

Implementation of ethereum blockchain on transaction recording of white sugar supply chain data

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Article Info

Article history:

Received May 19, 2022

Revised Sep 16, 2022

Accepted Sep 30, 2022

Keywords:

Data transaction recording

Ethereum blockchain

SDLC Waterfall

Supply chain

White sugar

ABSTRACT

The complex supply chain system for the sugar agroindustry supply chain involves many actors, resulting in the asymmetry of information data. It still leads to a lack of data transparency. In the past, data traceability could not be made efficient at every stage, so the record data transaction was not real-time, less accurate, and inefficient coordination between actors. Blockchain is one of the technologies in the 4.0 era as a distributed ledger technology. It can be transparency, traceability, security, immutability, and decentralization. This study aims to design a white sugar agroindustry system based on blockchain technology using the SDLC waterfall stage public. Ethereum is a proof-of-work convention based on the Ropsten test-net on the Metamask wallet. The sugar supply chain system that has been successfully developed allows consumers to track the purchased sugar products based on the transaction hash code sent by the seller. The data listed is the location of the plantation, the quantity (quintal) and quality of sugarcane (percentage), and the purchase price. A web-based blockchain application could be used as a model by national sugar factories to help them make enough sugar food for themselves.

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1. INTRODUCTION

Sugarcane (*Saccharum officinarum*) is the main sugar-producing crop [1]. The sugar agroindustry is one of the industries with extraordinary opportunities and prospects in Indonesia's economic development. To meet the sugar needs of people, sugar factories sometimes use imported raw sugar as raw materials other than sugar cane from farmers. According to the Central Statistics Agency, sugar companies are sourced from sugar companies to meet the community's needs, as much as 7,200 tons. The government imports 4,650 thousand tons because domestic production is only 2,050 thousand tons with a supply of approximately 915 thousand tons. Sugar has an essential role in the Indonesian economy as one of the staple food products regulated by the government based on Presidential Regulation 71 of 2,015 jo. 59 the year 2020. The Ministry of Industry stated that the sugarcane-based industry is a priority and economic driver involving many supply chain actors [2]. The government is also trying to determine policies regarding availability, quality standards, selling prices, and distribution to the market. The supply chain system is a series of sequential stages transforming products from farmers' commodities to consumer products [3]. The performance of the Indonesian sugar supply chain is considered. They are not yet integrated. It has less than optimal performance. The value of plantation performance is 61.78%, factory performance is 63.05% [4], and the performance of partner farmers is 75.86% [5]. So this is a challenge for the sugar supply chain. As we know, the supply chain system is still centralized, causing a lack of data transparency [6], and it cannot track data at every stage.

Complex supply chains involve many actors, resulting in asymmetry of information circulating among stakeholders, less accurate and less accurate-inefficient coordination. The visibility of the data information needed by the community is not yet available in real-time [7], [8]. Real-time and accurate traceability is essential, providing an integrated supply chain picture [9], [10]. Traceability can facilitate stakeholders to trace food products at every step in the supply chain [11], tracing back to the original producer and passing it on to the buyer. Transparency is an essential feature of traceability. At the traceability stage, the flow of product information is essential in developing the current agro-industrial supply chain [12]. Transparency is important because many consumers are interested in knowing the source or origin of their food. The current traceability stage is inefficient due to long time and dishonest resources, long time and conventional database technology [13].

Therefore, blockchain technology is needed that is more stable, reliable, and secure as a distributed network to store data stored throughout the network to be safe from attacks. The existing approach may face problems related to the reliability of data and information from the user perspective due to human intervention in the documents stored in the system [14]. The supply chain system was complicated to trace where the product came from in the past. The actors do not know the product's condition at the supply chain stage. It allows the occurrence of inaccuracies to the loss of recording transaction data that is not managed and well-documented by the supply chain system [15]. Meanwhile, nowadays, buyers are astute in ensuring the information or value of a product in the supply chain system to ensure data transparency and product traceability from upstream to downstream. The supply chain system is expected to be integrated and coordinated between actors and supply chain stages to improve supply chain efficiency. Supply chain system design enables fast and data-driven answers, resources, and technological innovation to complex and challenging supply chain questions such as the sugar agroindustry. That is why some supply chain managers are looking at the latest technologies, such as blockchain technology which is consistent across the network [16]. Blockchain is known as an encryption ledger technology and distributed computing power to create a continuous, transparent, traceable and cryptographically secure record of transactions [17]. All aspects of transactions are distributed in real-time. The actors involved can complete transactions faster and reduce human error [18].

The system is still essential, so we need blockchain technology, which has advantages [19]-[23]. Previous research on the Ethereum blockchain is [24], [25]. The agricultural product discussed is soybeans; to eliminate centralized authority [15], use Ethereum tokens for distribution to wine supply chain actors. The research uses Ethereum as an open-source platform that empowers users to make software systems available by solidity language smart contracts. With a public mode of operation, each party can participate in transactions recorded on the Ethereum network based on a proof of work (PoW) consensus. The way proof of work works is that every transaction will be announced to all network nodes so that the mining node succeeds in dismantling the code or transaction program. Then the mining node verifies so that it generates a new block [26]. The wallet used is Metamask with test-net Ropsten. Based on the problems above, this study aims to develop the implementation of an Ethereum blockchain-based sugar supply chain system. The current high complexity and lack of transparency in the sugar supply chain have made businesses eager to explore the possibilities of blockchain technology to improve performance efficiency. A digital data record is stored in a Distributed Ledger called a blockchain. This ledger is a database containing transaction details, information and documents called blocks. These blocks have unbreakable trust due to their highly secure nature and offer an attractive solution by combining accessibility with security and privacy [27]. Developed the sugar supply chain was based on real-time data transaction flow on product information along the supply chain. The application can be a pilot project for the national sugar supply chain. All internal and external stakeholders can use it to achieve food self-sufficiency in sugar.

2. METHOD

The proposed method in the study began by investigating the problems that occurred. Problems Lack of coordination and data not integrated between divisions causes decision-makers to be unable to make decisions quickly and accurately. These are caused by recording errors that are not real-time, operator negligence such as forgetting, duplicating, and transferring data incorrectly, and traditional technology, centralized databases. Lack of coordination and unintegrated data between divisions causes decision-makers to be unable to analyze or make decisions quickly and accurately. A long supply chain causes chain actors not to know the problems at each stage because of the non-integration of data transactions. Delays and limitations in this research are data storage that is still centralized, diversity of information sources, and irresponsible data changes so that data accuracy is difficult to obtain. Traditional databases use a client-server network architecture where the user can modify the data.

The solution to the problem in this paper is based on the systems development life cycle (SDLC) method from Rainer *et al.* [28]. They must review each completed step to ensure that the steps have been

carried out correctly and as expected. Uses the SDLC waterfall system development method, emphasizing sequential and systematic phases with a precise series of system flows. All information will be appropriately recorded and suitable for applications involving many actors and complex work procedures. SDLC waterfall emphasizes sequential and systematic phases with a precise series of system flows. All information will be appropriately recorded and suitable for applications involving many actors and complex work procedures.

The general sugar production process [29] consists of an agronomy section, with job descriptions of farmer contract data, plantation and area classification data, plantation area data, sugar cane categories and varieties data and sugar milling period data per day. Implementation of the system was designed based on the current condition of the sugar supply chain. Chain actors consist of farmer partners and sugar factories (production, logistics, sales and sugar consumers).

The following is a description of the actors who play a role in the system to be built based on blockchain technology: i) Admin: Admin acts like an operator in the blockchain who inputs farmer partner data, manages the software system by managing and controlling read and write access to the system by internal actors, and manages permissions if external parties require data retrieval; ii) Farmer partners are farmers grouped by location and ownership of the plantation or land. Farmers produce sugar cane which will be sent to the factory to be processed into sugar. Besides that, farmers also include the quality of sugar cane after it is cut, namely the percentage of Brix and trash; iii) The production department is the stage that represents all transformation activities from commodities to semi-finished and finished products, the transformation from semi-finished products to finished products, and the packaging phase of the transformation of finished products into product packaging packages that can identify through product batches [30]; iv) The logistics or warehousing section is the stage that involves changes in inventory volume (stock in and stock out). At the same time, smart contracts can be activated independently, making a record every time an anomaly is detected; v) The sales department is processing the transfer of sugar ownership from the factory to the buyer with a smart contract that can automate or record any volume data anomalies (e.g., the number of products purchased are more than the number of products available in the warehouse) as well as the date of purchase [31]; vi) The buyer is the first consumer to enjoy the sugar produced by PG. Where bulk sugar purchased in large capacity (quintals) can be packaged for small products and traded to the next market.

3. RESULTS AND DISCUSSION

That is assisted by software and supported by system applications, Ethereum platform with Metamask wallet, Test-Net Ropsten, language solidity, database MySQL with PHP language. The actors involved are farmers, production, logistics, sales and consumers. Brix and trash. The admin also records the date, the amount of milled sugar cane (quintals), processed sugar cane and raw sugar (quintals), milled hours (hours), and the quality of sugar produced (Icumsa, Bjb, and % water content). At the same time, the logistics information displayed is stock in, stock out, the amount of inventory remaining in the warehouse, and the number of sugar products returned to the factory for repackaging. The sales department is in charge of recording the date, order number, buyer's name, type of sugar, amount of sugar (quintals), with the total purchase price (Rupiah).

The actors in the system are divided into external and internal. External actors are not directly involved in the blockchain, which means they do not carry out transactions and record data on the blockchain. These actors are farmers and buyers. Meanwhile, internal actors are part of the PG involved in data entry (admin). Processing (production), storage (logistics), and product sales (sales) with transaction data are quality, quantity, and time. The linkage in providing objective and accurate transaction information so that the distortion of information can reduce information uncertainty and consumer dissatisfaction with white crystal sugar. Figure 1 illustrates the appearance of the prototype that will develop. The system actors who will write transactions to the blockchain are production, logistics, and sales. Meanwhile, the factory admin will write the profile data of partners and farmers into the database. Production is the first actor who will enter data transactions (time, quantity, quality, partner data) by writing a smart contract. They were uploaded with an active Metamask wallet, thus forming a data transaction block validated and verified by miners in a consensus proof of work. Consumers can browse product data received by scanning the QRcode based on the product purchase order number and the hash code generated by the seller when transacting on the application blockchain.

A front-end application is easy to use by simplifying querying traceability data recorded and displayed visually. The first step when using a blockchain application. Program applications can be run using Microsoft Edge. The architecture is built with react js as a backend and an application library (kitchen). The dashboard display serves to monitor and control data transactions in PG. Transactions are sent to all nodes in the supply chain network. Transparency refers to the availability and accessibility of information about the supply chain. Transparency can enable actors to obtain information about processes and materials in the supply chain.

Moreover, it has a positive impact and has been shown to impact the company's business processes. Our blockchain-based traceability is based on product flow, farm location and data logging time. Meanwhile, input traceability contains data requirements entered by each actor in the supply chain system, such as date, quantity, and quality of sugar cane and sugar, production batch number, and buyer order number.

The involvement of consumers in the sugar supply chain is illustrated in Figure 2. Consumers can track the quality, quantity, location and time of recording products so that the national sugar agroindustry becomes competitive. The perception of genuine sugar products with the listed quality of sugar makes buyers and consumers confident to consume sugar. In addition, the preference for sugar products produced from national sugar cane will support the region's economy. You can find out how farmers produce quality sugar cane. Furthermore, the garden's origin or location. The transparency and traceability implemented in this paper aim to restore consumer confidence in farmers and improve the national sugar data system. It is expected to increase the productivity of supply chain actors in the national sugar agroindustry. Miners in the system have accumulated all valid transactions since mining the last block into a new one. At this point, they start the PoW competition phase to see who adds the block to the blockchain and thus gets a prize. Transactions per second on a public blockchain displayed on Etherscan, according to Ren *et al.* [32], 10 tps–18 tps, which is very low and causes delays in real-time data downloads. It is a cost in terms of gas for each operating code associated with a smart contract that occurs on every transaction on the Ethereum platform [33], [34].

In this case, a network of computers, and miners active in the Ethereum blockchain, validate transactions and user status using a known algorithm. Verified transactions may involve contracts, records, or other information after Etherscan asks for success to validate and verify the language code uploaded in the smart contract. Code logging can be written on GitHub web as a cloud service for storing and managing code and documenting and controlling changes. Processes are required to create new blocks, making transactions secure on the blockchain. Define expensive computer calculations to leverage transaction legitimacy and reward miners [35]. The source code is for smart contract data transactions. Code extension on gith hub and viewable with visual studio on Ethereum blockchain platform network environment. Extensions aim to create smart contract projects and develop business logic with the solidity programming language. It contains data, get data, and the data types used. In addition to the Git Hub, the source code for smart contracts can be seen using visual studio code in the blockchain_project_pabrik folder and then at the command prompt location with the command to call \$ code. While to check the deployment of the smart contract that we have built is with a file that says dot sol (.sol). What is a glimpse of the admin dashboard smart contract display programmed with the solidity language in visual studio code? Solidity is a JavaScript and Java object-oriented combination programming language for writing rules, constraints, and business logic into smart contracts [27].

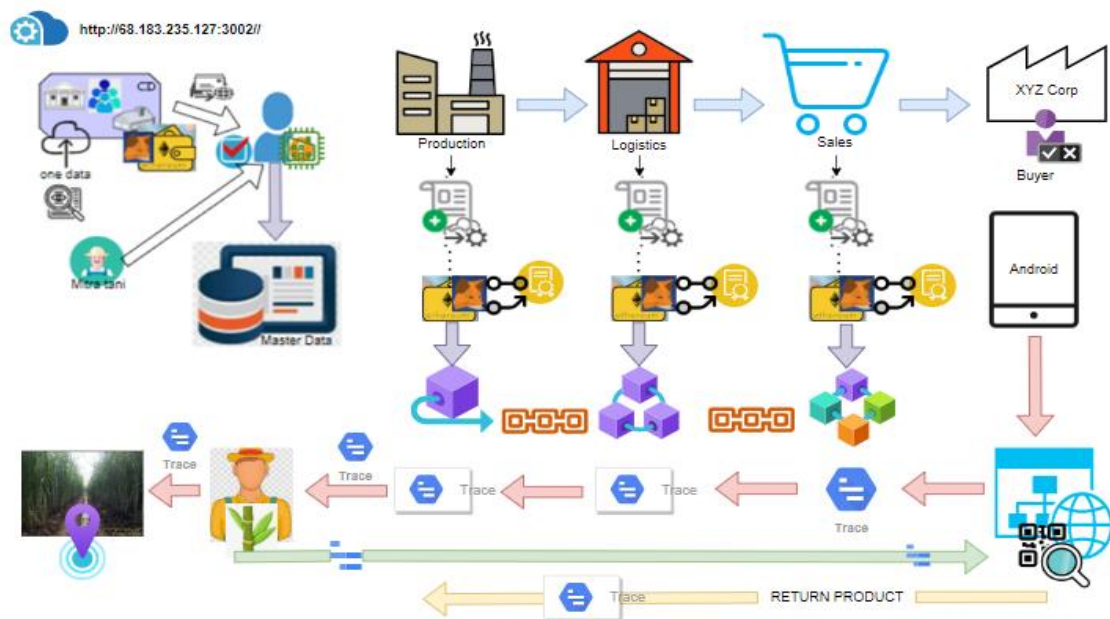


Figure 1. Design of a blockchain-based supply chain system prototype

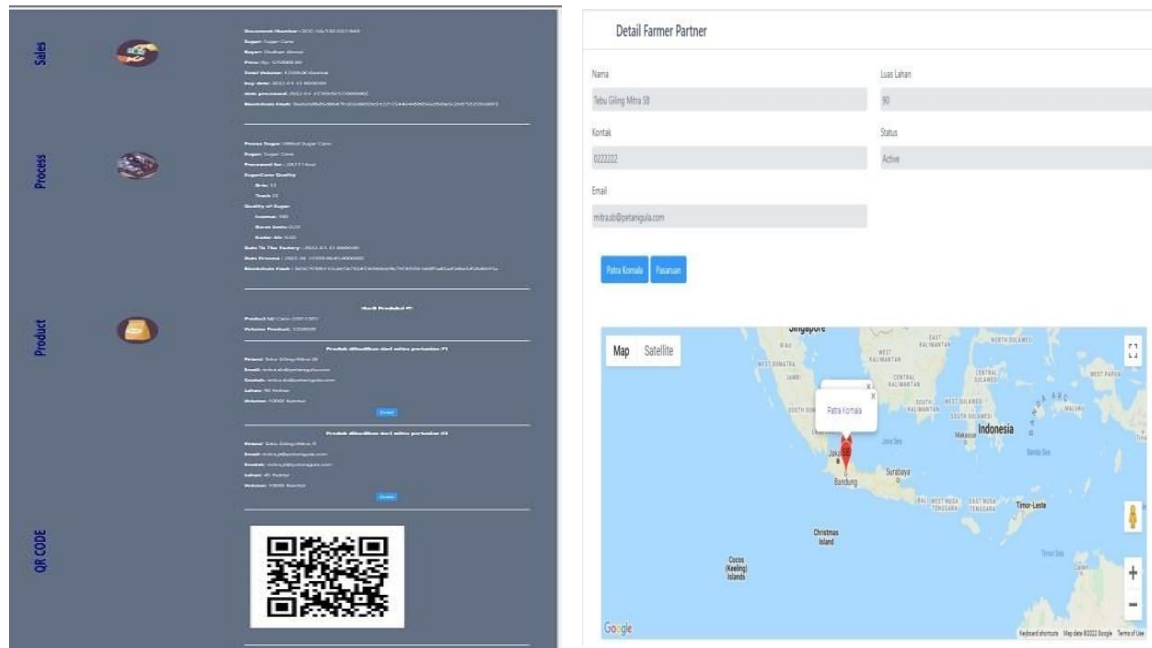


Figure 2. View of buyer traceability to the location of the gardens

Web-based applications have advantages over traditional desktop applications because they are easy to use. Users can create their conclusion report or view with a single-designed blockchain application. It is crucial to ensure the implementation of smart contracts is free from bugs and vulnerabilities and safe from attacks. Testing aims to determine whether the software follows the expected design and debugs or errors when the application is used. Transactions on the blockchain must be validated by network participants called miners. Transactions are considered valid when they reflect transactions on the public ledger. Blackbox testing is a test that can be done by observing. The tests carried out entirely only use software requirements and specifications. Testing only reviews the inputs and outputs of the software system without the need for knowledge of internal programs.

We are testing the results of the blocks formed using a black-box test. Testing expects the system to run correctly and successfully processed by the blockchain. The output results can be viewed on Etherscan as a web explorer. Etherscan can display transaction hashes, blocks, wallet addresses, smart contracts, and transaction gas data on the Ethereum platform. Etherscan can also see the transaction fees when users perform integrated functions with the Ethereum Blockchain. So that it can find out how much gas used affects the length of time for transaction execution. So in Table 1, there are results from the test scheme based on their respective functions. Two parameters are used in this test, such as the length of transaction execution time, calculated from the beginning of the function call until it is finished executing. The last is the amount of gas used and obtained from the transactions that have been successfully confirmed.

Table 1. Blackbox test

Block	Contract hash	Transactionfee (Eth)	Time (second)	Sized (bytes)	Status
12101421	0x1e4357f78f0a8c364596465a61374e78c18f2c0a	0.017032145	38	27,289	Success
12101428	0x894a67a5e142a2b0c7f5bf381343499968b3b3dd	0.015164101	16	37,992	Success
12101428	0x18051f91f99c3340043c10102e0c2bc399eb2803	0.008896272	16	37,992	Success
12101530	0x5b9846cd0a4beda9baefc3772705954511dd5a84	0.013652899	7	23,833	Success
12101561	0x29fa3dcacfeac752f000bf9481c04e72eee72ef0	0.006036331	20	2,736	Success
12109775	0x1e4357f78f0a8c364596465a61374e78c18f2c0a	0.002026878	1	19,594	Success
12109777	0x894a67a5e142a2b0c7f5bf381343499968b3b3dd	0.001917923	69	28,286	Success
12109782	0x18051f91f99c3340043c10102e0c2bc399eb2803	0.001161388	13	15,312	Success
12109799	0x5b9846cd0a4beda9baefc3772705954511dd5a84	0.000971703	68	26,066	Success
12109798	0x29fa3dcacfeac752f000bf9481c04e72eee72ef0	0.00175516	2	20,973	Success
12113535	0x1e4357f78f0a8c364596465a61374e78c18f2c0a	0.039890589	7	14,149	Success
12113545	0x894a67a5e142a2b0c7f5bf381343499968b3b3dd	0.024665275	9	3,018	Success
12113545	0x18051f91f99c3340043c10102e0c2bc399eb2803	0.025012273	9	3,018	Success
12113593	0x5b9846cd0a4beda9baefc3772705954511dd5a84	0.048616913	1	42,420	Success
12113587	0x29fa3dcacfeac752f000bf9481c04e72eee72ef0	0.048860153	54	34,942	Success

Blockchain technology, a distributed ledger, will track and collect all verification and validation data logging records [38]. Data integrity and consistency from the perspective of stakeholders and supply chain members is more than transparent, traceability, can and any party has accessibility. Metamask, as an active wallet on the web admin, has control over the approval of stakeholders concerning sugar industry data. The adoption of blockchain technology implemented in this research is data recording from upstream to downstream, expected to reflect factory performance more efficiently and effectively. Recording data on the quality and quantity of sugar cane and sugar saves time to minimize operator errors and saves energy and other resources so that the published data is accurate. Decision-makers can quickly determine the policies to be taken so that the national sugar agroindustry can contribute back to the country's exports. It can achieve self-sufficiency and food security.

4. CONCLUSION

Our proposed system provides an objective mechanism for collecting and storing data. A secure environment to effectively (data transaction speed, security, and transparency of transparency), track the authenticity of sugar products and increase trust (accountability, immutability of peer-to-peer transactions). They decentralized frameworks and solutions for controlling and monitoring distributed and data transactions. The design of the white sugar supply chain system was successfully implemented using a decentralized application. Blockchain technology has made the sugar supply chain system run more efficiently, faster, safely, firmly, reliably and transparently. Data transactions that can be carried out using the Ropsten test-net are 12 transactions/second, following miners' formation of new blocks mined. So that consumers can track the sugar products purchased based on the transaction hash code, with the data listed being the amount, quality, and date of the transaction data recording. The production part is of good quality sugar cane, namely the percentage of Brix and trash. In contrast, the quality of sugar is sugar colour (Icumsa), grain specific gravity (Bjb), water content (%). Consumers can find out the location of the farmer's area who sends sugar cane to the processing party at PG. The cryptography that underlies blockchain technology in recording data by converting it into a hash code cannot be changed by anyone when recorded in a blockchain application. Ethereum blockchain to achieve automatic recording of events accessible to all participating stakeholders. We also implemented and tested the functionality of the solution with Ropsten test net Ethereum. The framework presented in this paper with system architecture, design, algorithms, and smart contract code is relatively general. It can be extended supply chain systems of similar products involving version control and access to digital assets. For further research on the sugar supply chain, add the chain actors involved to sugar connoisseurs at the dinner table. Adding price traceability due to price changes or price imbalances occurs from the first sugar buyers to the mills to the smallest consumers, namely households or sugar connoisseurs. Implement a more comprehensive system for the national sugar industry upstream to downstream. Moreover, digitize data input using sensors/IoT on tools and processes sugar cane into sugar and integrated into storage, sales, and household consumers. As for the platform used, it is possible to use a platform based on layer 2 Ethereum, such as polygon, Solana, and Avalance. The main net Ethereum is valid for transactions and validity by miners active in financial decentralization so that transactions use real ether coins.

ACKNOWLEDGEMENTS




The author would like to thank BUDI DN LPDP as a supporter of scholarship funds, PT JT, which has allowed the author to conduct observations and collect data, and PT I, who has assisted and discussed the development of the resulting platform.

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