Information Systems and e-Business Management (2020) 18:527–543
https://doi.org/10.1007/s10257-018-0383-1

ORIGINAL ARTICLE

Research on e-commerce integrated management information system of cross-border enterprises based on collaborative information middleware

Ying Luan[1] · **Zhuo Zhang**[2]

Received: 22 October 2018 / Revised: 6 November 2018 / Accepted: 16 November 2018 /
Published online: 27 November 2018

Abstract

With the rapid development of information technology, transnational electronic commerce will occupy a larger proportion in the field of export. However, domestic e-commerce is in the development stage, and the market is changing rapidly. In order to meet the needs of customers, enterprises will further study the design and implementation of integrated management information system. This paper studies the function of cross-border enterprise e-commerce integrated management information system based on collaborative information middleware, and then analyzes the design method and implementation. In this paper, according to the research results of collaborative information system (CIMS), we propose and implement a model of information system (B-CISOM) to support the effective e-business activities among enterprises based on the requirements and background of e-commerce activities between enterprises. The system operators of cross-border e-commerce enterprises should fully grasp the function and performance of each module, improve the working efficiency of employees in essence, and strengthen the application of the system in the operation of enterprises. The experimental results verify the effectiveness of the proposed method of integrated management information system for cross-border enterprises based on collaborative information middleware.

Keywords E-commerce integrated management information system · Cross-border enterprises · Collaborative information middleware

✉ Ying Luan
3621759053@qq.com

[1] Foreign Language Department, Heihe University, Heihe, China

[2] Department of Statistics, Heihe University, Heihe, China

1 Introduction

The essence of electronic commerce is to reduce the cost of information, which includes sales costs, procurement costs and many other aspects. Its impact on the traditional economy lies in changing and shortening the traditional industrial chain and reshaping its trading rules and procedures (Elhoseny and Hassanien 2018a). E-commerce can only be established on the basis of timely, accurate and comprehensive information access and distribution, otherwise, all the models are only a concept. B-CISOM, an intelligent business cooperation information system model based on collaborative information middleware CISOM proposed in this paper, can build a bridge for efficient and convenient collaborative information sharing among enterprises. By joining the B-CISOM alliance, manufacturers can get accurate and comprehensive information about raw materials at any time, and suppliers can quickly push supply information to manufacturers (Zheng et al. 2018). The performance of information sharing mode provided by B-CISOM is better than that of information publishing and mining technology on Internet, so it has a broad application prospect. An example of E-commerce Integrated Management Information system for Cross-border Enterprises based on Collaborative Information Middleware is given in the Fig. 1.

China is the most mature country in the development of e-commerce, the Chinese have long recognized the Internet technology to their lives brought huge changes, and they have been able to fully enjoy the fun and convenience of online shopping. With the constant exchange of economy, politics and culture at home and abroad, and the improvement of people's consumption level, people are no longer satisfied with only buying domestic goods. They are more and more inclined to buy high-quality goods from abroad. The demand for overseas goods through the Internet is growing, and many overseas brands need to open up the vast market in China through cross-border business (Yao et al. 2018).

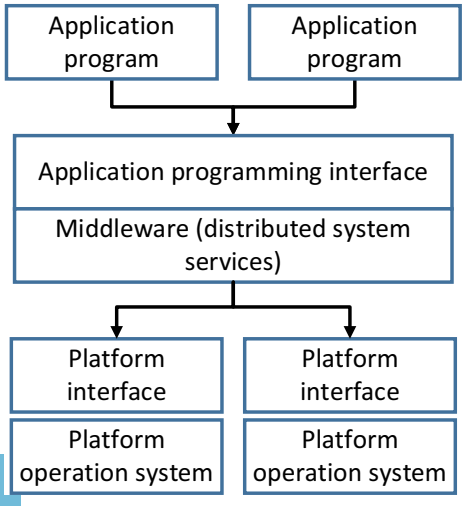

Fig. 1 An example of E-commerce integrated management information system for cross-border enterprises based on collaborative information middleware

Cross-border e-commerce refers to the transaction subject in different customs territory, through the e-commerce platform to achieve transactions, and the use of cross-border logistics and other ways to achieve international business activities. Cross-border e-commerce is conducive to the development of economic globalization, which has strategic significance for the development of e-commerce. Cross-border electronic commerce can not only cross the geographical and economic barriers among countries, but also cause revolutionary changes in the world economy and trade (Lin et al. 2017). For enterprises, cross-border e-commerce open, three-dimensional and multidimensional development model, to a certain extent, broaden the channels into the international market, and promote the win-win cooperation between enterprises. For consumers, cross-border e-commerce allows them easy access to details of foreign products and purchases.

2 Collaborative information middleware

2.1 Design of distributed information system

In the design of distributed information system in an open environment, it is a very important problem how to share the information of each other. In designing such an information system, the integration, security, network bandwidth and information organization of different information sources should be taken into account, and the system must be adapted to the movement of each information source effectively. The change of state makes the design work challenging (Li et al. 2017). In the face of such an application requirement, the traditional Client/Server computing mode is not competent, but the organic combination of distributed object technology, distributed artificial intelligence technology and database technology is the way to solve this problem. The formulation is expressed as follows

$$HopSize_i = \frac{\sum_{i \neq j} \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2 + \left(z_i - z_j\right)^2}}{\sum_{i \neq j} h_i} \tag{1}$$

The results of a large number of in-depth analyses of collaborative computing show that, although faced with different fields and solving very different problems, there are many common design elements, which are the design of any system that supports collaborative computing (Shivani et al. 2017). The problems that must be addressed are summarized as follows:

- How the parties involved in the collaboration share information and exchange information;
- How to ensure the security of information exchange;
- How to integrate computing entities in heterogeneous environment;
- How to ensure the performance of the system when the collaborators work in parallel.

We realize that the essence of these problems is "how to share information safely and effectively among all the collaborators", and urge us to deeply study the cooperative information sharing technology. The research shows that the essential design elements in the collaborative computing are extracted and implemented by middleware. We call this middleware a middleware for collaborative information systems.

- Advantages of using middleware.
- It can simplify the design difficulty of the upper level collaborative support system and make the designer focus on the collaborative work itself.
- It is convenient to realize the expansion of the system and the dynamic change of the structure.
- The system has more flexibility, the cooperation between heterogeneous systems becomes easier.
- It can provide better security and performance optimization for the system.

2.2 Idea of software Agent

Another important design idea of CISOM is to introduce the idea of software Agent and related technology into the system design. A set of collaborative Agent is used to construct the middleware to support collaborative information sharing, which makes CISOM different from the general concept of middleware technology. Each Agent represents the parties participating in the interaction, at the same time, through the negotiation between the Agent, the differences among the heterogeneous entities in the open system environment are shielded and have semantic consistency (Sun et al. 2018). Through the cooperation among the Agent, the distributed information resources can be integrated into an organic whole, thus providing an effective solution for the information integration. Each Agent can also form a corresponding alliance, according to the wishes of different entities they represent, so that they can share relevant information of common interest, which provides a new possibility for the effective use of information resources on the Internet. Government procurement operation diagram is given in the Fig. 2.

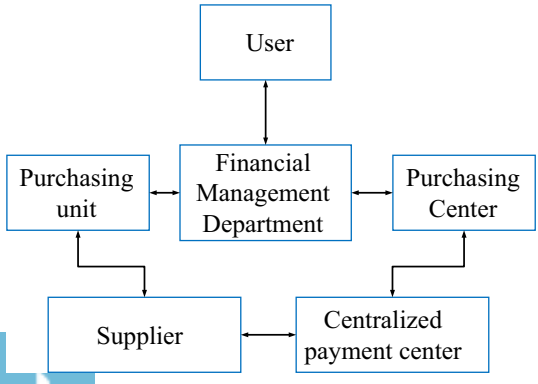

Fig. 2 Government procurement operation diagram

The Agent in CISOM system can be divided into two categories: one is the Agent, which represents the user's request for information access; the other is the information Agent, which represents different information resources, which can provide information access services for other Agent. In order to meet the requirement of distributed transparency of the system, we design a mediation Agent, which manages the information of all the information Agent, so that each Agent can dynamically obtain other Agent by interacting with the mediation Agent to interact with other Agent to obtain the required information (Elhoseny and Hassanien 2018b). Secondly, in order to improve the performance of the system, especially to reduce the requirement of the network bandwidth and reduce the delay of the network, we adopt the mobile Agent technology, and each Agent can move to the node where the information resource is to be accessed. To obtain the desired information by interacting with the information Agent representing it, and then returning the information to the user or storing it in a local repository for future use (Karthikeyan et al. 2018).

The CISOM system structure consists of a set of Agent subsystems distributed across different information nodes and an intermediate Agent system that manages the information of each Agent subsystem, as shown in the Fig. 3.

According to the depth of the information query, the whole process can be divided into the following five steps:

1. The user sends out the information access request to the intelligent user Agent through the Web browser;
2. Intelligent user Agent requests local information query Agent to complete local information query service;

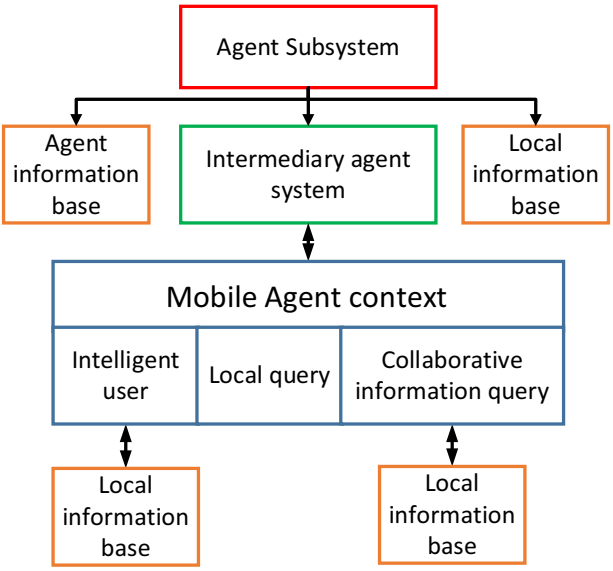

Fig. 3 Schematic diagram of structure and principle of CISOM system

3. After completing the local information query, we can further provide collaborative information query service according to the user's request. Firstly, the cooperative information is queried by Agent to request the attribute information of other Agent systems from the mediation Agent system;
4. After obtaining the context information of other Agent systems, the cooperative information query Agent can send the mobile Agent carrying the related operation request to other information nodes, and request the local in the context of the Agent system representing them. The information query Agent completes the operation and returns the result once;
5. When necessary, different cooperative information systems can form an alliance through their own intermediary Agent systems to share information more widely. Conversion of cost classification is shown in the Table 1.

In the implementation of the system, in order to satisfy the platform independence, we adopt pure Java technology. Java JDBC database technology to complete the transparent operation of different data sources. The mobile Agent technology based on Java (Shivani et al. 2017) is adopted to realize the mobility and security requirements of Agent. And the Servelet technology of Java is used to generate dynamic pages for users and realize the functions of intelligent user Agent (Hassanien et al. 2018). The communication between Agent is realized by the message mechanism of mobile Agent system, which is compatible with KQML.

3 Design and implementation of B-CISOM

According to the idea of software engineering for Agent, we design the development mode of cooperative information system based on CISOM. According to the model, a cooperative information system for specific applications can be developed efficiently. The design of B-CISOM is illustrated against this pattern.

1. Install the CISOM Agent subsystem at each information node of the cooperative information system

The enterprises that install the CISOM subsystem can be regarded as a virtual enterprise, each subsystem is very similar. If the information is stored in the relational database that supports ODBC, each subsystem can make no changes. Our approach is to first develop the full Agent functionality of the CISOM subsystem on one node or in the development environment, and then install the system on each enterprise server.

$$A_i \cap A_j = \emptyset, \quad i \neq j \tag{2}$$

$$A_1 \cup A_2 \cup \cdots \cup A_m = S \tag{3}$$

$$P(A_i) > 0 \tag{4}$$

Table 1 Conversion of cost classification

Time	Authors	Category	Research field
1987	Klemperer	Transaction cost, learning cost, contract cost	Banking
2002	Jones	Risk costs, pre-change search and evaluation costs, post-conversion behavior and cognitive costs, preparation costs, sunk costs, opportunity costs	Banking, hairdressing industry
2003	Patterson and Smith	Learning, continuing and sunk costs	Travel, medical, beauty services industry
2010	Burnham	Program conversion costs, financial conversion costs, relationship conversion costs	Credit cards and long distance calls
2013	Kim	Involvement, loss and adaptation costs	Mobile phone service industry
2017	Whitten and Wakefield	Looking for and assessing costs, uncertain costs, loss of benefits costs, cost of conversion, hiring and retraining costs, sunk costs, system renewal costs	Software outsourcing industry

2. Determine the collaborative information system domain server and install the CISOM mediation Agent system.

In B-CISOM, the intermediary Agent system is called the business center. It is the link that connects each enterprise. As long as each enterprise is registered in the business center, it can interact with all the enterprises in the system without the need that you should know about other enterprises in advance. The probability is expressed as follows,

$$P\left(\frac{A_i}{B}\right) = \frac{P(A_i, B)}{P(B)} = \frac{P\left(\frac{B}{A_i}\right)P(A_i)}{\sum_j P\left(\frac{B}{A_j}\right)P(A_j)} \tag{5}$$

3. Customize the functions of each Agent in the Agent subsystem of each information node.

In B-CISOM, the intelligent user Agent is the interface between the user and the system. It provides the user with information navigation through the Web browser and collects the user's input information. After analyzing the user input, the further work is completed by the local information Agent or the cooperative information Agent. Finally, the result of the information Agent is fed back to the user in the form of dynamic page, or stored in the local information base. The correlation probability is expressed as follow,

$$P\left(\frac{A_i}{B \wedge C}\right) = \frac{P\left(\frac{B \wedge C}{A_i}\right)P(A_i)}{\sum_j P\left(\frac{B \wedge C}{A_j}\right)P(A_j)} \tag{6}$$

The whole system of B-CISOM is composed of three functional modules: purchase information system, supply information system and system management.

4. Local information Agent

In B-CISOM, the local information Agent is responsible for the management of supply information and system management information. At the same time, it also provides PULL and PUSH services for the purchase information query from other enterprises. Of course, like other Agent, it must also be able to communicate with other Agent, cooperate to complete the system functions, such as accepting the service request of cooperative information Agent from other subsystems moving to the local, which providing the service and returning the result to other Agent and so on. The supply information system is mainly used to manage the information of the products produced by the enterprise, including the name, model, price, supply capacity, information update time and so on. Supply information, so supply information is the key to the B-CISOM system shared information source.

In the system management, we can manage and set up the business center configuration table, the service mode management table, and the request queue table. Because some important data are involved in system management such as the configuration of B-CISOM subsystem, considering the security of the whole system, we verify the account number and password of the users who enter the system management.

$$P\left(A_i/B_1 \wedge B_2 \wedge \cdots \wedge B_n\right) = \frac{\prod_k P\left(B_k/A_i\right)P\left(A_i\right)}{\sum_j \prod_k P\left(B_k/A_j\right)P\left(A_j\right)} \tag{7}$$

The business center is configured to mainly manage the domain server address information of the B-CISOM. The request queue mainly manages periodic service requests from other subsystems. Service mode management mainly manages the quality of service (QoS) that provides PUSH services, including the amount of time a request is allowed to exist in the queue and the size of the cycle time. It is important to note that the timing of the cycle is determined in conjunction with the server's performance and the size of the service queue.

5. Collaborative information Agent

In B-CISOM, the main task of collaborative information Agent is to query the supply information needed by the enterprise within the scope of B-CISOM. It can request two kinds of services, PULL or PUSH, and the service is provided and managed by the local information Agent. Different modes of information feedback are used according to the different service patterns requested (PULL or PUSH),). In B-CISOM, PUSH mode is the most commonly used mode, in which new information can be pushed in real time. In the purchasing subsystem, the user can query the relevant commodity information. In PULL mode, B-CISOM only makes one global information query, while in PUSH mode, the system periodically returns the new information of each subsystem to the user.

6. Configure the address information of mediation Agent in each CISOMAgent subsystem

Administrator users can set up and modify the name, address, port number of the business center server by changing the Business Center configuration Page.

7. Registering the information of each subsystem in the domain server's CISOM mediation Agent system

Register the information of each subsystem in the business center through the management page, including server name, server address, server port number, server type, server description, update time and so on.

8. Start up the mobile Agent environment of each subsystem

Through the above steps, the design and installation of B-CISOM is completed. Through the practical implementation of B-CISOM, we can understand the superiority of Agent oriented software engineering in the design of cooperative information system, and further demonstrate the rationality and efficiency of CISOM system. Schematic diagram of B-CISOM experimental environment is given in the Fig. 4.

4 E-commerce integrated management information system for cross-border enterprises

Cross-border e-commerce refers to the transaction subject in different customs territory, through the e-commerce platform to achieve transactions, and the use of cross-border logistics and other ways to achieve international business activities. Cross-border e-commerce is conducive to the development of economic globalization, which has strategic significance for the development of e-commerce. Cross-border electronic commerce can not only cross the geographical and economic barriers among countries, but also cause revolutionary changes in the world economy and trade. For enterprises, cross-border e-commerce open, three-dimensional and multidimensional development model, to a certain extent, broaden the channels into the international market, and promote the win-win

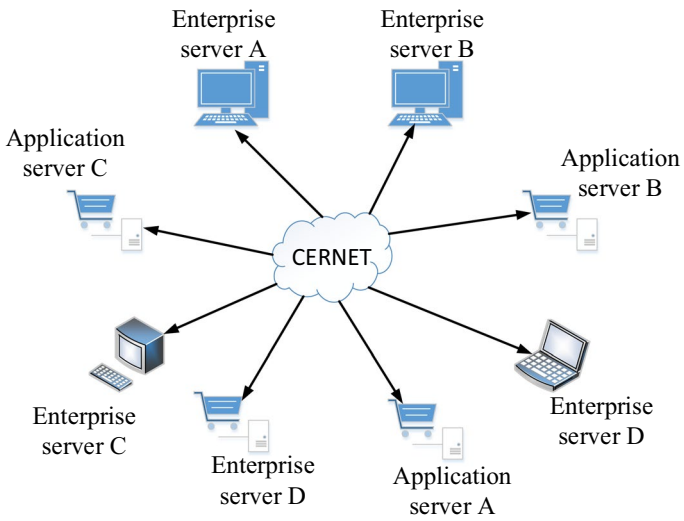

Fig. 4 Schematic diagram of B-CISOM experimental environment

cooperation between enterprises. For consumers, cross-border e-commerce allows them easy access to details of foreign products and purchases.

4.1 Functionality of an integrated management information system for cross-border electronic commerce

The integrated management information system of cross-border electronic commerce needs to draw up the corresponding flow according to the actual operation condition of the enterprise, and make the main business process of the enterprise electronic and information, and carry on the quantitative evaluation of each business content in the informationization. To make guiding contributions to the business direction of the enterprise and provide relevant information for the business decision makers to adjust the management strategy. In essence, the cross-border e-commerce enterprise is still a retailer, its core task is to purchase and sell products, and by risk control and logistics to support the formation of a complete business process. Integrated management information system needs to analyze the specific needs of enterprises according to this method and make a scientific and reasonable information system. The specific functions of the information system are expressed as follows.

$$z = \max\left(x_1, x_2, \ldots, x_n\right) \tag{8}$$

4.2 Supplier product management functionality

In the whole operation of cross-border e-commerce enterprises, supplier management is the starting point and the product is the basis. First, the salespeople needs to investigate the market demand, finds out the products that are easy to operate, then finds the suppliers according to the results of the survey, and inputs the relevant information about the suppliers and products into the system (Yao et al. 2018). Secondly, we discuss with suppliers the latest requirements in the development market, develop new products, and then input them into the system. From the above analysis, it is not difficult to find that information systems need to have vendor management functions (add, delete, change and query), product management (add, delete, change and query) and product audit. And the system can automatically input information into orders, generated trading time, sales volume, product qualified rate and other factors, which is conducive to the rating of suppliers. Then, according to the rating results, the purchasing plan is arranged to reduce the inventory risk. At the same time, suppliers can adjust their supply information in the system to further improve their rating. The formulation is expressed as follows,

$$z = \sum_i x_i \tag{9}$$

4.3 Income-and-inventory management function

In the whole process of the cross-border e-commerce enterprise operation, the purchase, sale and storage is the core part. The main profits of the enterprise mainly come from the dynamic process of the product from purchasing to selling. Under the premise of ensuring the normal circulation of the product, the enterprise can reduce the purchasing cost, reduce the inventory, and reduce the risk of management, and increase the economic profit of the enterprise (Karthikeyan et al. 2018). In addition, they try to avoid unsalable and other situations, and improve the reputation of enterprises. There are two modes of procurement, one is the immediate sale model, after receiving the platform orders, let the supplier send the products directly to overseas according to the product information, make sure that after quality inspection, and let the logistics personnel change the packaging, package and deliver goods. The formulation is shown in the following equation.

$$z = \frac{\sum_i \left(x_i - \bar{x}\right)^2}{N} \tag{10}$$

The second is the stocking model, which purchases the corresponding products according to the historical sales results, sends the products directly to the customers after receiving the platform orders, and the cross-border sales of e-commerce are closely linked to the operation work. Because products need to use various forms of advertising to increase exposure and increase sales (Elhoseny

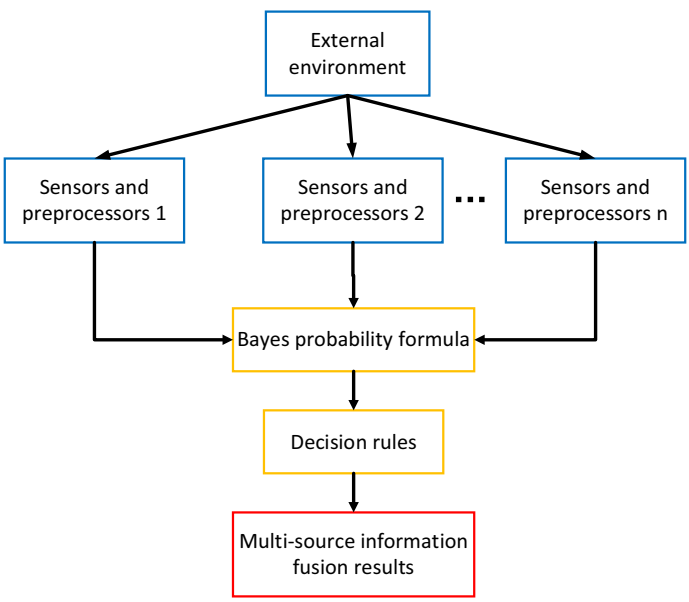

Fig. 5 Bayes method multi-sensor information fusion process

and Hassanien 2018b). The order information on the platform is imported into the integrated management information system, and the order processing begin. Warehousing refers to the process of entering, sorting, exiting, checking and reporting the loss of the products, in which sorting and exiting is the process of purchasing and selling. And inventory and reporting damage refers to maintenance products. Bayes Method Multi-sensor Information Fusion Process is given in the Fig. 5.

4.4 Logistics channel management function

Cross-border e-commerce companies choose to sell their products mainly by express delivery. At present, domestic express companies mainly include China Post, United Parcel, FedEx and DHL Express, but each express company each week in different weight products in different regions of the price changes. Therefore, it is necessary for cross-border e-commerce companies to choose the right express delivery companies to reduce transport costs. Operations and maintenance personnel can process weekly express delivery information, especially the transport prices of products of different weights, and put quotation lists into the logistics channel management system (Sun et al. 2018). After placing an order, let the product automatically select the best logistics channel according to the information of weight, destination and type, and automatically generate the logistics order as follows,

$$z = \frac{\sum_{i}^{N} (x_i - \bar{x})(y_i - \bar{y})}{N} \tag{11}$$

5 Design and implementation of cross-border e-commerce information system

5.1 Overall structural design of the system

The whole integrated management information system includes two parts: service and supply (Zheng et al. 2018). The whole system can be divided into seven parts: supplier management, purchasing management (Lin et al. 2017), sales management, warehousing management, operation and maintenance management, logistics management and financial management. Among them, financial management should choose more mature software, which can not only reduce the workload of development, but also save resources for the company.

$$A = 2 \times \begin{bmatrix} (x_1 - x_n) & (y_1 - y_n) & (z_1 - z_n) \\ (x_2 - x_n) & (y_2 - y_n) & (z_2 - z_n) \\ \cdots & \cdots & \cdots \\ (x_{n-1} - x_n) & (y_{n-1} - y_n) & (z_{n-1} - z_n) \end{bmatrix} \tag{12}$$

$$B = \begin{bmatrix} x_1^2 - x_n^2 + y_1^2 - y_n^2 + z_1^2 - z_n^2 + d_n^2 - d_1^2 \\ x_2^2 - x_n^2 + y_2^2 - y_n^2 + z_2^2 - z_n^2 + d_n^2 - d_2^2 \\ \cdots \\ x_{n-1}^2 - x_n^2 + y_{n-1}^2 - y_n^2 + z_{n-1}^2 - z_n^2 + d_n^2 - d_{n-1}^2 \end{bmatrix} \tag{13}$$

5.2 Overall database design

Database design refers to the design of a database schema that meets the requirements according to the requirements and objectives, and on the basis of which the effective storage of data is established to meet the needs of users. In order to achieve the ultimate goal, the design can be divided into five parts: requirement analysis, conceptual design, logical design, physical design and implementation. Among them, the most consuming time and energy is conceptual design. Conceptual design refers to the design of application system data according to the needs of users (Abbas et al. in press). The characteristics of conceptual design are that the objects of the objective world and the needs of users are represented by the way of information data. Conceptual database model can provide users with a data model which is easy to understand, so it is the basis of database design as shown in the Table 2.

The main purpose of using saturation testing method is to test whether the system can effectively provide services when multiple users access different services simultaneously in Internet environment. We access the system at the same time on six associative microcomputers, and test the PUSH/PULL mode together. The experimental results show that the system is stable and reliable, and the security also meets the design requirements of the system.

$$\begin{cases} m(\phi) = 0 \\ \sum_{A \subset U} m(A) = 1 \end{cases} \tag{14}$$

5.3 Design of vendor product management module

The reasons for designing supplier product management module are internal and external respectively. First of all, the internal reason means that with the continuous expansion of the scope of enterprise product development, the intelligent partition architecture can no longer meet the needs of the enterprise. Companies need to be responsible for different types of products, rather than let the general manager

Table 2 B-CISOM incremental test results

Number of subsystems	The time required to return the first data (s)	The time required to return all data (s)
2	12.5	15.6
3	12.7	17.4
4	13.1	20.2
5	13.1	23.7
6	13.4	26.3

Table 3 System performance indexes

System performance	Performance
Concurrency	Can meet 200 simultaneous access
Stability	The stability of the continuous operation of the system
Responsiveness	System response time does not exceed 4 s

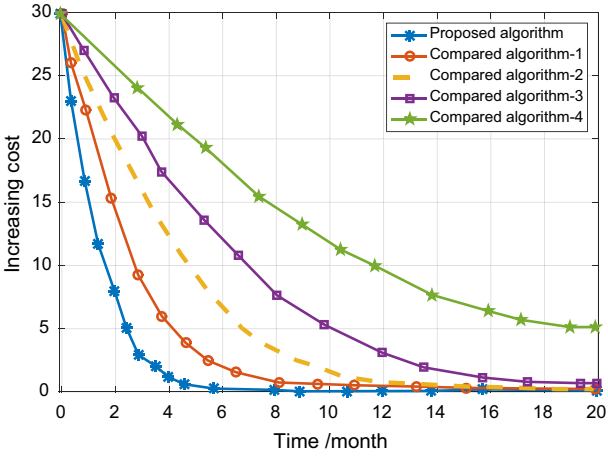

Fig. 6 Performance comparison between the proposed method and the comparison method in cost

take care of them all. Secondly, external reasons mean that the market demand has been changing with the development of technology, enterprises should subdivide products and markets in the face of complex external environment, and update their product types according to the needs of target customers. The products managed by different teams are different, and the responsible personnel should adjust their products to meet the needs of customers according to the changes in the market and competitors. Supplier management is to enable enterprises to have a cost-effective material source, but for cross-border e-commerce enterprises more focus on long-term cooperation with suppliers. In general, the supplier cooperation should follow the "Q.C.D.S" principle, that is, the quality cost to pay the service in advance. System performance indexes are given in the Table 3.

5.4 Design of order management module

Order management refers to the enterprise order management personnel processing customer orders, in the entire logistics activities this is the core business (Yao et al. 2018). The order manager is responsible for the whole process from the time the customer has placed the order to the receipt of the order. The order is generated when the platform receives the order, then carries on the input, the confirmation,

Table 4 Regression of loyalty: model summary

Model	Non-standardized coefficient		Normalization coefficient	Sig	R squared	Tuned R
	B	Standard error	Beta			
Constant	−0.119	0.366				
ESC	0.245	0.087	0.088	0.000	0.017	0.175
PSC	0.234	0.073	0.076	0.001	0.495	0.246
SA	0.288	0.075	0.074	0.000	0.029	0.289
LSC	0.173	0.064	0.063	0.007	0.319	0.304
F	26.34			0.000e		

the assignment and so on, finally sends out the specified product according to the customer demand.

As can be seen from the Fig. 6, the additional cost of the proposed method is decreasing over time compared with the comparative method. This shows that with the increase in the number of users can continue to reduce the operating costs of the system, so the method proposed in this paper can greatly reduce the cost of a single user, which is conducive to the promotion of the system. In the whole transaction process, we should ensure that every node of order information work on time record, no matter what abnormal, should be recorded, adjusted and modified according to the actual situation, to maintain the normal operation of the system, and to prevent losses to the enterprise. Therefore, after delivery does not mean that the order has been completed, shipping time, quantity, whether payment and whether there will be an accident will be an important factor in improving the level of service. In addition, it is necessary to establish order data files to provide decision information for enterprise decision makers. Regression of loyalty is given in the Table 4. It can verify the effectiveness of the proposed algorithm.

6 Conclusion

In order to meet the needs of customers, enterprises will further study the design and implementation of integrated management information system. This paper studies the function of cross-border enterprise e-commerce integrated management information system based on collaborative information middleware, and then analyzes the design method and implementation. In this paper, according to the research results of collaborative information system (CIMS), we propose and implement a model of information system (B-CISOM) to support the effective e-business activities among enterprises based on the requirements and background of e-commerce activities between enterprises. The system operators of cross-border e-commerce enterprises should fully grasp the function and performance of each module, improve the working efficiency of employees in essence, and strengthen the application of the system

in the operation of enterprises. The experimental results verify the effectiveness of the proposed method of integrated management information system for cross-border enterprises based on collaborative information middleware.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

References

Abbas H, Shaheen S, Elhoseny M, Singh AK, Alkhambashi M (in press) Systems thinking for developing sustainable complex smart cities based on self-regulated agent systems and fog computing. Sustain Comput Inf Syst. https://doi.org/10.1016/j.suscom.2018.05.005

Elhoseny M, Hassanien AE (2018a) Extending homogeneous WSN lifetime in dynamic environments using the clustering model. In: Dynamic wireless sensor networks. Studies in systems, decision and control, vol 165. Springer, Cham, pp 73–92. https://doi.org/10.1007/978-3-319-92807-4_4

Elhoseny M, Hassanien AE (2018b) Using wireless sensor to acquire live data on a SCADA system, towards monitoring file integrity. In: Dynamic wireless sensor networks. Studies in systems, decision and control, vol 165. Springer, Cham, pp 171–191. https://doi.org/10.1007/978-3-319-92807-4_8

Hassanien AE, Rizk-Allah RM, Elhoseny M (2018) A hybrid crow search algorithm based on rough searching scheme for solving engineering optimization problems. J Ambient Intell Humaniz Comput. First Online: 25 June 2018. https://doi.org/10.1007/s12652-018-0924-y

Karthikeyan K, Sunder R, Shankar K, Lakshmanaprabu SK, Vijayakumar V, Elhoseny M, Manogaran G (2018) Energy consumption analysis of Virtual Machine migration in cloud using hybrid swarm optimization (ABC–BA). J Supercomput. First Online: 05 September 2018. https://doi.org/10.1007/s11227-018-2583-3

Li J, Zheng Z, Tian Q, Zhang G, Zheng F, Pan Y (2017) Research on tridiagonal matrix solver designing based on combination of processors. Comput Electr Eng 62:1–16. https://doi.org/10.1016/j.compeleceng.2017.07.014

Lin Y, Zhu X, Zheng Z, Dou Z, Zhou R (2017) The individual identication method of wireless device based on dimensionality reduction and machine learning. J Supercomput 5:1–18. https://doi.org/10.1007/s11227-017-2216-2

Shivani S, Tiwari S, Mishra KK, Zheng Z, Sangaiah AK (2017) Providing security and privacy to huge and vulnerable songs repository using visual. Multimed Tools Appl. https://doi.org/10.1007/s11042-017-5240-6

Sun Y, Li C, Li G, Guozhang Jiang D, Jiang HL, Zheng Z, Shu W (2018) Gesture recognition based on Kinect and sEMG signal fusion. Mob Netw Appl 32:28. https://doi.org/10.1007/s11036-018-1008-0

Yao S, Sangaiah AK, Zheng Z, Wang T (2018) Sparsity estimation matching pursuit algorithm based on restricted isometry property for signal reconstruction. Future Gener Comput Syst 88:747–754. https://doi.org/10.1016/j.future.2017.09.034

Zheng Z, Sangaiah AK, Wang T (2018) Adaptive communication protocols in flying ad-hoc network. IEEE Commun Mag 56(1):136–142