Analysis and design of transparent smart contract based on blockchain technology for supply chain in "Gasol flour" industry

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Abstract. The current contract system that has been running in a supply chain is not necessarily going well. Particularly, this contract was attributed by unfairness distribution of margins in each stakeholder, which causes one of the stakeholders took place as disadvantaged ones. This challenges potentially overcome by industry 4.0 paradigm constructing a smart contract system based on blockchain technology. This study aims to analyze the task of each stakeholder to achieve a transparent smart contract system and design system for a transparent smart contract that is able to provide a fair and transparent contract for each stakeholder involved in the supply chain of "Gasol flour" industry. By the existence of a smart contract, each stakeholder visibly and determine what contracts to establish and to create with other parties a transparently. The relief method used in this research provides input in the form of features needed to make a contract system in the supply chain of "Gasol flour" industry. Furthermore, these features are selected to obtain an output in the form of contract items to display in the distributed smart contract system. The selected items are input to run IF-THEN logic on the smart contract system using the M5P Tree algorithm method. The main results of this study are to obtain features that have the most influence on a transparent smart contract system and the rule of the selected feature so that a system is able to provide a fair contract for each stakeholder established in the supply chain of "Gasol flour" industry.

Keyword: blockchain, gasol flour, industry 4.0, transparent smart contract

1. Introduction

In a supply chain, inequality and openness in terms of financing among stakeholders are often occurs. This causes some parties to take place as disadvantaged ones. For example, there is a theory that explains how to make a contract run optimally, but in practice, it provides a high complexity because it is unable to make decisions appropriately, fairly and transparently, which are able to adjust the desires of each stakeholder [1].

In the industrial revolution era 4.0, the presence of blockchain technology increases the transparency and accuracy of information. Blockchain technology is a method for exchanging information in a systematic and measurable way. Blockchain has a guaranteed authentication system, so any information flowing in the blockchain system can be accounted for from where it came from [2]. The blockchain technology allows each member in the supply chain to connect with each other because blockchain
technology is equipped with a smart contract that is able to lock and describe a goal specifically. This makes each supplier know how much raw material or product is sent, what price of raw material from the initial supplier, when the raw material or product will be received, where the product comes from, and how the quality from the raw material to the product. Smart contract can also transfer asset ownership automatically which has a clearer work scheme by reducing intermediation from third-party [3].

The supply chain system is a system that involves organizations, people, technology, various activities, and resources to channel products or services from initial suppliers to consumers. The concept of supply chain management is not only limited to efforts to integrate the supply chain but also includes the flow of goods or services, finance, and information carried out by each business chain. The financing process in the supply chain includes payments received by each supplier who sells his product. This payment is used for capital to procure raw materials so that they can be reproduced [4]. In this financing, suppliers will also get a margin. However, without a transparent contract in the supply chain financing system, the margin obtained by each supplier is unfair. The most disadvantaged parties are upstream parties and downstream parties.

Gasol flour has the main ingredients derived from organic rice. Gasol flour is made from rice which still has the epidermis (broken skin rice). Rice husk contains high nutrition. This flour is produced at the foot of Mount Gede in the Cianjur area, West Java, precisely in the District of Cugenang. The organic Gasol flour production process starts from threshing rice from the stem, then removing the husk. Rice which has been removed from the husk will be sorted traditionally to get the best quality rice, after which the rice is washed and dried to reduce the water content to no more than 5%. The dried rice will be ground to get flour, after which the flour is roasted to get a dry texture and the shelf life is longer. In the Gasol flour production process this will form a supply chain system. The supply chain network in Gasol flour production consists of organic rice farmers in Gasol village as the main raw material provider and the organic Gasol company which will process the raw material into value-added products in the form of MPASI flour. This product is then distributed to supermarkets, resellers and end consumers [5].

Analysis of the transparent smart contract system is an activity to evaluate elements system that relates to objectives of the system by analyzing the requirements of the entity and stakeholders in the system so that the needs of each stakeholder to create a transparent contract are known [6]. The design of a transparent smart contract system is an effort to construct a system to provide satisfaction with functional requirements specifications that are able to provide a fair contract for each stakeholder, meet the targets of a transparent contract, fulfill needs implicitly or explicitly in terms of performance and resource use. Satisfaction limits on the design process in terms of costs, time and devices [7]. Analysis and design of a transparent smart contract system that is in accordance with the System Development Life Cycle (SDLC) include the idea of creating a transparent contract, the needs of each stakeholder, the system requirements that must be met, the design, evaluation, and maintenance of the system [6].

This study aims to analyze and identify the components of the needs of each stakeholder in the supply chain contract system "Gasol flour". Designing a blockchain technology system that is able to transparently contract in the supply chain "Gasol flour" by using the Relief method as a feature selection to set the contract to be displayed and the Tree M5P Algorithm to run IF-THEN logic in a transparent smart contract system.

2. Methodology

2.1. Research framework

The analysis began with determined who are the actors in the supply chain of “Gasol flour” industry and what are the roles of this actor in the supply chain contract system. Then designed a transparent system for contracting in the “Gasol Flour” supply chain with a smart contract that can lock and distribute the contract to each supplier by selecting features that displayed in the smart contract, and determined the rules for the contract become a transparent system. This design will be illustrated into a use case diagram to explain the role of each actor, from the use case diagram then drawn into the BPMN to show how the
business processes and relationships between actors of the system designed. This research was conducted at the Gasol Organik headquarters, using a direct interview method with the owner of the Gasol Organik company. As known the name "Gasol flour" is taken from the name of the region in Cianjur which is the place of production of this MPASI flour product. Figure 1 is an overview of the framework for achieving the objectives of this research.

2.2. Business process identification
Identification of business processes is a process of analyzing who is the actor involved in the supply chain of “Gasol flour” industry. Business process is a workflow model that has a general concept based on collaborative modeling between interacting process partners [8]. Based on [9] the aspects of business processes are:

- Models with partners who interact, using personal models, public models and choreography.
- Approach, from top to bottom of the global choreography or from the bottom up from the local model.
- Selection of partners, remain with known partner priorities or partner selection and mapping at run time.

Figure 1. Research framework.
- Property for business processes. Properties are the consistency of implementation and observable behavior, compatibility of structure and behavior, and realization of process models from each partner [8]. In the process of identifying business as for, which is analyzing the problems what are the tasks of each of the actor involved and how the processes that occur in each actor in the supply chain contract flow. The system analysis based on blockchain technology completed by modeling used the Unified Modeling Language (UML). UML is a standardization of modeling languages to build software using object-oriented programming techniques [7].

2.3. Transparent smart contract system design based on blockchain

Based on the results of system analysis known what contract requirements are contained in the supply chain "gasol flour". These results are used as a reference for designing and formulating systems with blockchain technology. The blockchain groups all digital transactions into blocks and all blocks are arranged in chronological order to form a blockchain which is a blockchain [10]. The blockchain uses several cryptographic functions to encrypt data so that someone's anonymity or data is maintained throughout the blockchain network [11]. Blockchain technology can be used to create decentralized networks in various supply chain management in such a way as to provide transparency, security, neutrality and reliability of all operations occurring in the supply chain [12]. There are many use cases where blockchain technology is used in supply chain management, thus providing effective and efficient supervision of products in the supply chain between production, processing, warehousing, distribution and retail links [10].

The system is designed to use smart contracts to replace the trusted third actor. This is utilized with the help of automatic code execution that is distributed and verified by network nodes in a decentralized blockchain network [13]. Smart contract can save data. The stored data can be used to record information, facts, associations, balances, and other information needed to apply logic to real world contracts [14]. Relief method was used to select any feature included in the smart contract which is then locked and distributed to all stakeholders. Feature selection is the process of selecting from several feature subsets that are sufficient to provide a target concept. Relief algorithm is a simple, fast, and effective approach to weighing attributes. The Relief algorithm has an output in the form of weights between −1 and 1 for each attribute, with the largest weight and positive value indicating more predictive attributes. The main function of relief is to estimate the weight of features in an iterative manner according to their abilities. Relief is expanded to handle noisy and incomplete data and to solve multiclass problems that cannot be handled by genuine Relief algorithms. This Relief algorithm is named Relief F. Relief-F is an extension of the Relief algorithm. This F Relief made it possible to work with incomplete and problematic data sets [15]. Relief is determined by calculating the formula as follows [16]:

$$d_{diff}(F_j, R_1, R_2) = \frac{value(F_j, R_1) - value(F_j, R_2)}{max(F_j, D) - min(F_j, D)}$$ (1)

$F_j$ : vector of j feature  
$R$ : instance of space  
$d_{diff}$ : the distance between instances to find nearest neighbor

After knowing the selected features, then it is to determine the rule of the feature. The rule determination in this study is to use the M5P Tree algorithm method. The M5P Tree algorithm is an expanded version of M5, where the tree model basically has the main advantage, which is able to handle a large number of data sets efficiently that have high dimensions and can also be used to strengthen lost data [17]. In the opinion of [18] there are four details for the M5 Algorithm with the first M5P approach, the shape of the linear model is quite obvious. For certain vertices with attribute $k$, say with models $a1, a2, \ldots, ak$, ...
which is tested in the hemisphere below that node, using the \(k + 1\)-parameter model which includes the constants. Because this makes the compensation factor \(\frac{n+v}{n-v}\) used in calculating the expected unexpected error in the leaves that have one example (because \(n = v = 1\)), no separation is allowed which creates leaves with less than two examples [18].

Second, during the initial separation procedure, M5 does not divide a node if it represents very few examples or the value is only slightly different. Because leaves cannot contain fewer than two examples of training, nodes are not divided if used to represent three examples or less and also not divided if the standard deviation of class values from the examples at node is less than 5% of the standard deviation of class values from the entire set of original examples. Experiments show that the results are not too sensitive to the selection of the right threshold. Third, it is unobvious what attributes are used in the linear model. Bear in mind that, during pruning, the attribute is dropped from the model when the effect is so small that it actually increases the estimated error. Fourth, when making a decision whether to trim the sub-tree or not, it is necessary to compare the expected error estimates for the linear model at that node with the estimated error expected from the sub-tree [16]. Whereas according to [18] there are four main steps in the M5P algorithm, namely the first step of the input space is divided into several sub-spaces for building trees. The standard deviation of the values that reach the node is used to measure variability. Tree construction is done using the standard deviation reduction factor (SDR) which maximizes error reduction which is formulated into the following equation:

\[
SDR = sd(S) - \frac{\sum S_i}{|S|} \times sd(S_i)
\]  

\(S\) : set of the data records that reach the node  
\(S_i\) : sets from splitting node  
\(sd\) : standard deviation

In the second step, linear regression models are developed in each subspace using data that is in accordance with the subspace. Then, pruning to overcome over-training problems. Over-training problems occur when the SDR for the linear model in the root sub-tree is smaller than the expected error for the sub-tree. The process of pruning can cause sharp discontinuities between adjacent linear models. To compensate for this problem, the leveling process is carried out in the final step. The smoothing process is done to combine all the models from leaves to roots to form the final model of leaves. In this process, the predicted value of leaves is filtered because the pathway returns to the root. The combination of this value with the predicted value by linear regression for the node is carried out as follows [17]:

\[
E' = (n.e) + (a)
\]

\(E'\) : estimated value passed up  
\(e\) : estimated passed to current node  
\(a\) : predicted value  
\(n\) : number of training  
\(k\) : constant

3. Results and discussion

3.1. Analysis of a transparent smart contract system based on blockchain technology

The analysis of a transparent smart contract system began with evaluating elements in the supply chain system "gasol flour" to achieve the goal of contract transparency. Evaluation of this element analyzed the requirements of entity, actors, and system in developing a transparent smart contract system. This system analysis is outlined in an overview of the system entity diagram in figure 2.
Based on the description of the system entity to build a transparent smart contract system, it took 2 stakeholder communities, the internal community and the external community. The internal community consists of 3 actors named farmer, manufacture, and distributor/reseller meanwhile the actors involved in the external community have smart contracts and digital payments. The results of the system entity diagram also explained that in order to build a transparent smart contract system, the required contract requirement is a contract that is able to provide a detailed rule, so that the goal of obtaining a fair and transparent margin can be achieved. Figure 3 explained the details of the roles of each actor involved in the system.
Figure 3. Use case smart contract system in “Gasol flour” supply chain.

Figure 4. BPMN transparent smart contract system solution.
This paper focused on smart contract solution. Smart contract functions to store and collect data sent by stakeholders. The features of this data are selected and then shared with stakeholders. After stakeholders accepted the contract, the payment sent via digital payment. Digital payment also verified and validated the payment. Details of the smart contract task flow in the business process to achieve a transparent contract system are described by BPMN in figure 4 below.

Figure 4 described that smart contracts obtained data from stakeholders consists of rice selling prices, organic farm areas, planting capital, production costs, and flour selling prices. These data are used to inputs for design transparent smart contract systems.

3.2. Design of a transparent smart contract system based on blockchain technology

Smart contract system design began with formulating design. The first step of formulating design was determined by what features involved in the supply chain of "Gasol flour" industry contract. The relief method used to select the features displayed in the smart contract. This method displayed the features that most influence to realize a transparency smart contract system in determining the selling price of flour. The list of data to selected features is shown in table 1.

| Table 1. The feature influencing contract between stakeholder. |
|----------------------|------------------|
| Variable | Attribute |
| X1 | Rice selling price (Rp/L) |
| X2 | Organic farm area (Ha) |
| X3 | Planting capital (Rp/m²) |
| X4 | Production cost (Rp) |
| X5 | Flour selling price (Rp/box) |

These features then processed into the relief method, which results in a ranking of each feature. The feature that got the largest value and ranked in the top is taken as a feature displayed in the smart contract. The table 2 shows the ranking results of each feature.

| Table 2. The rank important features between stakeholder. |
|----------------------|------------------|
| Ranked | Attribute | Value |
| 1 | Planting capital | 0.003776 |
| 2 | Production cost | 0.000909 |
| 3 | Rice selling price | -0.001519 |
| 4 | Organic farm area | -0.017535 |

The results showed that planting capital has the greatest value and is ranked first and then there are production costs which are ranked second. This means that planting capital is features to be locked into the smart contract and distributed to stakeholders. After knowing the selected features, then look for a rule to run the IF-THEN logic on the smart contract system. Processing data to get this decision rule used the M5P Tree algorithm. The following is a description of the decision tree generated from the data processing of the M5P Tree algorithm. Figure 5 illustrates the rule tree generated from M5P algorithm. The table 3 shows rules resulting from processing the M5P algorithm and will be used in the contract system. The table 4 shows results of the overall values of the M5P algorithm processing.
Table 3. The rule for smart contract system.

| Rule | Notes |
|------|-------|
| LM 1 | Production cost (Kg) = (1.5988 * Rice selling price (Rp/L)) - (170.6821 * Organic farm area (ha)) + 3778.7916 |
| LM 2 | Production cost (Kg) = (0.4181 * Rice selling Price (Rp/L)) - (113.7881 * Organic farm area (ha)) – (0.1918 * Planting capital (Rp/m^2)) + 15801.4216 |

Table 4. Result for M5P algorithm.

| Result                  | Value          |
|-------------------------|----------------|
| Correlation coefficient | 0.7048         |
| Mean absolute error     | 1166.8001      |
| Root mean squared error | 1462.9934      |
| Relative absolute error | 76.5915%       |
| Root relative squared error | 72.5922%     |
| Total Number of Instances | 40              |

Based on these calculations known that for planting capital has 2 rules. These rules are run by smart contracts. From these results smart contracts are carried out for each stakeholder involved in the "Gasol flour" supply chain. The first rule explained to each stakeholder that if the capital is planted less than Rp 3925 the production costs incurred by manufacturers to produce flour are as big as the calculation on the Linear model (LM) 1. Conversely, if the capital is planted more than Rp 3925, the production costs incurred by manufacturing are as big as the calculation on the Linear Model (LM) 2 rule. The value of planting capital is a reference obtained by BPS data.

4. Conclusion
Transparent smart contract system is a system that is able to lock and share data transparently to all stakeholders involved. In developed this system started with analyzing the system. System analysis showed that the supply chain system in the "Gasol flour" industry requires a contract that is able to provide fair and transparent margins for each stakeholder with data consisting of planting capital, production costs, organic farm areas, rice selling prices, and flour selling prices. Furthermore, this data used as a parameter to design a transparent smart contract system that is processed using the relief method. Relief method used to select the data features, so that the most influential attributes are obtained to create a transparent smart contract system. The results of relief processing found that planting capital is the attribute with the first rank then locked in the smart contract. This result is used as input to determine contract rule with M5P Tree Algorithm, so it get 2 rules for planting capital contracts. These contracts and rules distributed to stakeholders by the smart contract, so that stakeholders got the contract transparently and also created price fairly.
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