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*Research article*

# A trading matching model for aquatic products based on blockchain and credit mechanisms

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**Abstract:** Current online transactions of aquatic products are often plagued by problems such as low efficiency, high platform supervision cost, insufficient trust and leakage of transaction data. Blockchain has been widely used in many different fields due to its decentralization, non-tampering and distributed data management. In order to resolve the existing problems, a blockchain-based aquatic product trading matching model integrated with credit mechanisms is proposed in this study to improve the efficiency, quality, security and satisfaction of online transactions for aquatic products. Then, based on this model, an online trading matching prototype system for aquatic products is developed, taking the Hyperledger Fabric as the underlying architecture. The performance testing of the prototype system has demonstrated that the introduction of the credit mechanism has a certain improvement effect on the trading matching results of aquatic products, and the system can complete more than 1000 transactions within half an hour, which can satisfy the normal business-to-business online transaction needs for aquatic products. To a certain extent, it can reduce the security risks and supervision cost, and improve the efficiency and satisfaction of online transaction. This study can also bring insights to blockchain-based online trading models in other industry fields.

**Keywords:** blockchain; online transaction; trading matching; aquatic products; credit mechanism

## 1. Introduction

The aquatic product transaction has changed from a traditional offline model to an online ecommerce platform. However, the current aquatic product trading platform is focusing on providing information sharing and has failed to support and monitor the whole online trading process. There is still information asymmetry between buyers and sellers. Meanwhile, there exist trading security issues such as user information leakage and false product information in the current e-commerce system for aquatic products. Online trading always has high requirements for the credit value of both parties to the transaction, and aquatic products, as a perishable commodity, have higher requirements for this. Therefore, there is an urgent need for a new solution to provide online transaction matching functions on the premise of not only improving the efficiency of aquatic product transaction matching and ensuring the information security of buyers and sellers, but also providing satisfactory transaction matching results and experiences for both parties.

Blockchain refers to the data structure which follows the timestamp sequence and cannot be forgeable, immutable and traceable based on transparent and credible rules, in a peer-to-peer network environment. The blockchain data structure can support the transaction processes and protect the transaction data security [1]. Each block consists of a block head and a block body. There is a hash value in the block head. If the data in the previous block changes, the hash values of all subsequent blocks need to be changed in order to achieve data tamper prevention. Blockchain integrates technologies including the consensus mechanism, distributed data storage, point-to-point transmission and cryptography, and has been widely valued by domestic and overseas scholars [2]. The introduction of blockchain into the field of aquatic products is an effective way to solve the supervision difficulty of aquatic product trading platforms, ensure data security and improve transaction matching efficiency.

Transaction credit evaluation is the result of the trader's evaluation of the transaction quality and experiences after the transaction is generated. The purpose of establishing a credit evaluation is to measure the product quality and service quality provided by one trader's historical transaction records and bring lessons or experiences to other traders who are pursuing a good consumption experience. After the appearance of e-commerce systems, the development of non-face-to-face transactions puts forward higher requirements to objectively obtain the credit level of both parties. In addition to introducing blockchain from the perspective of technical architecture, how to give full play to the role of a credit evaluation mechanism in the online transaction process has become another important issue faced in the online matchmaking transaction process for aquatic products.

In current online trading platforms for aquatic products, there exist the following problems: 1) security issues with transaction data; 2) lack of satisfaction for both trading parties due to the opacity of trading product information and the unequal information for multiple traders. Although combining blockchain technology with online trading platforms for aquatic products can effectively prevent data security issues caused by tampering with transaction data, reduce excessive management costs and potential human risks in centralized management models, relying solely on blockchain technology makes it difficult to solve the issues of opaque product information, low transaction quality and low transaction satisfaction caused by the lack of credit between both parties in online transactions. Under such circumstances, introducing a credit mechanism into blockchain-based online trading platforms for aquatic products can not only leverage the transparency and openness of information on the chain, but also facilitate consensus formation among trading participants, effectively solving the problem of information asymmetry between the trading parties. Meanwhile, by introducing a credit mechanism to optimize the trading matching process, both traders can be motivated to improve the transaction quality by striving to obtain higher transaction priority permissions, thereby continuously improving their own credit value. This can effectively overcome the intentional and subjective default behavior in the transaction credit system, improve the satisfaction of transaction matching, and maintain the economic interests of both parties involved in the online transaction.

Therefore, two main research contributions are provided by this study. First, a blockchain-based aquatic product trading matching model is established by integrating an improved ant colony algorithm. Second, through introducing a credit evaluation mechanism into aquatic product matching transactions, both parties' satisfaction with the trading matching results is revealed and improved.

The rest of this article is structured as follows: The Section 2 introduces the literary review. Section 3 presents the methodology design, including business process analysis of aquatic product trading matching, building of a blockchain-based trading matching model for aquatic products, as well as the trading matching algorithm and the design scheme of related smart contracts. Section 4 illustrates the design and implementation of the prototype system based on the proposed trading matchmaking model for aquatic products. Then, Section 5 elaborates the experimental results and discussions, followed by Section 6, which depicts the theoretical and managerial implications of this study. Finally, the conclusion in Section 7 explains the restrictions and deficiencies of this study and elicits further research directions.

## 2. Literature review

### *2.1. Blockchain technology*

Blockchain is a distributed ledger technology proposed by Satoshi Nakamoto in 2008 [3]. It is a data structure linking data blocks through random hashes in chronological order and can ensure the immutability and unforgeability of the distributed ledger in a cryptographic way.

Blockchain technology can be divided into three types: public chain, alliance chain and private chain [4]. Public chain takes Bitcoin as a typical example, alliance chain presents semi-decentralized characteristics, and private chain evolves into fully individual centralization. At present, the technical architecture of blockchain is usually divided into five layers, namely the data layer, the network layer, the consensus layer, the contract layer and the application layer [5].

Blockchain has the following three characteristics: 1) Decentralization. Blockchain technology is in the form of distributed ledger to record the data of each node, using the consensus mechanism between nodes to achieve data management so as to get rid of the dependence on centralized third-party institutions. 2) Consensus mechanism. Blockchain technology automatically exchanges and verifies data by setting norms and protocols agreed by consensus among each node, with the majority nodes' recognition of the behavior of a single node. 3) Data security. Blockchain secures all transactions on the chain by tracing the value of the root node of each block, while the data distributed storage form and consensus mechanism make the data tamper-free and ensure data security.

Smart contract was first proposed by Nick Szabo in 1994 and was defined as "a set of commitments defined in digital form, including an agreement on which the parties to the contract can execute those commitments" [6] and is a piece of code applied to a blockchain [7]. Smart contracts contain constraints on both parties to the transaction, ensure the irreversibility of the transaction, define commitments in digital form, control digital assets and include the rights and obligations agreed upon by contract participants. It is an agreement that uses computer programming language instead of traditional legal language to record the terms and contents. The working process of a smart contract is roughly as follows: A smart contract combines business planning or logic with code to form a contract code file, which is compiled and converted into a bytecode file that can be executed on an Ethernet

Virtual Machine (EVM). After the transaction request is verified, it waits for "Miner" to package the transaction and broadcast it. After the node receives the transaction, it processes the transaction, updates the data file and packages the transaction into a new block to add to the blockchain, waiting for the call of the application program interface. When appropriate input data is provided for a smart contract, the contract will return a trustworthy result after correct execution.

At present, cold chain logistics is a key factor in restricting the development of e-commerce of aquatic products. Montanari proposed that how to effectively track the cold chain conditions is one of the issues that need to be solved to minimize the cost of cold chain logistics [8]. Some scholars have introduced blockchain technology into food quality and safety traceability systems (including aquatic products), proposing some blockchain security architectures of the food chain or the entire industry chain in combination with Internet-of-Things (IoT) technology. Mezquita et al. proposed a system that uses smart contracts and blockchain technology to remove intermediaries and speed up logistics activities [9]. Kamath introduced a case that highlights the challenges of implementing blockchain technology into the food supply chain and the opportunities for deploying blockchain solutions throughout the global food ecosystem to increase safety and reduce waste [10]. Khan et al. constructed a public-private hybrid blockchain-based conceptual framework to solve the problem that there is a lack of efficient traceability capacity and holistic view of the supply chain [11]. Lu et al. proposed a food anti-counterfeiting traceability system based on blockchain and IoT in response to the problems of data centre-based storage, easy data tampering and data silos in traditional food anti-counterfeiting traceability technology [12]. Peng et al. made a qualitative and quantitative analysis of blockchain smart contracts in the agri-food industry, and summarized the research status, challenges and development trends [13]. Chatterjee et al. proposed a framework based on the concept of blockchain smart contracts [14] and Cao et al. elaborated a blockchain-enabled architectural framework for trustworthy communication about the sustainability attributes of food products [15]. Tsang et al. employed optimized consensus algorithms to integrate the novel deployment of blockchain, IoT technology, and fuzzy logic into a total traceability shelf life management system for managing perishable food [16]. The application of blockchain in the field of aquatic products is concentrated in trusted traceability and quality management methods. As an internationally recognized quality management method, the traceability system has become a hot focus at home and abroad [17]. Garrard et al. conducted studies on the role of blockchain in the traceability of Australia's aquaculture supply chain [18]. Howson used blockchain technology to ensure the equality of both parties in fishery supply chain management [19]. Larissa and Parung used blockchain technology to design new supply chain models to prevent illegally caught aquatic products from entering the supply chain [20].

In China, Ge and coauthors combined blockchain with Hazard Analysis and Critical Control Point (HACCP) to propose a quality traceability model for raw oysters [21]. Similarly, Wei et al. also combined blockchain and HACCP to design a new intelligent aquatic product traceability system [22]. Li et al. proposed a master-slave multi-chain storage model to manage supply chain traceability information for aquatic products [23].

The practical application of blockchain is still in the preliminary stage, but its fundamental technological characteristics can not only provide promising value in the quality traceability of aquatic products, but also can promote further development of aquatic product online transactions.

### 2.2. Online trading matching models and algorithms

Aquatic product online matchmaking transactions include supply-demand matching models and algorithms. At present, there is still a gap of the trading matching models and algorithms in the aquatic product field. Nevertheless, the online trading matching models and algorithms in other fields such as electric power industry are relatively advanced. Mengelkamp et al. presented a comprehensive concept based on a distributed information and communication technology, i.e., a private blockchain, which underlines the decentralized nature of local energy markets [24]. Doan et al. designed a peer-to-peer (P2P) energy trading system among prosumers using a double auction-based game theoretic approach and implemented their proposed energy trading system with blockchain technology to show the feasibility of real-time P2P trading [25]. In order to solve the problem of lack of privacy protection for a continuous double auction in the existing scheme, a privacy protection scheme of microgrids direct electricity transaction based on consortium blockchain and the continuous double auction was proposed by Zhang et al. [26]. Li et al. proposed a mechanism based on the combinatorial double auction to solve the intensive computation offloading problem of mobile blockchain applications [27]. Due to the characteristics of perishability, online matchmaking transactions in the field of aquatic products not only include the price attribute, but also involve multiple attributes such as freshness, logistics and timeliness. The key focus of research on online matchmaking transactions of aquatic products is how to construct a model based on multiple attributes and multiple objectives to maximize the matching degree between buyers and sellers and achieve the completion of online transactions within a specified time.

Currently, most online trading matchmaking systems consist of three parties, namely, buyers and sellers, and system platforms. The system platform obtains and manages the transaction demand and supply information and conducts trading matching for the buyers and sellers based on the transaction attribute constraints and the goal of maximizing efficiency. Pinker et al. regarded such online transactions as online two-way auctions [28]. According to the different conditions and rules for online transactions between buyers and sellers, Zhan and Wang divided online two-way auctions into continuous two-way auctions and interval two-way auctions [29]. The existing supply-demand matching models are subsequently divided into continuous supply-demand matching models and interval supply-demand matching models.

The continuous supply-demand matching model is a system that optimizes the trading matching in real time based on the transaction information and requirements of both parties. Sen et al. pointed out that the continuous supply-demand matching model has the characteristics of real-time and rapid matching [30]. The continuous supply-demand matching model is suitable for solving the matching problem of real-time transactions.

The interval supply-demand matching model is a system that periodically completes optimal matching based on the transaction information and requirements of buyers and sellers. Due to the fact that trading systems often receive a large number of transaction matching requests at the same time, and multi-attribute transaction matching requires a certain time cost, in most cases, both parties to the transaction do not necessarily require the system to achieve instant matching, but instead adopt a method in which the system uniformly processes and optimizes transaction requests within a certain period of time, namely, an interval supply-demand matching model.

Correspondingly, the algorithms for trading matching models can also be divided into two categories: optimization algorithms and heuristic algorithms. Optimization algorithms are mostly used to solve continuous supply-demand matching models and are also suitable for situations where transaction matching data volumes are small. Heuristic algorithms improve search efficiency by designing heuristic rules. When the data size is large, heuristic algorithms exhibit certain advantages in terms of efficiency. Luo et al. proposed a fuzzy interval language set applied in multi-attribute group decision-making, using probability intervals to improve the flexibility of information representation [31]. Liang and Qin developed a satellite layout decision support system integrating multi-objective optimization and multi-attribute decision-making [32]. Zhang et al. conducted a study using transformation, recombination and substitution of ribonucleic acid (RNA) computing in the iteration of the ant colony algorithm to improve its performance, in order to better solve the bilateral matching problem [33].

To sum up, constructing an efficient online transaction matching model based on multi-attributes and multi-objectives through online matching models and heuristic algorithms to maximize the matching degree between buyers and sellers has provided an effective solution in filling the research gap of online matchmaking transactions in aquatic products.

### *2.3. Credit evaluation mechanisms*

In response to the current credit problems between buyers and sellers in online aquatic product trading, the characteristics of decentralization, data tamper-proofing, traceability and verifiability of blockchain technology determine its ability to be applied into the establishment of a credit system infrastructure for online trading.

Currently, studies on the application of credit evaluation mechanisms can be divided into two categories. One category is subjective evaluation, which uses third-party credit evaluation agencies to provide feedback on transaction information, and then specialized technical personnel from the agency adopt better credit evaluation models to evaluate the credit ratings of buyers and sellers, providing final credit ratings; the other category is objective evaluation, which is the automatic establishment of credit ratings through trading systems that score or rate the credit of merchants and consumers based on information such as scores and comments, historical transaction volumes and historical performance information.

In the study of objective evaluation of credit mechanisms, Tan and coauthors proposed a blockchain-based distributed power trading mechanism considering credit management [34]. Their research builds a distributed power trading framework and designs a distributed power trading process that considers credit management. The actual credit of users is represented by a synthesis of historical credit scores. After each transaction, the user's credit rating is automatically updated based on the user's performance. Cui et al. introduced a credit scoring mechanism based on traditional trading mechanisms of carbon emissions and defined transaction priority values and proposed a blockchain network model for carbon emission trading [35]. Their credit rating is a subjective evaluation method, which is based on the credit rating of market participants by third-party rating agencies that will be later published on the blockchain network.

The credit mechanism has been relatively deeply studied and practiced in other fields. For instance, Kleinberg and Oren developed a credit allocation model in pathological research [36]. Alharbi et al. proposed a machine-learning-based solution to detect fraudulent credit card transactions [37]. Sun et al. designed a new virtual real-time power pricing scheme based on power credit incentive plans [38]. Moreover, Yang and co-authors used credit rating models to assess the credit of energy hubs and adopted Bayesian games to model and analyze price strategies to maximize expected returns [39], and Li et al. put forward a credit evaluation method for blockchain users in the Internet-of-Things of electric power based on improved Softmax regression [40].

Introducing a credit mechanism can fully leverage the role of credit evaluation mechanisms in online transactions, which can not only reduce the risk of credit loss for both trading parties involved, but also provide a better online trading experience for both parties.

## 3. Methodology design

In order to solve the problems of difficult supervision of online aquatic product systems, low data security and transaction matching efficiency, and lack of credit between trading parties, this article proposes a blockchain-based matching transaction mechanism model for aquatic products and introduces a credit evaluation mechanism to optimize the matching results. Though designing smart contracts to achieve functions such as transaction data on-chain and trading matching, and obtaining transaction evaluation information, a simulation experimental system for online trading matching of aquatic products is built using the alliance chain platform Hyperledger Fabric as the underlying architecture.

### *3.1. Analysis of the aquatic product trading matching process*

At present, the e-commerce sales models of aquatic products have been mainly divided into the following two types: cyclical procurement models and government-farmer e-commerce models. In the former model, consumers purchase quantitative aquatic products semi-annually or annually, and suppliers are responsible for delivery and transportation according to the transaction agreement. In this trading mode, for trading users who meet long-term and multiple trading conditions, both trading parties will form a state similar to offline trading, gradually establishing a relatively familiar trading environment, which is easier to meet the needs of both parties for trading products and trading partners, and can to some extent weaken the opacity of trading information in online trading platforms. For trading users who have not met the conditions for long-term and multiple transactions, the impact of opacity of transaction information can be mitigated by establishing a credit mechanism.

In the later model, the government is responsible for aquacultural promotion, as well as quality and safety management, providing a platform for suppliers and consumers. In this transaction model, the government acts as a third-party platform and regulatory agency, using the credit of the government or official institutions as collateral, and provides services to suppliers and consumers through e-commerce systems, alleviating the credit problems caused by the opacity of transaction information during the transaction process to a certain extent. In order to encourage more enterprises to participate in online aquatic product matching transactions, the second scenario in the first trading mode is the key concern of this study. Through survey and analysis of multiple e-commerce platforms for aquatic products, the online transaction matching process of aquatic products, as shown in Figure 1, has been derived and can be divided into the following four steps:

1) Company registration. Companies first apply to join the blockchain, in which enterprise nodes will be created and the blockchain will further verify the nodes. Then, the enterprise nodes apply for a certificate from the Certificate Authority (CA) institution, and after obtaining the certificate, the enterprise node will apply for entering the chain. After verification, the enterprise submits company information such as company name, legal representative and social credit code to become a transaction

system user. The system then verifies the legitimacy of the enterprise based on its registration information.

2) Submit supply and demand list. In this process, the sellers submit their product supply information, and the buyers submit their product demand information. The seller's enterprise publishes the supply information to check whether all the attribute fields are legal, then the supply order that passes the verification will be uploaded by the consensus of the blockchain distributed network; similarly, the buyer's enterprise publishes the demand order information to verify whether other attribute fields are legal, and the demand order that passes the verification will be consensually uploaded by the blockchain distributed network.

3) Match transaction. In this process, the trading matching will be completed based on the multiple attribute constraints and credit rating. The matching order is determined by the credit ratings of both trading parties with high credit ratings prioritized for matching. Before matching transactions, the credit ratings of multiple trading companies are determined, then for the first turn of match, the trading companies with the highest credit rating will select the traders with the highest credit rating. After the first match, a second match is performed between all remaining trading partners. In the first matching process, if there are no trading partners with the same rating, the trading partners with the next rating will be selected in sequence.

4) Transaction confirmation and credit evaluation. In this step, the trading partners first decide whether to accept the matching results. If both parties agree with the matching results, the transaction is established, and the two parties conduct transactions based on the contract. If there is one party who does not agree with the matching result, the matching fails and the transaction is not established. After confirming the transaction by two parties, the transaction contract information will be uploaded onto the chain through smart contract. Then comes the credit evaluation stage. The two parties will provide mutual evaluation feedback based on the other party's trading performance. After obtaining the relevant credit evaluation information, the credit scores of the relevant transaction companies are updated and their credit rating will be re-determined correspondingly.

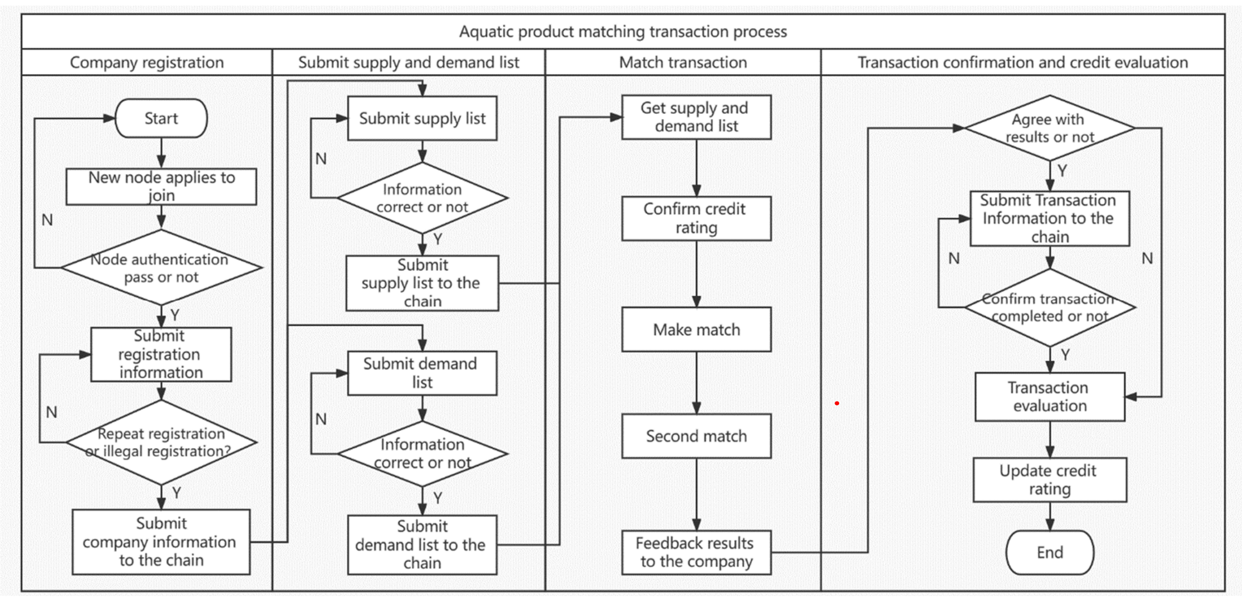



**Figure 1.** Aquatic product transaction matching flowchart.

### 3.2. Aquatic product trading matching model

Based on the analysis of the aquatic product online transaction matching process in Figure 1, a credit mechanism model for aquatic product online transaction matching based on blockchain was constructed (see Figure 2). Due to the fact that aquatic product trading systems receive a large number of transaction matching requests over a period of time, multi-attribute transaction matching requires a certain amount of time. Therefore, in most cases, both parties to the transaction are not required to achieve real-time matching. The principle of the interval supply-demand matching model, in which the system obtains the demand information of both parties in a certain period of time and achieves matching within a certain time, is more in line with the requirements of the application scenario in this study. To improve the transaction efficiency and maximize matching accuracy, this model adopts heuristic algorithms and improves search efficiency by designing heuristic rules.

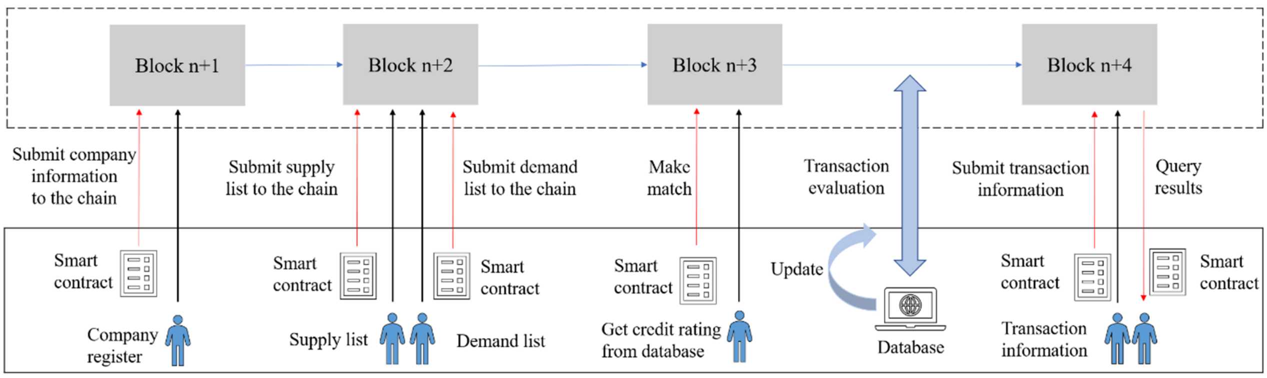



**Figure 2.** Aquatic product trading matching model.

Both parties to the transaction submit supply and demand orders to the system in any transaction cycle. The system will then calculate the obtained supply and demand orders in the next transaction cycle and match them based on different credit ratings of the trading companies. Through periodic data submission and processing, it ensures the efficiency of transaction processing without affecting the matching results of the current transaction cycle.

The specific matching process is as follows: Both trading parties submit supply orders and demand orders to the system based on their respective needs. Assume that the matching cycle is $T$ (two hours is one matching cycle in this study), and within the first 1/4 $T$ time, the system obtains the transaction information submitted by each enterprise in the $T$-$1$ cycle; in the next 1/4 $T$ time, the system will use smart contracts for matching based on the credit mechanism model of aquatic product online transactions; within next 1/2 $T$ time, the system waits for the users to receive feedback on the matching results and confirm the credit values of both parties in the transaction. Then, the system updates and re-determines the credit rating of the trading enterprises.

### 3.3. Key technologies

This section provides a detailed introduction to the key technologies and their implementation involved in this study, including the selection of heuristic algorithm, the processing of credit evaluation and feedback information, and the design and implementation of related smart contracts.

### 3.3.1. Heuristic algorithm

Heuristic algorithms improve search efficiency by designing heuristic rules, and exhibit certain advantages in terms of efficiency compared to optimization algorithms. The dominant heuristic algorithms include the simulated annealing algorithm (SA), genetic algorithm (GA), ant colony algorithm (ACO), artificial neural network (ANN), et al.

Ant colony optimization, also known as an ant algorithm, is a heuristic algorithm that simulates ants' foraging behavior. Ants can choose the path according to the pheromone secreted by other ants in their front, and the probability of choosing the food source route is proportional to the intensity of the pheromone secreted on the route. Therefore, a feedback phenomenon of information will form on the path that ants pass through. That is, the more ants choose a path, the more pheromone will be left on the path, and the more likely the ants behind will choose the path, so as to find the shortest path. ACO has been widely used in finding optimization paths and can be utilized to solve the problems of travel salesman, complex networks, deep learning and data processing [41].

In the principle of the traditional ant colony algorithm, ants tend to select nodes with a shorter distance from the current node and a higher concentration of pheromone. The heuristic function of traditional ant colony algorithms only considers the reciprocal of the distance between adjacent nodes, which can only reflect the relationship between the current node and adjacent nodes and cannot reflect the relationship between the current node and the target point. This local search range is a circular interval with the current node as the center and surrounding nodes as the radius, which is prone to falling into local optima. Therefore, this study adopts an improved ant colony algorithm for optimal path selection based on multiple constraints. This improved ACO algorithm improves the traditional ant colony algorithm by adding the linear distance between the next node $j$ and the endpoint $g$ to the heuristic function. On the one hand, it enhances the purpose of ant search and accelerates the convergence speed of the algorithm; on the other hand, it also reduces the risk of the algorithm falling into local optima.

As shown in Figure 3, the procedure of the improved ant colony algorithm used in this study is as follows:

1) Initialize the parameters of ant colony $k$, information inspiration factor $\alpha$, expected inspiration factor $\beta$, volatility coefficient of pheromone $\rho$, number of iterations $n$ and total number of ants $m$.

2) Calculate the probability of ants going to the next arbitrary path using the improved ant colony algorithm and select the path with the highest probability using the following Eq (1):

$$p_{ij}^{k}(t)=\begin{cases}\dfrac{\left(\tau_{ij}(t)\right)^{\alpha}\left(\eta_{ij}(t)\right)^{\beta}}{\sum_{s\in allowed_k}\left(\tau_{is}(t)\right)^{\alpha}\left(\eta_{is}(t)\right)^{\beta}}, j\in allowed_k,\\ 0, otherwise\end{cases} \tag{1}$$

wherein, $i, j$ represent the corresponding nodes, $\eta_{ij}(t)$ represents the heuristic function of nodes $i\rightarrow j$, $\tau_{ij}(t)$ represents the pheromone concentration of the path between nodes $i$ and $j$ in time period of $t$, $allowed_k$ represents a set of nodes that ants have not yet accessed and the nodes that ants have walked through are placed into the Tabu list.

3) Modify the pheromone concentration on the path the ants have been to and the path they have not been to, reducing the pheromone concentration of the worst path traversed and enhancing the pheromone concentration on the best path traversed. $t$ means the time and $tabu_k$ means the nodes

that the ants have gone through, $D_{best}$ represents the optimal position experienced by an individual ant and $G_{BEST}$ represents the optimal position experienced by the entire ant colony in this iteration.

In order to obtain the optimal solution faster, a constraint function $X(j)$ based on multiple constraint factors is established for path selection through multiple constraints including price, freshness and weight as follows:

$$X(j) = \varepsilon X_1(j) + \varphi X_2(j) + \gamma X_3(j), \quad (2)$$

where $X_1(j)$ represents the constraint factor of price, $X_2(j)$ represents the constraint factor of freshness, $X_3(j)$ represents the constraint factor of weight and $\varepsilon$, $\varphi$, $\gamma$ represent the weights of these relevant factors, respectively.

Correspondingly, in the improved ant colony algorithm, the pheromone concentration of the path between nodes $i$ and $j$ in time period $t+1$ can be calculated by Eq (3) as below:

$$\tau_{ij}(t+1) = \begin{cases} \frac{(1-\rho)\tau_{ij}(t)}{X(j)} + \mu(|D_{worst}| - |D_{best}|), (i,j \in D_{best}) \\ \frac{(1-\rho)\tau_{ij}(t)}{X(j)} - \mu(|D_{worst}| - |D_{best}|), (i,j \in D_{worst}) \\ 0, otherwise \end{cases}, \quad (3)$$

wherein, $\mu \in [0,1]$ represents the pheromone enhancement factor in the improved ant colony optimization algorithm, which punishes the worst path traversed by reducing its pheromone concentration and enhances the pheromone on the best path traversed, $D_{worst}$ represents the worst-case path traversed and $|D_{worst}|$ represents its length, $D_{best}$ represents the optimal path traversed and $|D_{best}|$ represents its length.

4) Repeat multiple times until the iteration termination conditions are reached to obtain the optimal path solution.

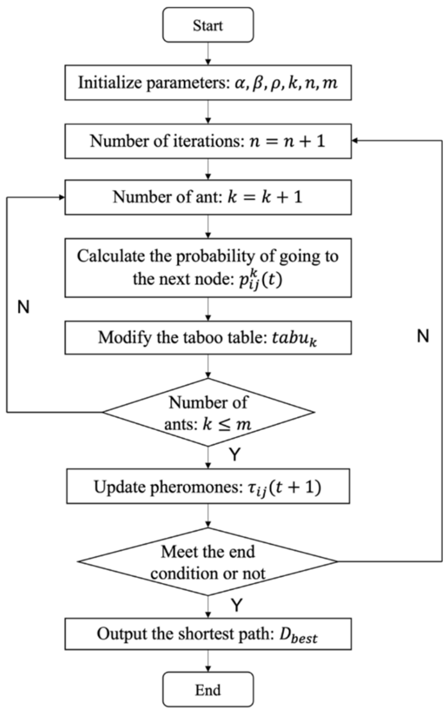



**Figure 3.** Improved ant colony algorithm.

### 3.3.2. Credit evaluation

Given the current situation of information inequality between the two parties involved in online trading for aquatic products, a credit rating model is established for the online trading system based on blockchain technology. Both parties of the transaction rate the credit of the trading companies based on information such as quality of historical transactions and satisfaction on matching results. Then, the system updates the rating of the enterprises after obtaining the credit scores of both parties involved in the transaction. The credit score $R$ is defined in this study. The higher the value $R$, the higher the credit rating. In order to avoid the impact of low transaction frequency on credit score, the following regulations are made for the credit score in this study. The total credit score is 5 and the impact of one transaction on the credit scores of both parties is 0.1.

$$0 < R \leq 5. \quad (4)$$

In the experiment of this study, in order to simplify calculations and improve the efficiency of the system, the credit scores were graded as shown in Table 1.

**Table 1.** Credit score and grade table.

| Credit scores (R) | Credit rating |
|---|---|
| 5.0~4.1 | A |
| 4.0~3.1 | B |
| 3.0~2.1 | C |
| 2.0~1.1 | D |
| 1.0~0.0 | E |

Based on the above credit evaluation method, a semantic analysis algorithm based on the bag-of-words model was used in this study to establish a semantic processing model and classify transaction evaluation information into different tendencies. Those that positively support transaction results are considered excellent evaluation, those that maintain neutrality towards transaction results are considered good evaluation and those that negatively support matching results for this transaction are considered bad evaluation. Although there are many open-source datasets for evaluating various goods, it is still difficult to find evaluation data sets for aquatic products and their transactions. In order to make the data set as close as possible to the evaluation vocabulary that may appear in actual aquatic product trading scenarios, the Amazon Fine Food Reviews English data set was selected [42]. This data set is a summary of evaluation information for various goods on the Amazon platform, which can not only meet the requirements of data volume but also expand the coverage of evaluation vocabulary and improve the efficiency of model training.

The process of the semantic analysis algorithm is as follows:

1) Obtain the input text content and preprocess it, including data missing, duplicate values, etc.;

2) Perform word segmentation and frequency statistics on the text data to prepare it for vector conversion;

3) Convert comment statements into feature vectors based on the bag-of-words model and handle meaningless words such as stop words. Each feature vector contains the frequency count of each word in the data set;

4) Train a logistic regression classifier based on the bag-of-words model using the training set data;

5) Input evaluation information to obtain positive, neutral and negative sentiments corresponding to excellent, good and bad transaction results, respectively.

According to the tendency classification result, if both parties' evaluation results are excellent, the value update of their credit scores will be + 0.1; if both parties' evaluation results are good, the value update of their credit scores will be + 0.0; if both parties' evaluation results are bad, the value update of their credit scores will be – 0.1; and if there is a difference in evaluation results between the two parties, for example, the evaluation result given by the buyer is excellent, while the evaluation result given by the seller is bad, then their credit score update will be + 0.0.

The flowchart of the credit evaluation algorithm is as follows:

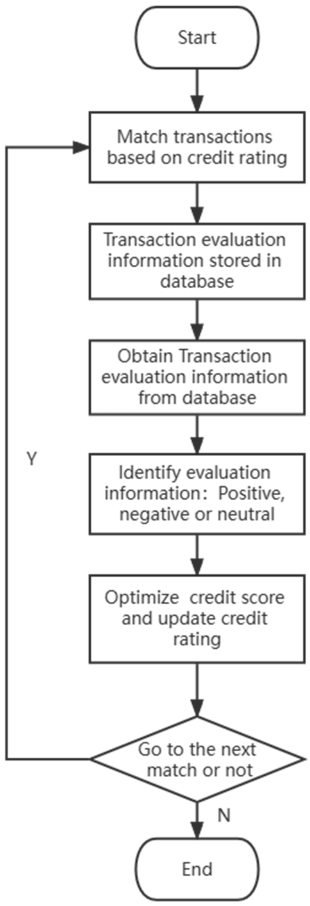



**Figure 4.** Credit evaluation algorithm.

### 3.3.3. Design of smart contracts

Smart contract is a piece of code running on the blockchain. Smart contract is a commitment defined in digital form, controlling digital assets and containing the rights and obligations agreed upon by contract participants. It is an agreement to use computer programming language instead of traditional legal language to record the content of terms.

The smart contracts involved in this study are as follows:

1) Company registration (RegisterCompany): Trading companies need to apply to join and

register on the blockchain, and the key submitted information includes the company name and social credit code. The system verifies whether the company name has been registered and whether the social credit code is unique and valid. After verification, the enterprise information will be uploaded onto the chain through the smart contract of company registration, and a token corresponding to the enterprise will be randomly generated for future use. The code logic of the company registration smart contract is as follows:

Algorithm 1: Company registration

**Input**: Corporate name (Name), social credit code (UniFiedSocialcreditid)
**Function** RegisterCompany (args [] string) {
Try {While (! Exist_company) // Confirm whether the company has been registered
Company: = & Company {ObjectType, Key, Name, UnifiedSocialcreditid}
Token += chars.charat (math.floor (math.random ()*chars.length)) // generate random token
Companyjsonasbytes: = json.marshal (company) // Data serialization
Stub.putState (key, CompanyjsonasBytes) // Enterprise information comes up
} catch (error) {Enterprise name exists! Output registration error information!}
**Return** Token} return the company registered token

2) Supply and demand list submission (DemandList_submit, SupplyList_submit): The sellers and buyers upload the supply and demand orders onto the blockchain respectively. The system calls the supply and demand order submission smart contracts to broadcast the supply and demand order information to various nodes in the blockchain network. After the endorsement node completes the endorsement operation, it is sent to each node, and the consensus node agrees on the transmitted data. The logic of the submission smart contracts for supply and demand orders is similar, and here the supply order submission smart contract is taken as an example:

Algorithm 2: Submit supply list

**Input**: Company number ID, variety (Breed), quantity (Amount), price (Price), freshness (Fresh), weight (Weight)
**Function** SupplyList_Submit (args [] string) {{
Try{While (! Exist_supplyList) // confirmed whether the company has submitted the supply list
SupplyList: = & SupplyList {ObjectType, Key, ID, Amount, Breed, Price, Fresh, Weight}
SupplyListjsonasbytes: = json.marshal (Supplylist) // data serialization
Stub.putState (key, Supplylist jsonasbytes) // Supply list information chain
}catch (error) {The supply list exists! Output supply list submit an error message!}
**Return** Supplylist_id} return the supply list id

3) Matching algorithm (Match): The system obtains the supply and demand order information submitted by both parties in the previous cycle, forming an input set of supply and demand orders. Then, after determining the credit ratings of both sellers and buyers, their transaction priorities are defined. Finally, the system uses an improved ant colony algorithm based on multiple constraint conditions for optimal path selection to solve trading matching problems of aquatic products. The code logic is as follows:

Algorithm 3: Match

```
Input: Supply list set S_i, Demand list set D_J
Function Match (args [] string) {
    Initial k, α, β, ρ, n,m
    Try {While (! (Supplylist_isEmpty or Demandlist_isEmpty)) {
        While (n ≤ n) { Choose ant and start point
            Choose next target // Select the next goal point
            Calculate the evolution value
            Update the Global Pheromone}} // Update global pheromone
      }catch (error) {The supply form exists! Output supply bills submit an error message! }
  Return Match_scheme} return the matching scheme
```

4) Submission of transaction contract (Info_submit): After obtaining the matching results of the transaction, the two parties decide whether to accept these transactions, then the trading parties mutually evaluate the performance of their matching partners, based on which the system updates the credit scores of both parties in the transaction. During the last quarter of the cycle time, the system will submit the transaction contract information and credit score to the chain and to the local database, respectively. Its code logic is as follows:

Algorithm 4: Submission of transaction information

```
Input: Trading enterprise number Sub_id, Dem_id, variety (Breed), quantity (Amount), total price (Total_price), freshness (Fresh), weight (Weight), credit rating (Cre_rating (A-E))
Function Info_submit (args [] string) {{
    Try {While (! ContractList_isEmpty) // confirmed whether the transaction already exists
            Update Credit_point // Update credit score
          Contract: = & Contract {ObjectType, Key, Sub_Id, Dem_Id, Breed, Amount, Total_price, Fresh, Weight, Cre_rating}
            ContractJsonAsBytes, err: = json.marshal (contract) // data serialization
            Stub.putState (key, ContractJsonAsBytes) //
        } catch (error) {The transaction contract exists!}
    Return Contract_id} return the trading serial number ID
```

5) Transaction information query (info_query): Transaction information can be queried through multiple methods, such as querying enterprise ID to obtain all transaction contract information related to the enterprise, or querying transaction contract information that occurred during specific time

periods, etc. For the convenience of conducting an experiment, this study will realize one method of transaction information query, namely, only after the transaction is completed and the transaction contract information has been uploaded onto the chain can the enterprise query historical transaction information through the transaction sequence ID. The code logic is as follows:

Algorithm 5: Transaction information query

```
Input: Transaction sequence ID
Function Info_query (args [] string) {
    Try {While (! Exist_contract_id) // Confirm whether the trading sequence ID exists
        Keyasbytes, err: = Stub.getState (key) // Get transaction data
      } catch (error) {trading does not exist!}
    Return Contract_info} return the transaction information
```

## 4. System implementation

In order to test the feasibility of the proposed trading matching model for aquatic products based on blockchain and credit mechanisms in Figure 2, a prototype system platform was developed, including six layers: application layer, contract layer, consensus layer, network layer, data layer and functional layer, as shown in below Figure 5.

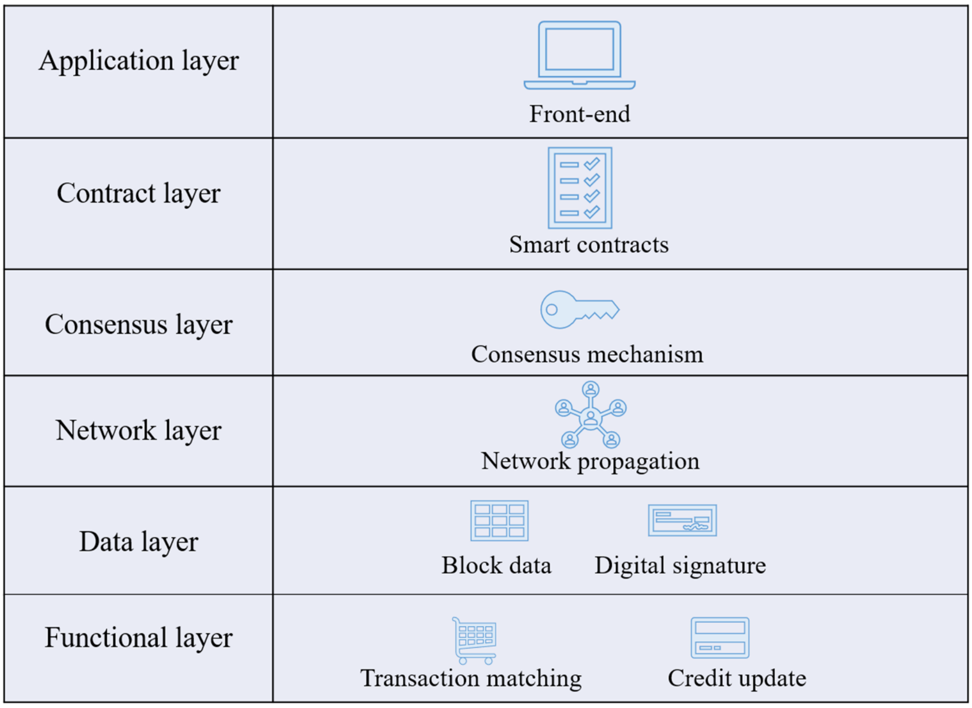



**Figure 5.** System architecture.

The application layer provides a visual interface for user operations. The platform obtains various data information uploaded by enterprises through the webpage front-end, including enterprise registration information, supply and demand order information, transaction information, enterprise credit scores, etc.

The contract layer includes the following smart contract functions: company registration, supply and demand list submission, matching algorithm, submission of transaction and transaction information query. The platform calls the corresponding smart contracts through the smart contract interface to achieve the corresponding functions.

The consensus layer includes consensus algorithms and node identity authentication. The consensus algorithm is a mathematical algorithm that can establish trust and gain benefits between nodes that do not trust each other.

The core of the network layer is the P2P network, data transmission, data validation mechanism, etc.

The data layer includes the specific data forms of block data, digital signature, hash function and Merkle trees.

The functional layer displays the main functions implemented by the platform, which include two major modules: transaction matching and credit update.

Taking the alliance chain platform of Hyperledger Fabric as the basic architecture and using Go language to complete the design of smart contracts, this study implements a blockchain-based trading matching system for aquatic products. On the basis of inquiring into related literature and industry information, sorting out the current transaction information on the well-known aquatic e-commerce platforms in China and investigating the needs of aquatic product trading enterprises through questionnaires, the experiment of this study was designed and conducted.

We assume that after both parties submit the supply and demand orders, the types of aquatic products provided in the supply orders can meet the demand and the differences between the trading parties only lie in other attributes such as quantity, price, freshness and weight. In this experiment, it is assumed that during the $T$ period, the system collected 5 pieces of data each from the supply and demand orders submitted by the sellers and buyers, as shown in Tables 2 and 3.

**Table 2.** Demand list.

| Buyer's company serial number | Breed | Amount | Price (￥) | Fresh | Weight (kg) |
|---|---|---|---|---|---|
| 1 | Lobster | 100 | 8000 | 3 | 20 |
| 2 | Lobster | 120 | 10,000 | 3 | 30 |
| 3 | Lobster | 400 | 32,000 | 3 | 110 |
| 4 | Perch | 200 | 5000 | 2 | 300 |
| 5 | Carp | 600 | 7000 | 2 | 400 |

**Table 3.** Supply list.

| Seller's company serial number | Breed | Amount | Price (￥) | Fresh | Weight (kg) |
|---|---|---|---|---|---|
| 1 | Crab | 100 | 3000 | 3 | 160 |
| 2 | Lobster | 120 | 10,000 | 3 | 30 |
| 3 | Carp | 400 | 1000 | 2 | 100 |
| 4 | Perch | 500 | 8000 | 3 | 600 |
| 5 | Crucian | 1600 | 10,000 | 2 | 620 |

## 5. Experimental results and discussions

### *5.1. Experimental results*

In order to verify the applicability of the model and smart contract framework proposed by this study, a prototype system was designed and developed with the alliance chain platform of Hyperledger Fabric as the underlying architecture, CouchDB as a status database in Hyperledger Fabric, SQL Server as the centralized database, Go language for the development of smart contracts, Vue framework for the design of the front-end interface, and JavaScript for the development of interaction between the front and the back end. The experimental environment was built using 64 bit Ubuntu, with Ubuntu version 16.04, memory size of 8 GB, disk space of 100 GB, Docker version 20.10.7 and Hyperledger Fabric version 1.4.4. The experiment is conducted with the prototype system and the specific experimental process and results are as follows.

**Step 1: Company registration and login**

The trading enterprises first register and fill in their enterprise information on the front-end web page and apply to join the blockchain. After receiving the application from the enterprise node, the blockchain supervision center will verify it, and the admission mechanism of the alliance chain is implemented through the CA center. Firstly, the enterprise node applies for a certificate from the CA center, and after obtaining the certificate, the enterprise node carries the certificate to apply for chain entry. Afterwards, the blockchain network will verify the authenticity of the certificate to the CA authority center and decide whether to agree to the enterprise node joining the blockchain. After verification, the system platform will verify the legality of the enterprise registration based on the submitted company name, social credit code and other enterprise information, ensuring that the unique social credit code is not duplicated and completing the enterprise registration authentication. Figures 6–8 display the blank registration, testing registration and login interface of the system, respectively.

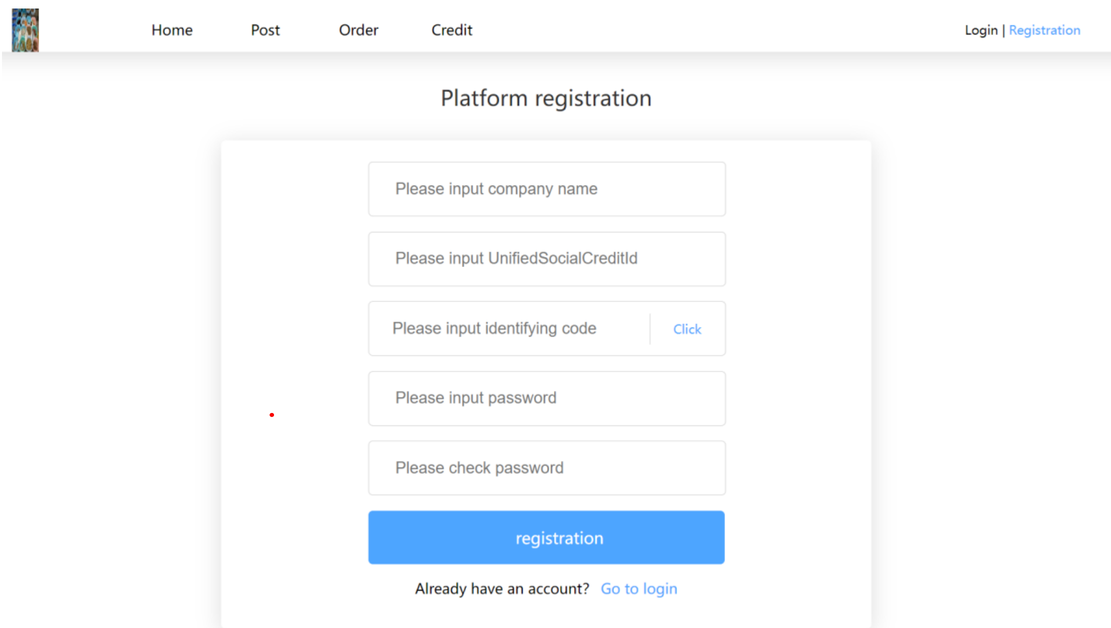



**Figure 6.** Company registration interface.

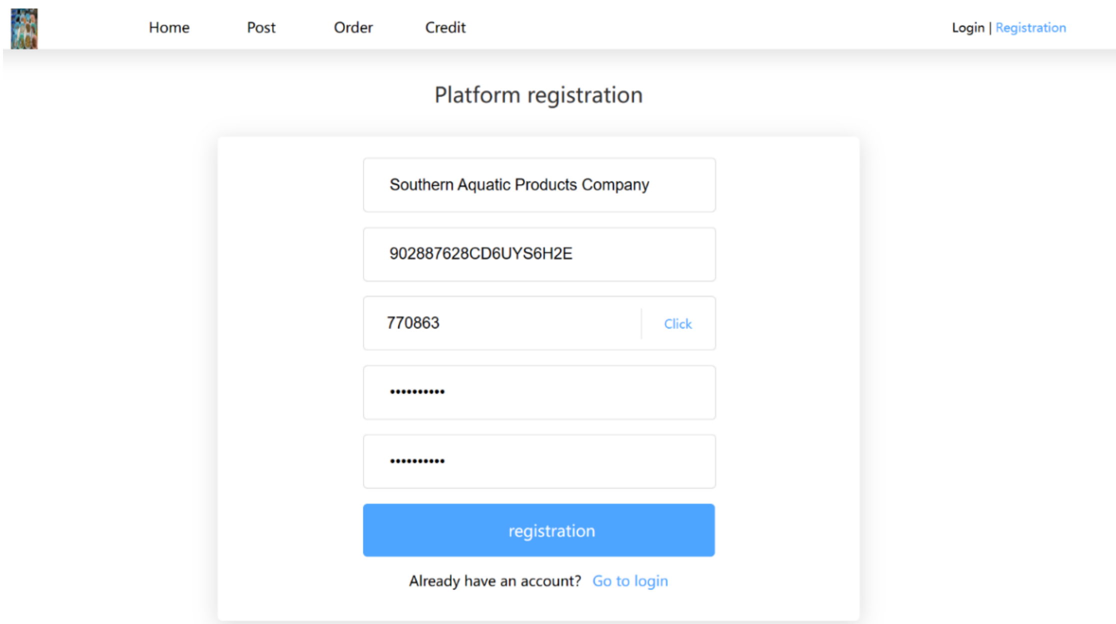



**Figure 7.** Company registration interface with testing data.

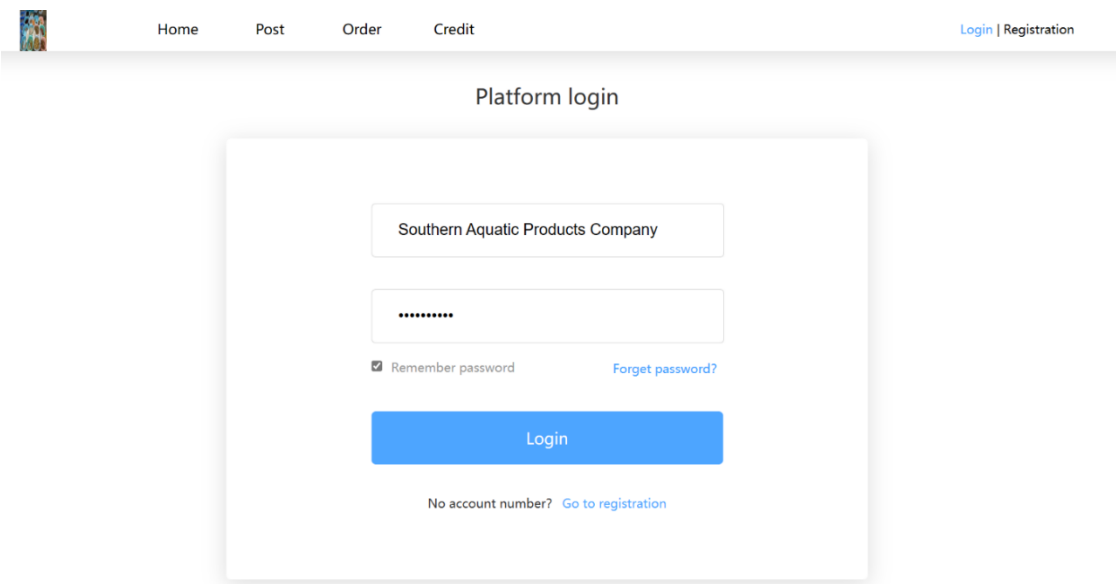



**Figure 8.** Company login interface.

**Step 2: Submit supply and demand list**

After logging in, the trading enterprises need to submit supply orders or demand orders. The sellers publish the corresponding supply order information, and the system verifies the validity of the supply order information through checking the legality of the product attribute fields. The verified supply order is uploaded onto the chain by the consensus of the blockchain distributed network. With the same process, the buyers release demand order information, and the system verifies the validity of the demand order information by checking the product attribute fields. The demand order that passes the verification is uploaded onto the chain by the consensus of the blockchain distributed network. These two processes are implemented through the similar system interface shown in Figures 9 and 10.

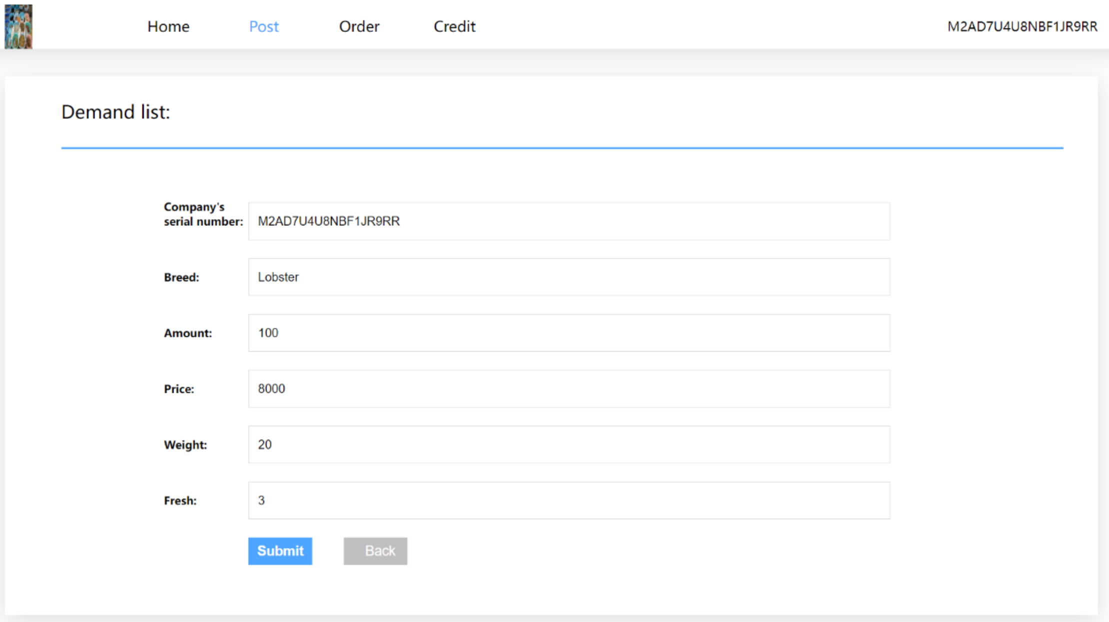



**Figure 9.** Submit demand list.

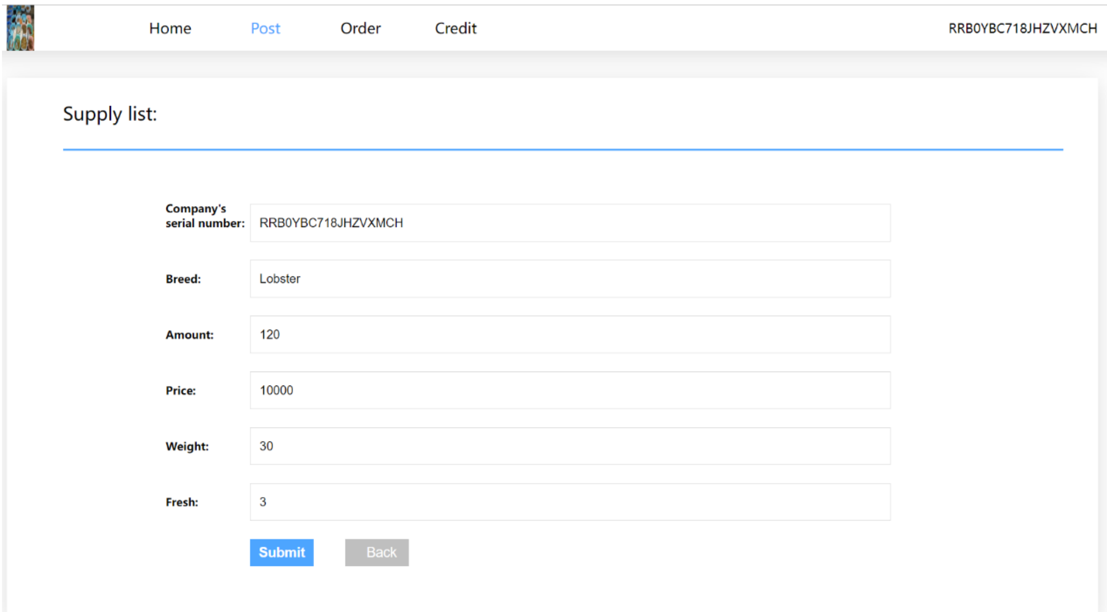



**Figure 10.** Submit supply list.

**Step 3: Transaction match**

The third step is to match the transaction after obtaining the supply orders and the demand orders. The system collects the supply orders and demand orders uploaded by the enterprises. After determining the priority of the traders, the supply-demand matching algorithm is employed to match the transaction, and the matching results are returned to the trading enterprises, with the specific matching results being displayed on the front-end interface. With the demand lists and supply lists in Tables 2 and 3 as the trading parties, their transaction results returned by the system are shown in Figure 11.

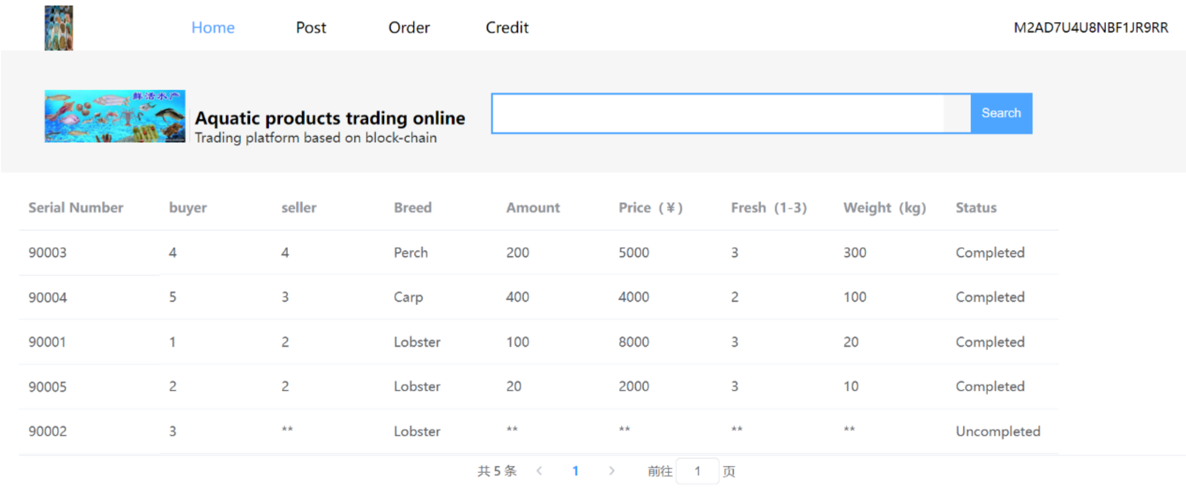



**Figure 11.** Transaction matching result interface.

**Step 4: Transaction confirmation and credit evaluation**

In the fourth step, when the matching results are displayed on the front-end page, transaction users can view the specific results of this transaction matching on the Order page and decide whether to accept the matching results, as shown in Figures 12 and 13, which are the Order page results for seller 2 and buyer 1, respectively. If both buyer 1 and seller 2 choose to confirm acceptance, the transaction is established, and a transaction contract is generated and then uploaded onto the blockchain through smart contract calls; if one of them choose not to accept, the two traders will fail this matching and the system will return to the Home page.

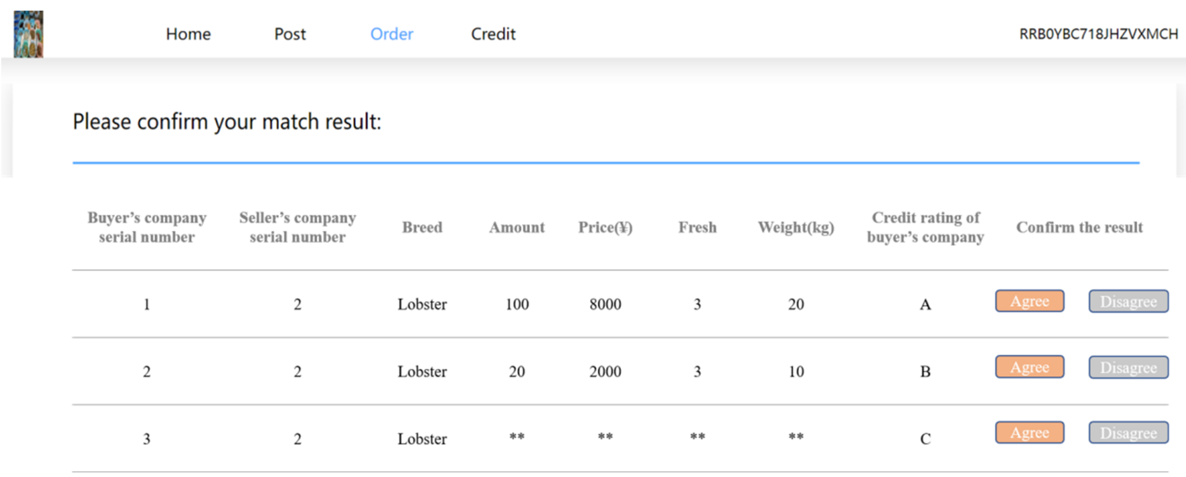



**Figure 12.** Transaction matching result interface for seller 2.

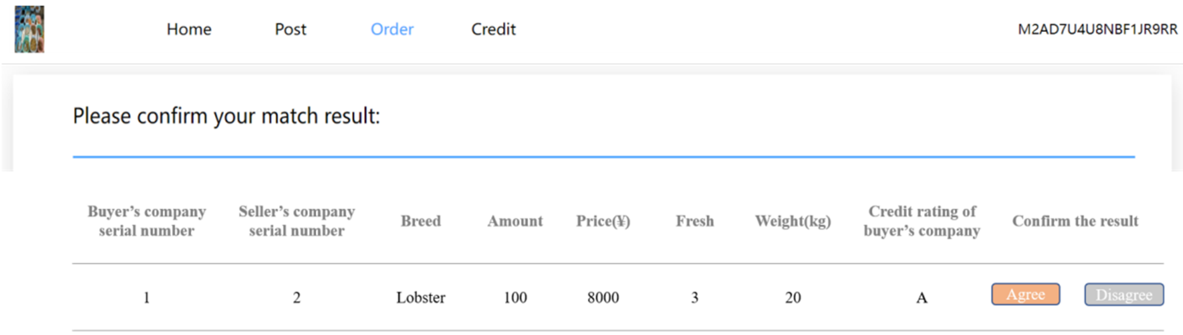



**Figure 13.** Transaction matching result interface for buyer 1.

After the transaction is completed, users can enter the Order page again to view the order list and conduct transaction evaluations, as shown in Figure 14. The platform then updates the enterprise credit information based on the submitted transaction evaluation information. Figure 15 displays the updated credit rating of buyer company 1 through this transaction with the transaction serial number 90001, which is automatically assigned by the system platform. The same token value of M2AD7U4U8NBF1JR9RR on the upper right corners in Figures 13 and 15 represents that the two web interfaces are accessed by the same company.

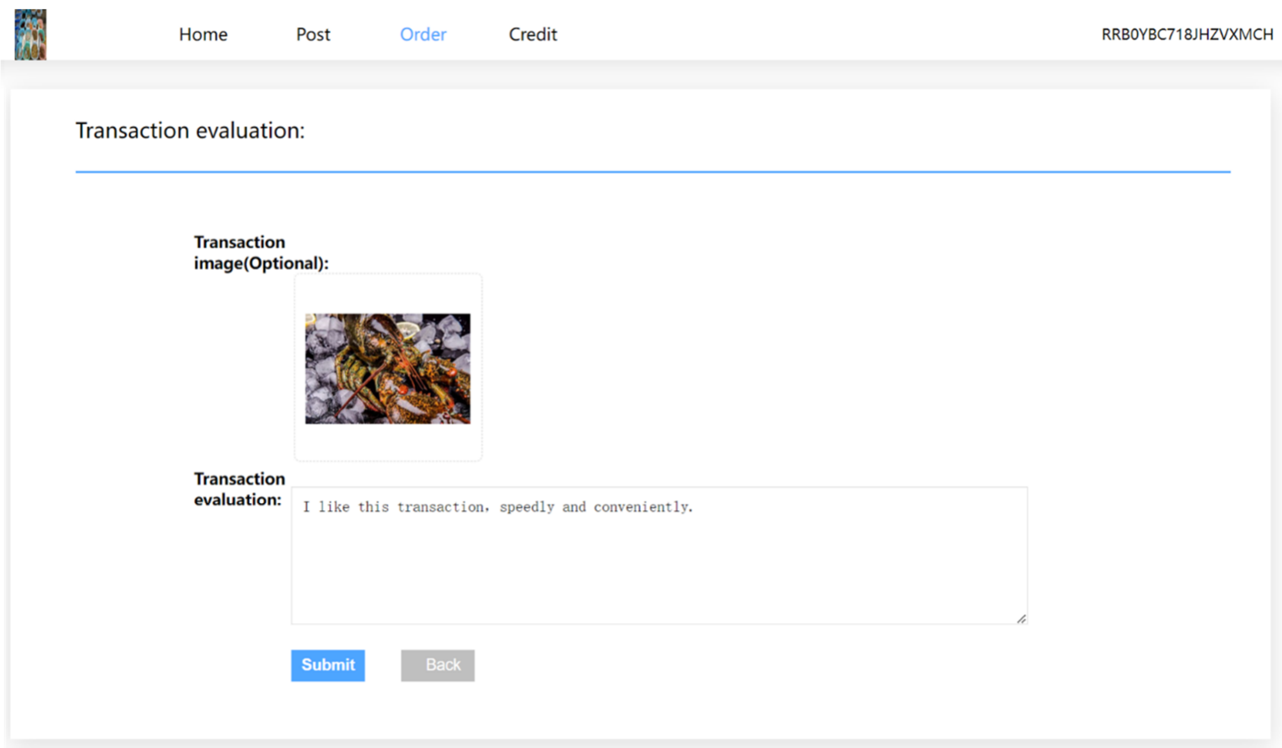
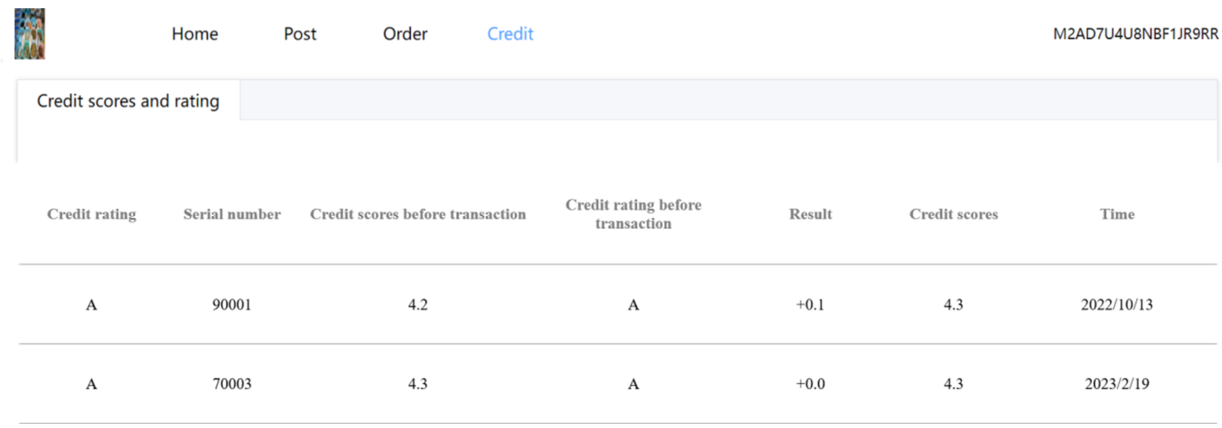



**Figure 14.** Transaction evaluation interface by seller 2.




| Credit rating | Serial number | Credit scores before transaction | Credit rating before transaction | Result | Credit scores | Time |
|---|---|---|---|---|---|---|
| A | 90001 | 4.2 | A | +0.1 | 4.3 | 2022/10/13 |
| A | 70003 | 4.3 | A | +0.0 | 4.3 | 2023/2/19 |

**Figure 15.** Credit scores and rating updates for buyer company 1.

### *5.2. Discussions on credit evaluation*

This experiment takes insufficient supply orders and excessive demand orders as an example to verify the update of the buyer's enterprise credit rating. Figure 14 displays the front-end interface of credit evaluation, where both parties submit their feedback information for this transaction. Trading companies can provide textual evaluations of this transaction and selectively submit related transaction images.

The serial numbers of buyer and seller enterprises are integer values randomly assigned by the system when the enterprises register with the system, as a substitute for the actual serial number of the enterprise. It can be seen from Tables 2 and 3 that buyer companies with serial numbers 1, 2 and 3 all have a demand for lobster, but only the seller company with serial number 2 can supply lobster. Through Figure 12, it can be seen that the buyer enterprise with enterprise serial number 1 has the highest credit rating (A) before the transaction, followed by the buyer enterprise with enterprise serial number 2 (B), and the buyer enterprise with enterprise serial number 3 has the lowest credit rating (C). The final matching result is that the buyer enterprise with serial number 1 obtained the optimal matching result with the fulfillment of a complete order list. The buyer enterprise with serial number 2 achieved the second transaction priority in the following matching step after the matching of the buyer enterprise with the highest credit rating was completed, and only part of buyer 2's demand list was fulfilled. The buyer enterprise with serial number 3, which has the lowest credit rating, failed to achieve any matching. For transactions with perch and carp, the matching results are normal as there are no insufficient supply-demand conflicts.

After completing this transaction with serial number 90001, based on evaluations of the traders, the credit score of the buyer company 1 has been updated by + 0.1, from 4.2 to 4.3, and its new credit rating is still A (see Figure 15). The new credit ratings will continue to affect the next round of matching transactions.

The experimental results have revealed that under the same conditions, enterprises with higher credit ratings will obtain better matching results, while enterprises with lower credit ratings will have a lower likelihood of obtaining the optimal matching results. Nevertheless, in the absence of credit mechanisms, all enterprises will be matched only based on the attributes of aquatic products, and all participating enterprises in the transaction matching have equal opportunities to obtain accessible trading partners even though some of them may have bad trading performance records.

Through this experiment, it can be concluded that the introduction of a credit mechanism has a certain improvement effect on the transaction matching results of aquatic products, which can to some extent reduce the risk of untrustworthy behavior in online transactions, solve the problem of credit deficiency between both parties in actual aquatic product online transactions, enhance practical applicability and thus bring better online trading experiences to e-commerce enterprise users.

*5.3. System performance testing*

Zhou et al. [43] took the optimal matching degree of particle swarm optimization (PSO) as the performance metric of the algorithm and compared the experimental results with those of traditional genetic algorithms. According to their experimental results, both particle swarm optimization and genetic algorithm ultimately obtained approximate optimal solutions. However, the convergence speed and efficiency of particle swarm algorithm are better, which proves that using particle swarm algorithm can improve the performance of the online trading system of aquatic products.

Wang et al. [44] built a system model based on an improved ant colony algorithm (ACO) based on historical state transition, and used the transaction matching success rate as a performance indicator to measure system stability. They calculated the success rate of each group of transactions by adding the number of transactions in different groups, and then calculated the global average transaction matching success rate. Based on the average transaction matching success rate of the final experimental test results, their proposed trading system has feasible stability.

This study optimizes the transaction matching process by introducing a credit mechanism. Prior to each transaction matching, priority trading rights are determined based on the credit ratings of both parties, thereby stimulating both parties to increase their own transaction credit value and obtain higher transaction priority permissions. The update of credit rating depends on the subjective transaction evaluation information of both parties, so the impact of a credit mechanism on transaction results cannot be well-measured through specific numerical values. The matching success rate and the optimal matching degree of transactions cannot effectively demonstrate the optimization effect of a credit mechanism on matching results.

In order to verify the effectiveness and practicality of the proposed online trading matching model and algorithm in this study, the system's carrying capacity for different scale transaction data volumes and the efficiency of transaction matching are used as performance metrics. Experimental results of the particle swarm optimization algorithm [43] and the improved ant colony algorithm based on historical state transition [44] are compared with the trading matching model for aquatic products based on blockchain and the credit mechanism proposed in this study, as shown in Figure 16.

It can be seen from Figure 16 that when the data volume is larger, the two trading models without a credit mechanism consume slightly less time than the method proposed in this study. However, when the transaction volume reaches a thousand pieces of trading data, the overall time consumption of the system is still less than half an hour, which is within a considerable transaction matching time range for the proposed method in this study. This indicates that the system can operate normally when processing over a thousand transaction data volumes, and the effectiveness and practicality of the algorithm can be guaranteed. Hence, compared with two other studies, the method proposed in this study does not significantly reduce efficiency while ensuring the volume of transaction data, and furthermore, it has effectively enhanced the credibility of both parties and facilitated their sustainable and healthy trading partnership.

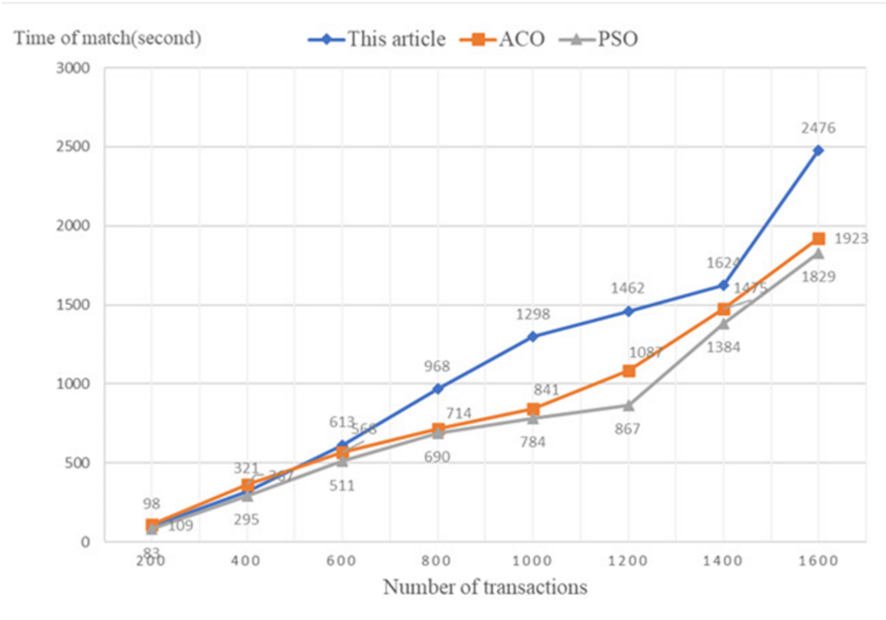



**Figure 16.** Comparison with ACO and PSO.

Under the experimental environment of Hyperledger Fabric, the framework of Caliper was used to test the performance of the trading matching system for aquatic products based on blockchain and credit mechanisms. When the transaction data volume was 5, 20, 100, 200, 500 and 1000, the completion time of transaction matching was tested. The system performance testing result was displayed in Figure 17.

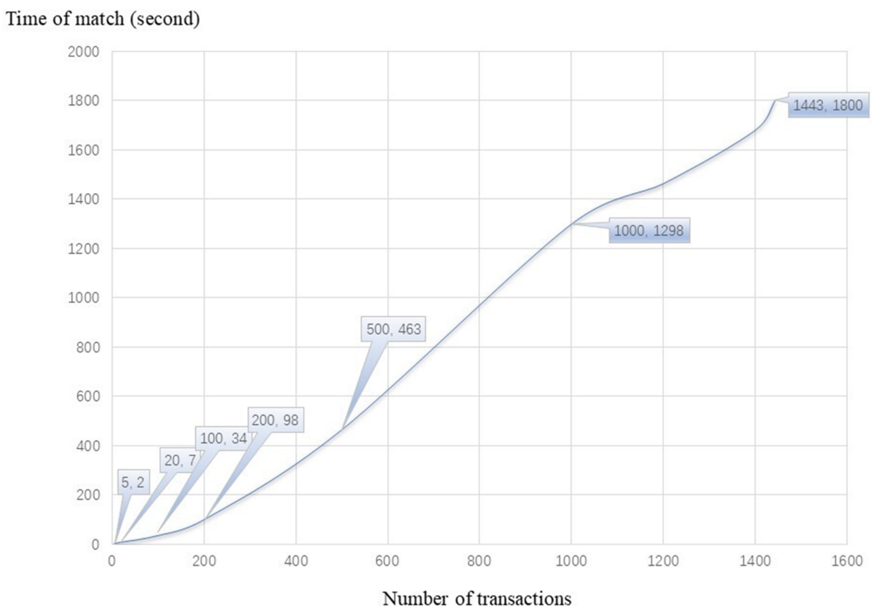



**Figure 17.** System performance testing.

It is shown by Figure 17 that within 1298 s (approximately 21.6 minutes), the system can complete up to 1000 transactions. At the same time, it can also be seen that as the volume of transaction data continues to increase, the time required for transaction matching shows an upward trend. Two hours are taken as one matching cycle (*T*) in this study, and the first 1/4 *T* time is 30 minutes, thus it is predicted by Figure 17 that during one matching cycle (*T*), more than 1000 transactions (1443 as the up limit) can be matched and processed by the system.

In the case of low transaction data volume (less than 100 transactions), the amount of transaction evaluation data is also small, and there are few credit data updates for both parties. The credit data is not sufficient to reflect the actual credit rating of the current transaction parties. Therefore, in this case, the transaction matching results after introducing a credit mechanism are not significantly different from the results of manually simulated transaction data, only reflected in the priority of the transaction. In the case of moderate data volume (100–200 transactions), some trading partners have already conducted a certain degree of transactions, and credit evaluation information can reflect the actual credit value of the trading partners. Therefore, the actual matching results of transactions are optimized compared to those without credit mechanisms. When the amount of transaction data reaches up to 1000, the system response time was close to the maximum transaction time limit set by the system (30 minutes). In the final simulation experiment, when the amount of transaction data reaches 1443, the matching time reaches the maximum transaction time limit of 30 minutes; namely, the method proposed in this study cannot presently handle transactions over 1443 well.

In the case of high data volume (201–1443), as the number of transactions increases, the credit evaluation information of both parties in the transaction becomes more objective. The transaction model based on credit mechanisms has more prominent advantages compared to ordinary blockchain-based transaction models.

In addition, in the matchmaking transaction model with a credit mechanism, it is necessary to train the semantic analysis model of credit evaluation before the initial transaction to ensure that accurate credit rating update data is obtained in the credit evaluation stage after the transaction. The training process takes about half an hour, which to some extent affects the operational efficiency of the entire system. However, it has little impact on the time cost of the transaction matching process and can basically meet the daily needs of actual online transactions.

## 6. Theoretical and managerial implications

At present, an increasing number of e-commerce trading platforms for aquatic products have highlighted that traditional aquatic product trading methods cannot meet the needs of the people's daily lives in today's society, and there is a lack of reasonable solutions to the various problems brought about by online trading.

Although Zhou and coauthors attempted to introduce intelligent matching algorithms into online aquatic product trading platforms [43], their research did not consider the technical security of trading information (such as uploading important information onto the blockchain) or the satisfaction feedback of both parties involved in the transaction. Wang and coauthors first combined the scenario of online matchmaking transactions for aquatic products with blockchain technology [44], but they only considered the technical security of transaction information, neglecting the satisfaction feedback of transaction experience and product quality that both parties value more. In the actual online transaction matching process of aquatic products, the efficiency and technical security of the matching platform are important concerns for both buyers and sellers. However, how to meet their specific transaction needs and ensure high satisfied transaction experiences and quality are also top priorities for both parties.

Therefore, based on research on existing blockchain-based transactions in aquatic products, this article introduces a credit mechanism and establishes an improved blockchain-based trading model for aquatic products. Through employing more efficient heuristic algorithms, the proposed method in this study has not only led to optimized matching results, but also provided transparent transaction evaluation and credit information for both parties involved in the transaction, effectively overcoming human and subjective intentional default behavior in the credit mechanism, reducing potential transaction risks that may arise from opaque transaction information and improving the transaction quality of online trading platforms and the satisfaction of both parties involved. Hence, the proposed method in this study can not only ensure the safety of online aquatic product matchmaking transactions in terms of technology, but also improve the benign and sustainable development of online matchmaking transactions through satisfaction evaluation from multiple aspects such as transaction modes, trading experiences and product quality, which is beneficial to building a positive online trading ecosystem for aquatic products.

The trading matching model for aquatic products based on blockchain and credit mechanisms proposed in this study has provided a novel and effective solution. It has brought substantial theoretical and managerial implications as stated below in detail.

Theoretically, this study has introduced blockchain into the online trading process of aquatic products and technologically ensured information security, matching efficiency and maintenance cost reduction, filling the current research gap of only employing blockchain into quality traceability processes of aquatic products without covering their entire supply chain. In addition, this study has integrated credit mechanisms into matchmaking algorithms in e-commerce trading platforms for aquatic products. Based on reviewing the historical transactions and performance of both parties, trading priority of sellers and buyers are determined before further matchmaking, which ensures the credibility of both parties. This has expanded and enriched the existing studies on the application of credit evaluation mechanisms.

Practically, the involvement of blockchain has ensured the data security of the entire trading matching process, including enterprise registration information, aquatic product information, e-contract, etc. Through the trading matching model for aquatic products based on blockchain and a credit mechanism, the online trading platform benefits by reducing supervision costs and improving matching efficiency. Furthermore, the credit mechanism can encourage both trading parties to leave and maintain good transaction records on the platform, in order to promote the sustainable and long-term development of good transaction relationships. This study has provided a novel approach and solution for online matchmaking transactions for aquatic products, and also brought innovative insights for efficient online transaction matching in other industries.

## 7. Conclusions

Online transaction matching models of aquatic products not only requires the authenticity, security and accuracy of the information during the transaction, but also should provide the best transaction matching results for both parties. As a distributed and decentralized technology, the blockchain can ensure data security, trading record traceability and user privacy protection. The aquatic product trading matching model and prototype system based on blockchain and credit mechanisms proposed in this study can ensure the security of trading enterprise information, product information and contract information, reduce the supervision cost and difficulty of aquatic product trading platforms, and provide an open, transparent and credible automated trading solution for e-commerce enterprise users. Nevertheless, the prototype system developed in this study has not been examined with large volumes of real transaction data, which will be the focus of the next research step. Moreover, the online transaction matching model and system of aquatic products based on blockchain and credit mechanisms may also be promising in other online trading scenarios.

## Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

## Acknowledgments

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## Conflict of interest

The authors declare there is no conflict of interest.

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