Robin

As stated before, there are various consensus methods available for blockchain networks. One such example is the proof of work method, which is used by Bitcoin. In this consensus method, peers are required to complete a puzzle to create a block. The puzzle is designed in such a way that it is difficult to solve, but easy to check the correctness [7]. The puzzle itself is based on cryptography. Cryptography is a technique for securing information by using mathematical functions against attacks that attempt to obtain and understand that information [8]. By using cryptography, the confidentiality of information can be maintained even when there are outside parties who have access to the information [9].

One of the technologies that can be used to implement a blockchain system is Hyperledger Fabric. Hyperledger Fabric is a distributed ledger technology platform. This platform is an open source project from the Linux Foundation, which implements a permissioned blockchain system. Hyperledger Fabric is also the first blockchain technology to facilitate the creation of smart contracts that can be written in common programming languages such as Go, Java, and Javascript.

IV. Registration of Land and Building Certificate Ownership Using Blockchain Technology System Implementation

The system developed will be divided into three main components that will interact with each other, namely the blockchain network, frontend, and backend. The connection between the user and the system to be developed is illustrated by the following diagram.

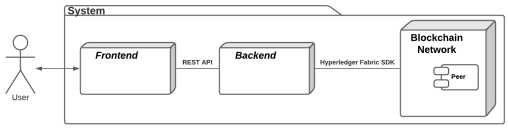

Fig. 4. General design of the system

Users, both regular and authorized users, interact with the system using web-based frontend components. These components can be accessed on a web browser. The frontend will then interact with the backend component by using the HTTP REST API in the form of a request which will be returned with a response from the backend. If the operations performed by users require data stored on the blockchain network, the backend components will interact with the blockchain network using the Hyperledger Fabric SDK which provides various features to interact with the Hyperledger Fabric-based blockchain network.

The blockchain network in this system is a collection of nodes that are on the same network. This network can be run by the government, such as BPN, together with external parties who have been given permission and are willing to provide the infrastructure to run the network.

A. Blockchain Network

Hyperledger Fabric is a platform for blockchain networks that already supports asset management. Thus, assets stored on this network are not only in the form of tokens or cryptocurrency, it can also be in the form of other assets that can be defined in advance when building the blockchain network. This is different from some other technologies that still only support asset management in the form of tokens or cryptocurrencies.

Hyperledger Fabric already supports chaincode, which is code that will be executed or can be executed on an asset when a transaction is defined previously in the smart contract. Chaincode can be seen as business logic related to previously defined assets. With this, the business logic related to assets can be defined directly on the blockchain network and does not need to be defined in the backend component. The operations that can be performed on the Hyperledger Fabric blockchain network are determined by the chaincode that has been approved by the members of the blockchain network.

Hyperledger Fabric is also permissioned. The consensus method used in this technology does not require a large amount of computing power. That way, the blockchain network does

not require nodes that have high computing power, thus the costs used to run the network are also not large. This is different from some other permissionless technologies that use heavy consensus methods and require large computing power.

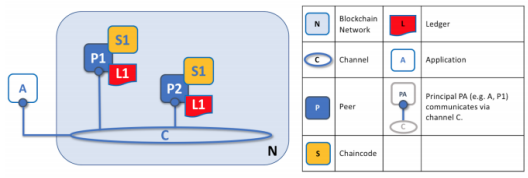

Fig. 5. Blockchain network

On the blockchain network, there are peers that are run by various organizations or parties who have been given permission to participate in running the blockchain network. Each of these organizations will have access to the operations provided by the chaincode, so each organization can provide its own application to provide access to the blockchain network. For example, organization A can create its own application that interacts with the blockchain network using chaincode. However, organization A will not be able to tamper with the data stored on the blockchain due to the anti-tamper nature of the blockchain itself.

There are several models that are stored as assets on the developed blockchain network. The models are as follows:

TABLE I
CLASSIFICATION OF SENTIMENT CLASS

Model Name	Attributes
User	+ nik: string + name: string + isAuthorized: boolean + hashedPassword: string + lastUpdateBy: string
Certificate	+ ownerNik: string + certificateNumber: string + address: string + city: string + province: string + postalCode: string + length: number + width: number + measurementTime: number + issuanceTime: number + isInTransaction: boolean + buildingLength: number + buildingWidth: number
Transaction	+ transactionNumber: string + certificateNumber: string + originNik: string + destinationNik: string + hashedTransactionPassword: string + status: TransactionStatus + creationTime: number + receivalTime: number
Log	+ id: string + nik: string + msg: string + creationTime: number

- Init Ledger
- Operations related to User (Information retrieval, credential checks, etc.)
- Operations related to Certificates (Information retrieval)
- Operations related to Transactions (Information retrieval, transaction creation, acceptance, and cancellation)
- Operations related to Logs (Information retrieval)
- Operations related to authorized operations (User creation, password change, authorization change)

B. Backend

The next component of the system to be developed is the backend component. As previously mentioned, this component will act as an intermediary between the frontend and the blockchain network. This component will also handle other things that are required by the frontend with the REST API through requests and responses. The technology chosen for the development of this system is Typescript with Node.js.

This backend component must be able to interact with the network blockchain. To do these interactions, Hyperledger Fabric provides the Hyperledger Fabric SDK. However, the SDK is currently only available for Java and Node.js.

The backend component provides various REST APIs which can then be used by frontend components and other applications. For each operation provided by chaincode, a REST API endpoint is provided that can be used to perform the operation, with a few exceptions for operations that this backend component does not need to expose.

Apart from acting as an intermediary to perform operations on the blockchain network, the backend component makes adjustments to the endpoint provided to make it more tidy and friendly to components that will consume the REST API provided by this backend component.

For example, the blockchain network does not yet support user session management, the operations in the chaincode always require validation credentials every time an operation that requires authentication is executed. In this implemented system, the backend component wraps user authentication of the blockchain network and provides session management. This is done using JWT technology to generate session tokens. That way, the use of the REST API on other components will be more seamless without the need to provide credentials for each request.

C. Frontend

The frontend component will act as an interface used by the user to interact with the developed system. This component will interact with the backend component by using the REST API. This component will serve a dashboard that can be accessed on a web browser. Through the dashboard, users can do things that are supported by the system. In the development of this system, the technology used is React.

In the frontend component, there are several pages that accessible, such as:

- Login Page

On this page, users can login to the application by entering credentials in the form of NIK (National Identification Number) and user passwords that have been previously determined by authorized users.

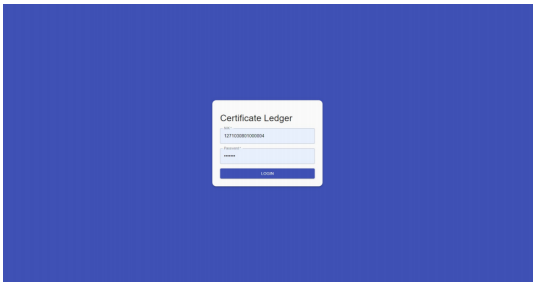

Fig. 6. Login page

- Home Page
  On this page, the user can see a list of certificates owned by the user. Users can perform operations on owned certificates, such as transfer of ownership, as long as the certificate is not involved in another transaction. In addition, users can use the search feature available on the top bar of the application to search for certificates based on certificate numbers or search users based on NIK. Users can also navigate to other pages through the menu provided.

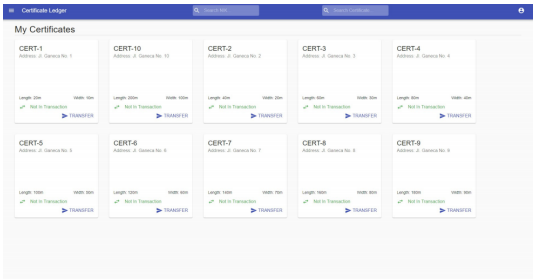

Fig. 7. Home page

- Transactions Page
  On this page, users can see a list of transactions involving the user, both as origin and destination of transactions. Users can also perform operations on these transactions, such as accepting or canceling transactions.

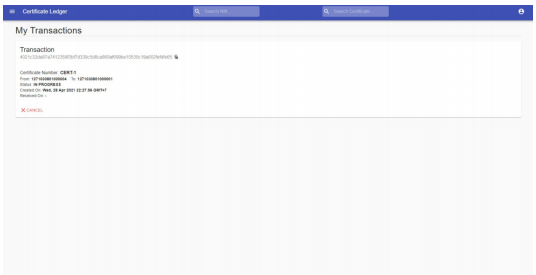

Fig. 8. Transactions page

- Admin Page
  This page is only available to authorized users. On this page, users can perform operations that require authorization, such as adding a new user or searching for a transaction by transaction number.

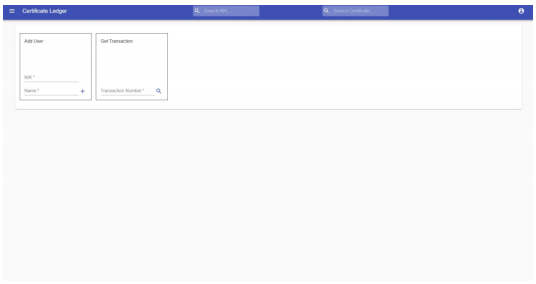

Fig. 9. Admin page

- User Information Page
  This page displays information related to a user, for example NIK and the name of the user. As for authorized users, there are additional operations that can be performed, such as setting a password or authorization for that user, and viewing the list of certificates owned or transactions related to the user.

Fig. 10. User information page

- Certificate Information Page
  This page displays information related to a certificate, such as certificate number, address, area, and status of the certificate (e.g. currently in transaction).

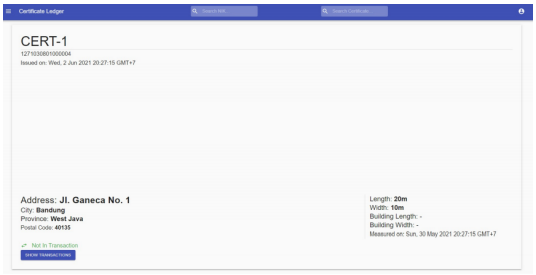

Fig. 11. Certificate information page

V. System Testing

The system was tested in two types of tests, testing the system functionality and testing the integrity and transparency aspects of the data provided by the system.

A. Functional Test

The test was done on the functional requirements of the system. The purpose of this test is to ensure that the implemented system meets the determined functional requirements of the system. With the fulfillment of these requirements, the implemented system will fulfill the business processes of the previous manual system. Based on the functional test done in accordance with the functional requirements of the system, the results obtained are that the implemented system has met these functional requirements and is running well. Each point of the functional requirements has been tested against the expectations of those requirements.

B. Non-Functional Test

The purpose of this test is to ensure that the implemented system has met the non-functional requirements of the system related to data integrity and transparency. The data integrity test was done by trying to add data through an operation without involving other peers on the blockchain network. The transparency test was done by ensuring the functionalities regarding transparency are fulfilled. Another test was done regarding the security of the blockchain network, by trying to add a peer to the network without approval of the other peers.

Data integrity testing was done and based on the test case, it is found that the system refused the operation because it did not meet the endorsement policy. This shows that the integrity of the data on the blockchain network can be maintained.

Data transparency testing was carried out by checking the system functionalities that allow users to view information related to users and certificates. This is done by performing a search on the system which will then display the related results.

Network security testing was also carried out and it was found that the additions made failed. This shows that even though there are parties who may have access to the network used, they still cannot add peers independently.

VI. Related Works

In 2016, Sweden announced that the government was collaborating with one of the blockchain companies in Sweden, ChromaWay, in developing a land registration system using blockchain technology [10]. The Swedish government stated that it had passed the first pilot phase of integrating the system with Swedish banks.

According to a report published by ChromaWay, the land registration system that uses blockchain technology is working well. The system succeeded in making the land registration system digital [11]. During the trial, all relevant parties had digital land certificates. The entire process of checking, transactions, and others runs digitally without any problems. The process is recorded on the blockchain as a whole. All data related to land registration which is designated as public data by the Swedish constitution has been successfully made transparent and accessible to the public, and confidential data has been successfully maintained and cannot be accessed by the public. The Swedish government agency that regulates land and cadastral records, Lantmateriet, runs the blockchain network. However, outsiders can also help run the blockchain network.

Another example of similar work is the Mauritius government implementation of a digital system for land ownership called e-registry [12].

VII. Conclusion

The system that was implemented using blockchain technology can be used as a system for recording ownership of land and building certificates and are more robust against errors, because the system developed is able to record ownership of certificates without problems based on functional testing of the system and facilitates checking on each operations performed and capable of performing failsafe methods for several operations such as transactions, as well as non-functional tests related to data integrity and transparency.

The design of the land and building certificate ownership registration system using blockchain technology is generally divided into three main components, namely the frontend as the interface used by the user, the backend as the frontend intermediary to perform operations on the blockchain network, and the blockchain network that is run by more than one peer on a network.

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