



Article

# Design of a Blockchain-Based Service Platform for Industrial Interconnection Supply and Demand Networks

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**Abstract:** With the continuous cross-border cooperation among industries, the concept of an industrial interconnection supply and demand network is constantly mentioned. As industry interconnectivity continues to grow, collaboration models have changed as companies work more closely with each other, and the synergy model has changed. In order to improve the efficiency of collaboration and to promote the free allocation of resources in the trading process of the industry interconnection supply and demand network, an industry interconnection supply and demand network resource matching platform based on the Alliance blockchain was built, steps for resource trading on the platform were proposed. Using blockchain technology's smart contract technology to simplify the transaction process, the triggering mechanism and algorithm rules of smart contracts in the trading process of the platform were designed, and the smart contract code was developed, deployed, and tested using Remix IDE, and the test results showed the transaction process between the supply and demand sides. Through blockchain technology, it achieves information security and transparency in the process of resource trading in the industry interconnection supply and demand network, establishes a trust mechanism on both sides of the transaction, reduces redundant steps in the transaction and improves the operational efficiency of the industry interconnection supply and demand network by increasing the efficiency of resource allocation.

**Keywords:** supply and demand network; smart contracts; synergy



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## 1. Introduction

At present, the development of information technology has led to great changes in the supply chain from physical form to operational mechanism, and the cooperation between chains has become closer. The needs of enterprise operation, the boost of supply side reform and the rise of industrial internet have all promoted the evolution of supply chain from chain to network. The development of industrial interconnection has led to changes in the system attributes, organisational components, boundary scope, etc., of the supply chain. As industrial interconnection continues to be applied in depth, it will bring about a reshaping of the entire supply chain architecture and a revolution in the paradigm of supply chain collaboration. This requires us to change the traditional mode of collaboration and explore new modes of collaboration for management, and to migrate from the traditional linear single chain to a non-linear network chain. The rapid development of the Internet has broken the space and time constraints of enterprises in the process of production cooperation, making cooperation between enterprises increasingly close, and promoting the flow of commodity production factors and the free allocation of resources. In Industry 4.0, vertical integration, horizontal integration and end-to-end integration are gradually being realised. The integration of customer needs is accompanied by cross-industry and cross-enterprise integration of resources, the establishment of a resource sharing system, improved efficiency and reduced production costs [1]. The theory of an industrial interconnection supply and demand network is to transform the perspective

of traditional supply chain management into a dynamic network model composed of supply and demand relationships [2]. Strengthening synergy and cooperation among enterprises within the supply and demand network and improving the multifunctional cooperation execution of enterprises can promote the formation of cooperation systems and the building of cooperation platforms [3]. Realizing the matching of supply and demand resources in the supply and demand network is the key issue for promoting enterprise cooperation under the supply and demand network theory. It has been argued that in shared manufacturing, the use of platforms to address the matching of supply and demand between manufacturing services and customers is a more desirable solution [4].

This paper proposes a third-party collaborative platform that can automate operations, reduce human intervention and invoke built-in algorithms for resource provisioning. At present, the research on the construction and operation of third-party platforms mainly focuses on the ASP (Application Service Provider) model and the SaaS (Software as a Service) model. Li Dakai studied the establishment of an enterprise management integration and information platform within an Internet of Things environment and proposes a mechanism and framework of resource integration, using web-based ASP technology to build an enterprise management information platform to realize the matching of supply and demand resources [5]. Allaoui H. proposed a collaborative decision-making framework for sustainable supply chain planning that facilitates the development of multi-party partnerships across networks, aiming to establish a set of collaborative centres in multiple supply chains. The authors developed the “Collaborative Planning Tool” (CPT) software system to plan multiple supply chains, combining different collaborative decisions to optimize costs [6]. Taking the mould industry as an example, Minbo Li designed an enterprise collaborative application platform to realize collaborative design and collaborative planning of moulds and to empower intelligent manufacturing. The platform uses j2ee technology to propose the process and steps of the collaborative application [7]. One of the common issues to be addressed by these cloud manufacturing service platforms is to realize the effective and intelligent supply–demand matching among various manufacturing resources and capabilities in the form of services [8]. However, the above third-party cooperation platforms have complex issues of element conversion in terms of quality assurance, monetary guarantee and credibility. At the same time, due to the scattered services and resources on third-party platforms, with different scales and structures it is difficult to establish a trust mechanism among platform participants. Therefore, an intelligent mechanism must be established to minimize or even eliminate the credit crisis among anonymous participants based on third-party cooperation platforms. The current solutions are different. Lei Wang and others believe that the credit problem of e-commerce platforms is serious; thus, they proposed a consumer-to-business-to-consumer (or MP-C2B2C) model based on a margin policy to strengthen trust supervision, but for e-commerce transactions. In this process, information about merchants and consumers is asymmetric, and merchants fully grasp the commodity information and are in a favourable position and, thus, there will still be certain trust problems [9]. Jing Chen et al. found that with the development of e-commerce platforms, information leakage and abuse frequently occurred, and the disadvantages were prominent. The article scored the autonomous rules of an online e-commerce platform business and used multiple parties to urge the platform to improve its autonomous rules. The method had a large cost in data collection and report analysis [10].

Blockchain technology is considered to be one of the most promising technologies in the information technology era and has broad application prospects in the field of smart manufacturing, such as distributed collaborative production and supply chain [11]. The emergence of blockchain technology is changing the way traditional supply chains are managed and can improve the traceability and accountability of complex supply chain networks [12]. Some scholars have concluded that blockchain has an enabling effect on supply chains from the technical, organisational and internal and external environment perspectives [13] by creating smart contracts, enhancing traceability and transparency, and having a significant positive impact on overall supply chain performance [14,15]. Moreover,

blockchain offers solutions in addressing trust mechanisms [16,17]. Almasoud A. S. proposed a smart contract-based reputation system framework that implements a reputation system based on Ethereum smart connections in order to transmit the reputation value of suppliers [18]. Blockchain is a distributed ledger that has applications in fields such as logistics. Unlike most existing information systems, blockchain has the following five characteristics: decentralization, openness, independence, security and anonymity. As scripts on the blockchain, smart contracts are executed in different subsections, similar to the laws and regulations that apply in transactions and contracts. According to pre-agreed terms and conditions, smart contracts can be executed securely, trusted, on-demand and under supervision. Research on using blockchain to build third-party platforms mainly focuses on the establishment of information systems. Zhu L. established a big data sharing model based on blockchain and developed an agricultural information sharing system combined with cloud computing [19]. Yuan proposed the supply chain management information system collaboration mechanism from the perspective of blockchain, designed the supply chain management information system platform architecture under the collaboration mechanism and provided a reference for performance improvement and a platform architecture design of a blockchain-based data trading systems path [20]. The above literature focuses on the fact that blockchain can facilitate supply chain management and take advantage of the security of blockchain's information storage to build information platforms, break down information barriers and better enable the noiseless flow of information. Different from the above studies, this paper integrates third-party platforms and various technologies of blockchain, using blockchain to solve the problem of trustworthiness of third-party platforms, and this paper proposes a cooperative platform based on coalition chain to trade resources (physical and virtual resources) from the perspective of business transactions, and designs a transaction process that mainly involves three types of participants, namely platform operators, resource demanders and resource suppliers. The allocation and scheduling of all resources are performed on the Alliance blockchain cooperation platform through its built-in algorithms, which are intelligent and automated without human intervention. Both the resource supplier and the resource demander are anonymous and will be satisfied with the scheduling and allocation of the Alliance blockchain cooperation platform.

The third-party platform based on the Alliance blockchain is not limited to the interaction of "products", but also covers many aspects involved in supply and demand online supply and demand flow such as information, funds, talents, technology (knowledge), facilities, management and corporate culture and resource interaction to meet the different supply and demand cooperation relationships of different nodes. Enterprises use the Alliance blockchain cooperation platform to realize the matching transaction and collaboration of supply and demand of manufacturing resources and capabilities. The resource supplier connects its manufacturing resources and manufacturing capabilities to the Alliance blockchain cooperation platform to form a resource pool, enabling the clouding of resources [21], integrating shared resources and encapsulating them [22]. At the same time, the resource demander sends tasks to the Alliance blockchain cooperation platform. The platform will store the requirement information in the task pool. According to the built-in algorithm of the smart contract, the relevant conditions are triggered to match resources with needs, so that the platform can run intelligently and automatically.

As a distributed database, blockchain is different from traditional databases and has the characteristics of decentralization, non-tampering, traceability and joint maintenance by multiple parties [23,24], while third-party cooperation platforms are an inevitable product of the cloudification of industrial interconnected resources. The efficient, secure and trustworthy characteristics of the blockchain are highly consistent with its needs. Combining blockchain technology with third-party platforms aims to solve the problems of supply-demand matching transaction agreement information traceability, transaction credit protection and protection of corporate users' data privacy on third-party platforms. The introduction of smart contracts into the transaction process of the third-party cooperation platform improves the credit mechanism of the trading platform. On the one hand, it can

provide a credible trading environment for enterprise users and ensure the security of supply and demand matching transactions under different trading modes and the interests of users; on the other hand, the application of blockchain in the platform avoids third-party intermediaries to ensure the credibility of transactions, which saves transaction costs and improves the response efficiency of the supply chain. The main contribution of this paper is to propose a blockchain technology-based trading platform for industrial interconnection supply and demand networks. Through a preliminary discussion on the application of blockchain in industrial interconnection supply and demand networks, we analyse the changes in the transaction mode of the alliance chain cooperation platform, explore how the alliance chain cooperation platform can formulate a corresponding smart contract to guarantee the fulfilment of the contract, build a third-party collaboration platform through blockchain technology, realise the collaboration in the business of supply and demand networks, achieve the purpose of effective resource replacement, improve the transaction efficiency of supply and demand networks, and thus enhance the reliability of platform transactions and solve the problems of information sharing and transaction trust of the third-party collaboration platform. Specific contributions include: (1) the design of a system architecture for a blockchain technology-based resource collaboration platform for industry interconnected supply and demand networks; (2) the development of a process for trading on the platform; (3) the design of smart contract rules to improve the efficiency of trading on the platform, thereby guaranteeing a more intelligent operation of the platform.

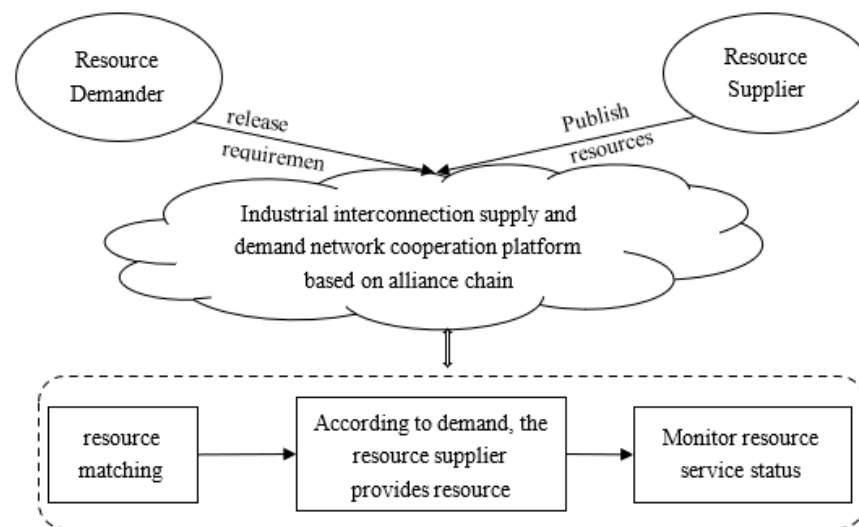
## **2. Blockchain-Based Industrial Interconnection Supply and Demand Network Transaction Mode**

In recent years, blockchain research has received widespread attention, and as application scenarios have become increasingly complex and varied, the focus of blockchain technology research has entered the application-oriented blockchain 2.0 era. In order to enable users to customise and develop suitable script code according to their own application scenarios, there is a higher demand for code that can be flexibly designed according to the scenarios. Therefore, the Ethereum platform, developed based on blockchain technology, is gradually coming into the public eye. The Ethereum platform is a Turing-complete public blockchain technology platform, and is the first to support the development and application of Smart Contracts. Users can use blockchain technology as the underlying support technology to write smart contracts to meet the logic of cooperation between devices or nodes in the application according to their needs, and finally realize a decentralised application built on Ether as the blockchain technology platform and using smart contracts as the means to achieve the function.

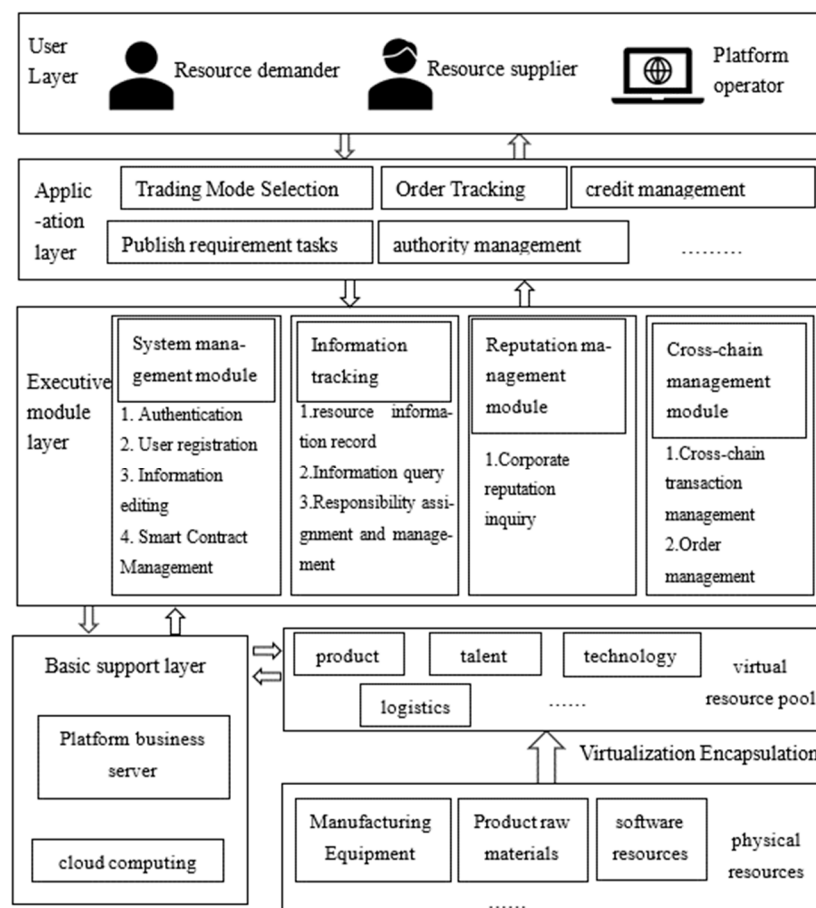
In the blockchain-based industrial interconnection supply and demand network transaction model, three types of participants are mainly involved: resource providers, resource demanders and Alliance blockchain cooperation platforms (hereinafter referred to as “platforms”). The allocation and scheduling of resources are all conducted on the platform based on its built-in algorithms. The industrial interconnection supply and demand network cooperation framework based on the Alliance blockchain platform is shown in Figure 1. The demand side releases requirements on the platform and the supply side posts proposals based on the requirements, thus matching resources.

### *2.1. Platform Framework*

In order to enable the matched supply and demand parties to achieve a series of cooperative events, such as resource matching in a safe, real and reliable environment, and to improve the degree of platform automation, the platform system architecture diagram based on the Alliance blockchain was constructed according to Figure 1, as shown in Figure 2.



**Figure 1.** The cooperation framework of the industrial interconnection supply and demand network based on the Alliance blockchain platform.



**Figure 2.** System architecture of the industrial interconnection supply and demand network resource matching platform based on the Alliance blockchain.

- (1) User layer: this layer is the identity mapping of different types of users on the platform. Different identities have different functions and powers on the platform, and they are divided into resource demanders, resource suppliers and platform operators;
- (2) Application layer: this layer is a system application corresponding to the identity of the user at the user layer. Users from different perspectives use various application

functions of the platform to achieve their own needs and tasks through the platform's various terminal interfaces. The applications on the demand side and the supply side include Trading Mode Selection, Publish requirement tasks, and Order Tracking. The applications of the platform operator include authority management and credit management;

- (3) Execution module layer: this layer includes multiple execution modules that implement the various application functions of the application layer. These modules are divided according to the theme of the system tasks that need to be performed to realize these application functions, mainly including the system management module (including authentication, user registration, information editing, smart contract management, etc.), the information tracking module (including resource information recording, information query, responsibility assignment and management, etc.), the reputation management module (including the industry's own reputation query and the reputation query of other companies wishing to cooperate) and the service resource management module (cross-chain transaction management, order management, etc.);
- (4) Basic support layer: this layer is composed of related technologies and servers that support the operation of the platform including platform business servers, cloud computing technologies and blockchain databases. Among them, the blockchain section is used to store historical factual information about the business object before it reached its current state, including all versions of changes and how they were made. Blocks are linked into a chain by hash pointers, and each block is formed by packaging a series of endorsed transaction proposal responses in a defined order through an ordering service.
- (5) The virtual demand pool cloud platform connects physical resources such as manufacturing equipment, product raw materials and software resources to the network through the use of resource-aware technology, defines manufacturing services for physical resources and encapsulates them as virtual services, and finally converges them in the cloud platform to form a virtual resource pool so that the appropriate manufacturing services can be invoked when supply and demand are matched.

## 2.2. Transaction Process

According to the system architecture of the Alliance blockchain-based industry interconnection supply and demand network resource matching platform, the transaction process formed by the node supply and demand sides in industry interconnection supply and demand network trading on the platform occurs in three stages: matching the transaction object, formulating the smart contract stage and executing the smart contract stage.

### (1) Matching transaction objects

The supply and demand network of the industry interconnection consists of different enterprises,  $E = \{e_1, e_2, \dots, e_n\}$ , where  $e_n$  is the node enterprise of the industry interconnection, which gains profit by satisfying the demand of other enterprises in the supply and demand network. Demand is described by  $D_{nt} = \{q_n, t\}$  with  $q_n$  denoting the resources demanded by the enterprise, and  $t$  denoting the time specified to complete the demand. Each firm evaluates demand,  $D_{nt}$ , according to its own resource capacity  $m(D_{nt})$ . If the resource capacity of an enterprise is greater than the current quantity demanded (i.e.,  $m(D_{nt}) > q_n$ ), it is defined as a resource supplier,  $e_i$ ; conversely, it is defined as a resource demander,  $e_j$ .  $E$  contains two sets of resource suppliers and resource demanders: the set of resource suppliers,  $E^+ = \{e_i | e_i \in E, m(D_{nt}) > q_n\}$ ; the set of resource demanders,  $E^- = \{e_j | e_j \in E, m(D_{nt}) < q_n\}$ . Enterprises enter the platform with no pre-defined identity of being on the supply or demand side. The dynamic selection of the enterprise identity of the resource is carried out based on the demand posted by other enterprises.

The resource demand side releases the demand task in the resource matching platform of the industry interconnection supply and demand network,  $D_{jt} = \{q_j, t\}$ . The resource supplier gives a resource supply proposal according to the demand,  $P_{iDjt} = (s_{it}, t^{lt}(s_{it}), c_{it})$ ,

where  $s_{it}$  indicates the available resources;  $t^{tt}(s_{it})$  indicates the time required to supply the resource;  $c_{it}$  indicates the proposed cost required for this proposal. The demander of the resource chooses the object of the transaction according to its preference, and both parties reach a consensus on the transaction.

## (2) Formulating smart contracts

After the supply and demand matching parties are identified, the platform negotiates and collaborates on the business process according to the arrangement between the supply and demand parties. At this time, the supply and demand parties can only negotiate the costs in the proposal, and after a consensus, the platform makes the relevant contract for the matching transaction parties. The contract mainly includes the price negotiation contract, the deposit delivery contract and the order transaction contract.

**Price negotiation contract:** this contract involves a price negotiation process between the two parties involved in the transaction. According to the proposal, the demand side chooses whether to accept the proposed cost; if not, the two sides negotiate the price to reach an agreement to determine the final transaction price.

**Deposit delivery contract:** After the price negotiation is determined, a deposit is charged to both parties involved in the transaction for the order, based on a percentage of the total transaction amount, and it is temporarily held by the platform party.

**Order transaction contract:** once the negotiated price is confirmed, the demander of the resource can purchase the required resource through this smart contract. The supplier sends a purchase order to the demander for delivery of the goods at the agreed upon price. Once the goods are delivered, the order is closed. To prevent both parties from not completing the treaty (i.e., defaulting on the contract), the supply and demand sides deliver a deposit to the platform before the order is transacted. If the order is successfully completed, the supply side deposit is returned and the demand side deposit is converted into a portion of the transaction amount and delivered to the supply side together. If the transaction fails due to the fact of a certain party, the deposit of that party will be deducted and the defaulting party's deposit will be refunded to the non-defaulting party together with the non-defaulting party's deposit.

With the agreement of both the supplier and the demander, a smart contract is generated according to the contract content, and the chain code where the smart contract is located is packaged into a chain code package, which is signed by the cloud manufacturing service platform, the manufacturing service demander and the manufacturing service provider with private keys. Finally, the signed chain code package is installed and instantiated on the designated peer node (i.e., a node in the organization; the default is a bookkeeping node, and some bookkeeping nodes are endorsing nodes, master nodes and other nodes with special responsibilities).

## (3) Execution of smart contracts

After the demander or supplier of resources issues a demand task or supply solution, the platform invokes a smart contract to automatically execute the relevant rules, including contract transactions and default transactions, and these transaction terms are recorded as historical transaction orders and stored in the blockchain ledger. Supply and demand parties can check the personalized information published on the platform by virtue of their identity IDs such as order progress information, deposit information, delivery acceptance and after-sales follow up. Each transaction generates a credit record based on the transaction records of both parties and updates the matching credit score in their user information, which helps the resource demander choose a transaction partner according to their preference.

## 3. Reputation Management-Based Matching of Transaction Objects

Reputation management is responsible for determining the reputation of each stakeholder on the supply and demand network, achieved by referencing data stored on the blockchain from previous transactions. Reputation information stored on the blockchain



is difficult to tamper with, and the credibility of its reputation index is greatly enhanced. Reputation management requires the demander to rate the satisfaction of the supplier of that task after receiving an order and receiving the service. This metric will be used as the main parameter to calculate the final reputation level of the supplier.

It is assumed that when a resource demander posts a demand task on the platform, more than one resource provider offers a proposal, and the demander can select one of them to work with based on reputation management. The calculation of reputation management consists of three main indicators: delivery performance indicators, average satisfaction and a composite cooperation selection index. As shown in Equation (1),  $R_i$  denotes the reputation index of the supplier;  $P_i$  denotes the delivery performance indicator of the supplier;  $S_i$  denotes the average satisfaction of the supplier; and  $C_i$  denotes the overall cooperation selection index of the supplier. The values of each of these three indicators range from 0 to 100; therefore, the final reputation index also ranges from 0 to 100.

$$R_i = \frac{P_i + S_i + C_i}{3} \tag{1}$$

The rules for calculating the three sub-indicators are as follows:

$$P_i = 100 \times \frac{M_{isuc}}{M_{iall}} \tag{2}$$

$$S_i = \frac{\sum_{m=1} \sum_{n=1}^{N_{jmi}} S_{jmin}}{\sum_{m=1} N_{jmi}} \tag{3}$$

$$C_i = \frac{1}{n} \times \sum_{m=1} \left( 100 \times \frac{N_{jmi}}{N_{jm}} \right) \tag{4}$$

In Equation (2),  $M_{isuc}$  denotes the number of times that supplying party  $i$  successfully completes a demand task, and  $M_{iall}$  denotes the total number of tasks accepted by supplying party  $i$ . According to the calculation of the delivery performance indicator, it can be seen that each correct completion of a demand task will increase the credibility of the resource supplier to some extent, while failure will decrease their credibility. In Equation (3),  $N_{jmi}$  denotes the number of times demand side  $j$  ( $j = 1, 2, 3, \dots$ ) cooperates with supply side  $i$ .  $S_{jmin}$  denotes the satisfaction rating given by demand side  $j$  to supply side  $i$  after each cooperation ( $0 \leq S_{jmin} \leq 100$ ). In Equation (4),  $N_{jmi}$  denotes the total number of demand tasks issued by demand side  $j$ . The ratio of  $N_{jmi}$  and  $N_{jm}$  is the proportion of demand side  $j$  choosing supply side  $i$ , reflecting demand side  $j$ 's preference for cooperation with supply side  $i$ . The ratio of  $N_{jmi}$  to  $N_{jm}$  is the ratio of demand side  $j$  choosing supply side  $i$ , reflecting demand side  $j$ 's preference for cooperation with supply side  $i$ . The composite cooperative choice index,  $C_i$ , is obtained by adding up the ratios associated with all demand-side cooperation with supply side  $i$  and dividing them by the number of demand-side parties.

By calculating the three sub-indicators, a final reputation index,  $R_i$ , for the supply side can be derived, and the demand side can refer to  $R_i$  to select the supply side and its proposal.

#### 4. Smart Contract Triggering Rules and Design

##### 4.1. Trigger Rules for Smart Contracts

In the Alliance blockchain-based industry interconnection supply and demand network resource matching platform, smart contracts are designed for the matching of supply and demand resources. When the platform receives a trigger event from the relevant code, it will read and call the code from the database within the platform and trigger the execution of the smart contract. Various transactions in reality trigger the smart contract and invoke its automatic execution, resulting in the transfer of funds between different parties. Various transactions, in reality, trigger the smart contract and invoke its automatic execution, resulting in the transfer of funds between different parties. These smart contracts introduce



many opportunities to implement and enforce financial transaction rules without relying on trusted third parties. The mechanical execution of code in smart contracts replaces manual monitoring and provides a transparent, de-trusted service delivery mechanism that does not require human intervention. These contracts can be programmed to perform functions automatically without interference from third parties. They act as software agents, ensuring that all stakeholders in the platform comply with the terms and conditions set out in the contract.

The platform is set-up as a system captured as a series of functions and events in a sequence diagram, where the interactions between each stakeholder and the contract are captured as shown in Figure 3. Firstly, the platform allows each member of the supply and demand network to register on the platform for information sharing on supply and demand flows. The demand side posts a demand task on the platform, the supply side offers a corresponding solution and the demand side makes a selection to reach an initial consensus on cooperation. The demand side then initiates a new price negotiation contract for a specific product or group of products in the demand task. The supply side uses the Contract Price Negotiation () function to negotiate and provide a new supply side desired transaction price. The demand side confirms or rejects the proposed price using the contract status () function. When the contract is confirmed, an event is then triggered to notify all stakeholders in the network using the contract confirmation () function. The successful contract is then uploaded to the decentralized storage system and published to the supply side. Stakeholders are then notified of the successful completion of the contract agreement using the contract completion () function. The demand and supply sides simultaneously trigger the order delivery contract and deliver the deposit to the platform side. Both parties can check the Contract Deposit Delivery () function to see if they have reached an agreement on the transaction. The demand side is then allowed to place an order using the submit order () function in the purchase order contract. The supplying party delivers the order when the delivery status () function is provided. Once the order has been successfully delivered, Contract Order Delivery () function is used to trigger an event.

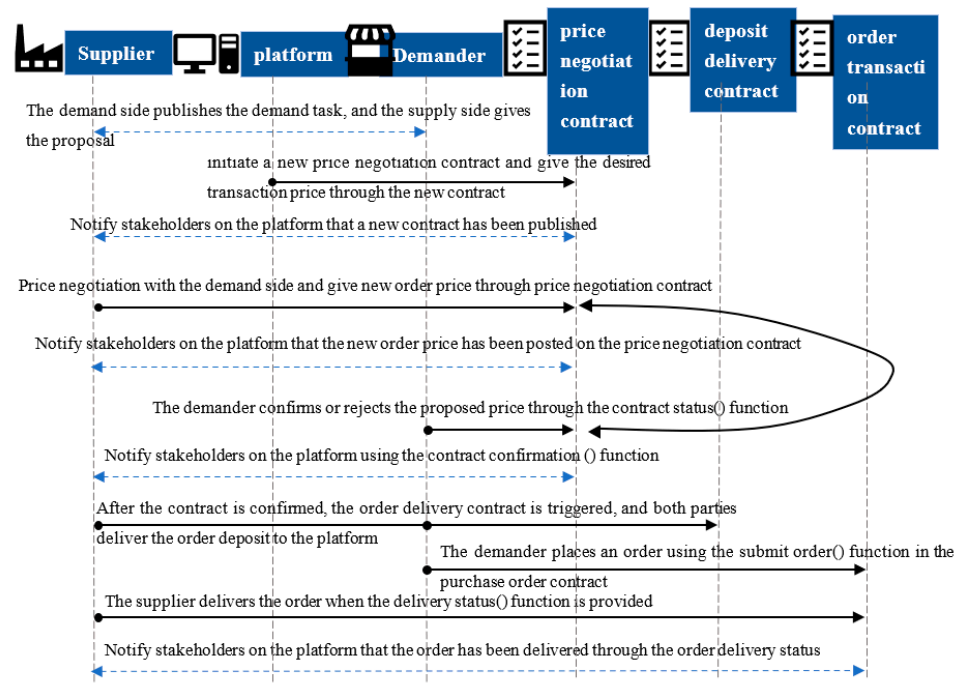


Figure 3. Function calls and events for stakeholder smart contracts in the platform.

#### 4.2. Design of Smart Contracts

The demand side posts the demand task on the platform, the supply side provides a proposal and the demand side chooses the most suitable proposal among the various proposals given to reach an initial sense of cooperation. As shown in Algorithm 1, the supply and demand sides negotiate the price. The demand side can accept or reject the initial offer from the supply side, and if it is rejected, the demand side gives its budget range, and through back and forth communication, the price of the demand task is finally determined. Once the price is determined, the status of the price negotiation contract is changed to completed, the matching channel between the task and the proposal is closed and the transaction officially starts. Once the transaction officially starts, both parties need to deliver 10% of the amount of this transaction as a deposit to the platform side as shown in Algorithm 2. If the deposit is not delivered, it is considered a breach of contract and impacts on the credit of the defaulting party. If both parties pay the deposit, the order status is changed to open. The supplying party delivers resources such as goods or services. When both parties complete the delivery, the demander pays 90% of the transaction amount to the supplier, and the order status is shown as completed. According to the completed order status, the platform delivers the prepaid deposit from the demand side to the supply side, completes the whole transaction between the supply and demand sides and returns the prepaid deposit from the supply side, as shown in Algorithm 3. If either party defaults after the deposits are delivered, the platform delivers the deposit of the defaulting party and the deposit of the non-defaulting party to the non-defaulting party as compensation and the transaction will be closed.

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#### Algorithm 1: Contract Price Negotiation

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Input:  $P_{IDjt}$ , request price

```

1  if contract is newly created and Price (P) was rejected by the Demander then
2      Demander gives the budget range for the Supplier
3      if the range is accepted then
4          Supplier offers a Price (P) again
5          if Demander accepts the Price (P) then
6              Change the contract status to confirm the Price (P)
7              The new order is formed
8              Trigger price confirmation event
9          else close the contract //reselect new Supplier
10     else close the contract
11 else change the contract status to confirm the price
12 The new order is formed
13 Trigger price confirmation event

```

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**Algorithm 2:** Contract Deposit Delivery

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```

1  contract status( ) is announced to the stakeholders
2  Deposit_D = Price * 10%
3  Deposit_S = Price * 10%
4  Demander pays the Deposit_D to the Platform
5  Supplier pays the Deposit_P to the Platform
6  if Deposit_D and Deposit_S is delivered successfully then
7      | Change the Order status
8  else confirm the Deposit delivery status of both
9      if one party refuses to pay the Deposit then
10         | Platform returns Deposit_D and Deposit_S to the other party
11     else Demander and Supplier refuse to pay Deposit_D and Deposit_S
12         close the order
13         announce order status( ) = unaccomplished

```

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**Algorithm 3:** Contract Order Delivery

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```

Input: Order number
1  if the Demander requests the transaction to order
2      | if the Supplier receives the request then
3          | Remaining_Price = Price *90%
4          | Demander pays Remaining_price to Supplier
5          | Demander announces the order is accomplished
6          | Change order status( )
7          | Platform check order status
8          | Platform pays Deposit_D to the Supplier
9          | Platform returns Deposit_S to the Supplier
10         | end
11     else Platform pays Deposit_S to the Demander
12         | Platform returns Deposit_D to the Demander
13         | Close Order
14         | announce order status = unaccomplished
15 Else Platform pays Deposit_D to the Supplier
16     Platform returns Deposit_D to the Demander

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### 5. Assessment and Testing

#### 5.1. Assessment of the Reputation Index

Suppose demander  $j_1$  receives proposals from suppliers  $i_1, i_2$  and  $i_3$  in total and gives the same proposal for supply side selection based on reputation management. Demand side  $j_2, j_3$  and  $j_4$  have previously worked with supply side  $i_1, i_2$  and  $i_3$ . The results of the reputation calculations for supply side  $i_1, i_2$  and  $i_3$  are shown in Table 1.

The reputation index of the supply side will be different when the value of each parameter varies, and the results can reflect the true reputation level of the supply side to a certain extent. With a reasonable reputation calculation to assess the supply side, the data are recorded and updated by the platform in the supply and demand network trading project, and the behaviour of the supply side will directly affect the change of its reputation. When selecting partners in the future, reputation will be used as an important reference for selecting matches, and due to the non-tamperable nature of blockchain data, each enterprise will strive to maintain its reputation.

A composite reputation index for the three suppliers can be calculated based on delivery performance indicators ( $P_i$ ), average satisfaction ( $S_i$ ) and a composite cooperative choice index ( $C_i$ ).

For supply side  $i_1$ , a total of 12 orders were received and 9 orders were successfully completed, so the delivery performance indicator is  $P_i = 100 \times \frac{9}{12} = 75$ .

The number of times the demand sides cooperated with  $i_1$  and the evaluation of each cooperation are shown in Table 2.

**Table 1.** Test data for reputation calculation method.

Supplier		$i_1$	$i_2$	$i_3$
$M_{isuc}$		9	9	8
$M_{iall}$		12	10	11
$N_{jmi}$	$N_{j1i}$	3	2	3
	$N_{j2i}$	2	4	4
	$N_{j3i}$	5	3	0
	$N_{j4i}$	2	1	4
$S_{jmin}$	$S_{j1in}$	n = 3 S = {90,85,89}	n = 2 S = {97,89}	n = 3 S = {80,85,90}
	$S_{j2in}$	n = 2 S = {93,88}	n = 4 S = {90,94,75,83}	n = 4 S = {74,90,87,83}
	$S_{j3in}$	n = 5 S = {90,85,89,80,94}	n = 3 S = {90,95,92}	-
	$S_{j4in}$	n = 2 S = {87,92}	n = 1 S = {91}	n = 4 S = {83,90,88,71}
$N_{jm}$	$N_{j1}$		8	
	$N_{j2}$		10	
	$N_{j3}$		8	
	$N_{j4}$		7	
$P_i$		75.00	90.00	72.73
$S_i$		88.50	89.60	83.73
$C_i$		37.14	29.20	33.66
$R_i$		66.88	69.60	63.37

**Table 2.** Number of times demanders have worked with  $i_1$  and satisfaction ratings.

Demander	Number of Collaborations	Satisfaction Ratings
$j_1$	3	{90,85,89}
$j_2$	2	{93,88}
$j_3$	5	{90,85,89,80,94}
$j_4$	2	{87,92}

Therefore, the average satisfaction is

$$S_i = \frac{90 + 85 + 89 + 93 + 88 + 90 + 85 + 89 + 80 + 94 + 87 + 92}{12} = 88.5$$

The number of times the demanders traded is 8, 10, 8, and 7; where the number of times  $i_1$  is chosen as the object of trade is 3, 2, 5, and 2. According to Equation (4),

$$C_i = \frac{1}{4} \times \frac{3}{8} + \frac{2}{10} + \frac{5}{8} + \frac{2}{7} \times 100 = 37.14$$

Therefore, the reputation index of supply side  $i_1$  is to find the average of the above three indicators as 66.88.

Similarly, the supply side  $i_2$  and  $i_3$  reputation indicators are calculated as shown above.

The parameters and the results given by the current test data show that the supply side  $i_2$  has the highest reputation index. Different values for each parameter have an impact on the reputation index of the supply side. According to this method of calculating the reputation index, the reputation of the supplier can be assessed more objectively and reasonably. When supply and demand network business transactions are selected for the supply side, the recording and updating of data is controlled by a smart contract and the service of the supply side will directly influence the change in its reputation. In this way, the credit of the supplier in the supply and demand network can be automatically assessed.

When selecting a partner, the demand company uses the reputation index of the supplier as a reference. Thus, with such a control mechanism, each firm will strive to maintain its own reputation. The process of constant change of the reputation index is done by trusted intelligent contracts without human intervention, ensuring the authenticity and credibility of the information. The reputation evaluation strategy also allows for better monitoring of business integrity, contributing to the health of the supply and demand network.

### 5.2. Testing of Smart Contracts

Smart contracts are deployed and transacted on the Remix IDE, which provides a richer environment for deploying and testing smart contracts and providing feedback on each transaction and exception handling function, as it matches the two sides of the transaction and determines the transaction. The Remix IDE provides details of each ethernet transaction including the sender’s address, call parameters and output. The Remix IDE’s exception handling messages include runtime errors and constraints set by the smart contract.

Figure 4 shows details of a demander posting a demand task. As can be seen, the address of the supplier has not yet been determined, as it is currently in the state of posting a demand task, the blockchain address of the demander and the number of demands are shown. However, because matching of supply and demand has not yet taken place, and price negotiations have not yet begun, thus, the price is also shown as 0. The supplier has not yet been determined, and the price has still not been proposed.

Then, after the supplier has been identified, the supplier submits a proposed price on the proposal. Figure 5 represents the price negotiation event between the two parties, which is triggered when the supplier proposes the first proposed price, and the demander can choose whether to accept the proposed price (i.e., newPrice:1200 in the figure) from the supplier or, if not, to continue the negotiation until both parties agree on the price.

Both sides of the transaction deliver the deposit of the transaction to the platform, and the delivery of the transaction amount takes place after the transaction is completed by both sides. If the transaction is successfully completed, the deposit from the supply side will be returned, and the demand side will pay the transaction amount.

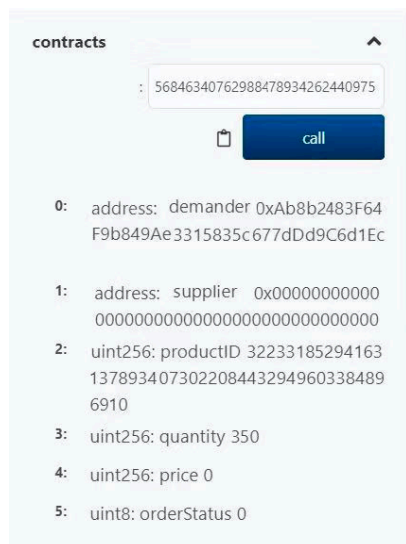


Figure 4. Contract specific information for demand task release.

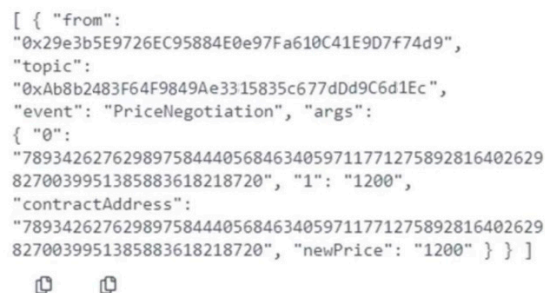


Figure 5. Price negotiations between supply and demand.

### 6. Discussion

Build a third-party platform for matching resources of the industry interconnection supply and demand network, and use blockchain technology to solve the major information security problems of data availability, trustworthiness and malicious attacks on the third-party platform.

Transparency: Apart from the private information of both sides of the transaction, which can be selectively encrypted, other specific data such as transmission volume are open to the blockchain, which allows node enterprises to know the data in real time and synchronise the updated data with each node, ensuring the data is real-time and transparent. Timestamps even guarantee the authenticity and reliability of the data. Stakeholders on the third-party platform can view the real historical data of the relevant transactions.

Anonymity: the personal data of each participant is kept highly confidential. Both parties involved in a transaction exchange information by address and only the node with the private key has access to the relevant information. The advantage of anonymity is that only the information of both parties to the transaction is effectively protected, without affecting the real-time data information.

Security: Asymmetric cryptography and consensus algorithms make third-party platforms resistant to malicious attacks, and secondly, distributed ledgers make it possible for the overall system not to be affected by one node going out of control.

Intelligence: Smart contracts can automatically identify and judge execution conditions, reducing human intervention, improving the accuracy of process processing and operations, simplifying processes, reducing transaction steps and lowering input costs.

## 7. Conclusions and Future Research

This paper combined blockchain technology with an industrial interconnection supply and demand network and built an industrial interconnection supply and demand network matching platform based on Alliance blockchain. It discussed the structure of the platform, the transaction mode and the processes required when the demand side, the supply side and the platform side conduct a transaction. In addition, a reputation management evaluation system for the supply side was developed to effectively help the demand side select supply proposals, and rules for triggering smart contracts and internal transactions were designed.

With “supply and demand” as the main motivation, the industry interconnection supply and demand network is a complex system with a large scale and many elements, and there are problems such as scattered supply and demand resources and different structures. The resource matching platform based on the Alliance blockchain provides a channel to effectively solve the problem of resource allocation, and the demand side has the characteristics of fairness, openness and a high degree of freedom when looking for task proposals. In terms of the transaction process, the historical transaction quality of both the supply and demand sides should be fully considered, and a transaction deposit that meets the level of both sides should be set to ensure that the credibility gains brought by node performance are greater than the costs of default, so as to increase the motivation of both the supply and demand sides to perform as much as possible. From the square perspective, it has the function of supervising the occurrence of the transaction process, fully utilizing the tamper-evident and traceable features of blockchain technology to record transactions regardless of whether they are successfully performed, providing powerful historical data for calculating the reputation index of the supply side. Smart contracts under blockchain are still essentially contracts, distinguished from traditional textual contracts in that they are transformed by algorithms and code, and the information it deploys and publishes can all be shared with stakeholders on the platform, reducing the number of redundant steps in trading on the industry’s interconnected supply and demand network and improving the efficiency of resource allocation.

However, the design of the smart contract in this paper is not good enough for more complex applications and the robustness and security of the smart contract needs to be examined in more ways. If there are vulnerabilities in the smart contract, it is not possible to patch the operation on the blockchain system, and the development and testing of the smart contract needs to be improved.

Going forward, our research work will advance in the following areas.

- (1) There are still many elements in the supply and demand network that need to be collaborated, such as: knowledge collaboration, talent collaboration, innovation collaboration, etc. This paper mainly focuses on the research of business transaction synergy in the industry interconnection supply and demand network, and can further explore how to achieve other synergy methods on the third-party platform.
- (2) Consider introducing IoT technology and developing communication methods from IoT sensors to blockchain to make data collection more convenient and reliable, and reduce the possibility of manual operation and artificial interference.

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