

Application of Multi-Agent Based Decision Support System in Supply Chain Management

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Abstract. Following the increasing intensity of competition in the market, more and more enterprises choose supply chain as its model of business operation. In this paper, a multi-agent based model of supply chain system in manufacturing is constructed on the basis of supply chain system with complex adaptive system. The same agent model is constructed respectively from the enterprise entity perspective and the business process perspective, and the whole process from receiving customer order to delivering the product of supply chain system is realized by the intercommunication between independent agents. It is to improve the decision-making efficiency in supply chain management by analyzing and studying the application of this decision making system in supply chain management practice.

Keywords: Supply chain management; multi-agent; complex adaptive system; decision support system.

1. Introduction

Supply chain is a networked structure of upstream and downstream enterprises involved in the production and distribution process supplying products or service to end consumers. It is an alliance of competition made up of manufacturers, suppliers and retailers by supplying raw materials, components, products and service to each other. In the whole process, the information flow is on demand and supply. The capital flow is the flow of capital incurred in the flow of materials. The value flow is the continuous value addition of materials when it moves along the supply chain. The work flow is the business process of enterprises, which involves human resource factor. Supply chain management covers the whole range of process from the suppliers of suppliers to the customers of customers, including purchase, distribution, inventory management, transportation and customer service etc. Enhancement of supply chain management is a strategic option for enterprises to realize low cost and good responsiveness [1].

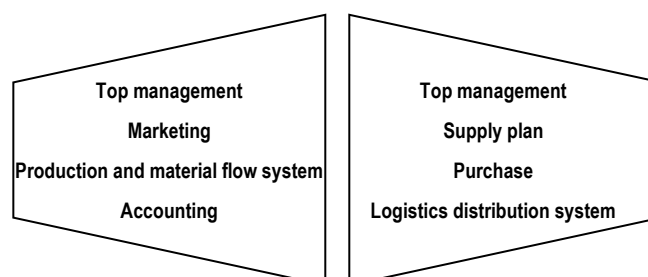


Fig. 1 Diamond partnership

2. Aspects and targets of supply chain management decision

2.1. Aspects of decision.

The supply chain management decision support system is based on the data of the daily business processing system of enterprise, with which it applies intelligent approaches to analyzing and

summarizing data, forecasting the trend of development and providing information support to decision makers. This system is distributable, intelligent, and extendable and integrated [2]. The basic decision making aspects in supply chain management are:

(1) Positioning decision, which means the positioning of facility when the supply chain is made, including manufacturing facility, inventory spots and source of supply etc. This decision is thought to be the basic market entry strategy of enterprise.

(2) Production decision, which is to determine the route of material flow between the existing facilities, such as what product to make in which factory, how to arrange production and distribute materials between all the supply chain members etc. A benign decision could balance the stress on all supply chain members and keep the logistics smooth.

(3) Inventory decision, which takes care of the form, quantity and management approach of inventory.

(4) Transportation decision, which includes forms, batches, route of transportation and height of transportation tools.

2.2 Targets.

The following design targets are concluded according to the demand for supply chain decision support system in the integration between enterprises in the supply chain:

(1) To combine the model analysis technique with data storage and retrieval technique as well as the search technique, in order to realize intelligent reasoning. (2) To realize the information sharing between related enterprises in the supply chain across geographic distribution. (3) To highlight the agility and adaptability to the change of environment and of user's decision making method. (4) To acquire the raw data necessary for decision support from the daily operation of the enterprises in the distribution. (5) To facilitate a benign data communication environment for users. (6) To realize the information integration of this heterogeneous platform. (7) To offer an easy user's interface for amateur users to interact and converse on it.

3. The framework of agent based decision support system

Agent is usually called "intelligent agent" or "independent agent", it is a new discipline developed from distributable artificial intelligence. Now the word Agent has become a basic term in the discipline of artificial intelligence research. At present, the widely accepted definition of it was raised by Wooldridge and Jennings, which is to interpret Agent to macroscopic and microscopic perspectives, where a weak notion as well as a strong notion of agent concept are highlighted [3].

(1) The weak notion of agent concept

An agent must possess the following four aspects, in order to be called Agent:

Self-ruling: during the performance of an agent, it is not subject to direct control by people or by external rulers, it has the control power over its own behavior and its internal conditions.

Social capability: in terms of the existence of an agent in the society of agents, it needs to have the capability to interact with other agents, in order to fulfill its design objectives.

Response capability: change of ambience may incur the corresponding behavior of agent, and the behavior of agent has certain impact on the external environment too.

Spontaneous behavior: the behavior of agent should be a result of its own wish. An agent can catch the change of ambience and behave accordingly based on its objectives.

(2) The strong notion of agent concept

Besides what are with the weak notion of agent concept, the strong notion, the strong notion of agent concept possesses the following characteristics: longevity, mobility, reasoning capability, planning ability, learning ability and adaptability, as well as rationality etc.

3.1 The framework of agent based decision support system in common use.

In the common use of agent based decision support system framework, it is classified as interface agent, task agent and information agent in terms of characteristics. The decision making target is completed through the collaboration between these three kinds of agents [4].

(1) Interface agent

An interface agent is to perform the following: decision maker is to collect related information to initialize a decision making task; the agent delivers the processing result of related information to the decision maker; it prompts the decision maker to provide supporting information during decision analysis; it also prompts the decision maker to provide confirmation during the analysis. Interface agent usually has the learning capability, which leads to the creation of a customized interface agent.

(2) Task agent

Task agent is to perform the following: it takes the task of decision analysis from interface agent; then it interprets the decision making task and derives from it the targets of the pending issues; it performs to form the plan for completing the decision making objectives; then it derives from the plan sub objectives related to the information; finally, it breaks down the plan, executes the plan by the collaboration between task agent and information agent to yield the result.

(3) Information agent

Information agent is an agent that performs a variety of operations about the essential information to the system. Information agent can search and find the information from information sources that are necessary for the decision makers to make solutions. There are two kinds of information agents: one is to perform intelligent search only without any processing to the information; the other processes information during search, and forms solutions to some of the issues, which means it has some problem solving capability.

3.2 Improvement of agent based decision support system framework.

All the existing decision support system frameworks are not considerate about their changeability and integration possibility, they are built for more functional considerations. Therefore, analysis and comparison are made about all kinds of frameworks in this article, upon which the commonly used agent based decision support system framework is improved to fulfill the functional needs, and also to meet the needs of changeability and integration capability [5].

4. Multi-agent based supply chain

Supply chain is a typical kind of complex adaptive system. The whole supply chain is driven by customer order, to design and manufacture product according demand, which is the “pull” style of production. This one way material flow system does not involve the adverse flow, where the bilateral information flow is mainly about order information and about the inventory information of all the stock holders. This simplification /modeling of the supply chain of manufacturers is not just a close-to-the-fact description of the interaction and collaboration between supply chain members and between agents, it also makes a real reflection on the change of members in the real world by changing the property of agents.

4.1 Description of system demand.

In the supply chain system, sellers have two departments: inventory management department and purchase department. The inventory management department performs decision analysis task about inventory, and the purchase department performs the decision making task on products supply.

This article has simplified supply chain system, derived from it the portions where decision making analysis is necessary to set up the decision analysis system of supply chain. The following is a brief description of this supply chain decision support system: in order to ensure the availability of products on sale and to minimize inventory level at the same time, sellers need to perform analysis and decision making about the time and quantity of incoming goods, to work out a list of it; there might be multiple suppliers of a specific product, so the purchase decision has to go through a comprehensive consideration of product price, quality and supplier’s credit etc. to yield an order; suppliers need to assure delivery in time and to minimize transportation cost, to combine all the factors to decide the final delivery list[6].

4.2 Determination of agent.

List and determine the agents that exist in this decision support system. In the decision analysis system, every agent is for the analysis process to reach a specific target, which actually corresponds to a department in the organization. It is therefore assumed that every case of application can be realized with a specific agent, and the decision making analysis task performed by the corresponding agent needs to be described at the same time. Here is an application case that highlights “agent”, see Figure 2[4]:

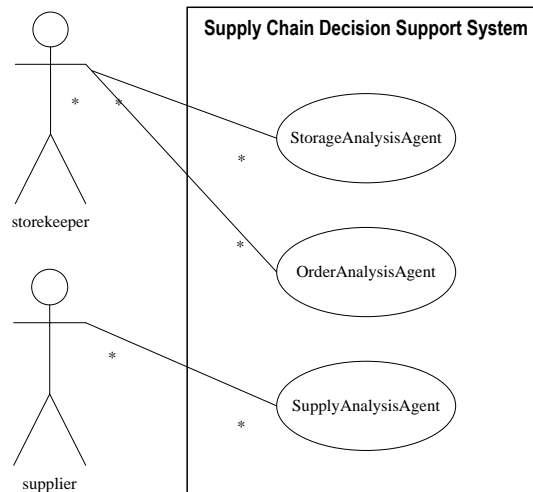


Fig. 2 Diagram of application case

1) Description of agent functions

a) Storage Analysis Agent: This agent performs inventory analysis, decides when to supplement to the inventory and how much to supplement to it, which includes the analysis of safety stock and order size, thereafter a notice is sent to the corresponding agent about the supplementing plan.

b) Order Analysis Agent: This agent performs ordering analysis, it determines the ordering list by considering supplier's price of product and supplier's credibility etc., to send the ordering information to the corresponding agent on supplier's side.

c) Supply Analysis Agent: This agent performs supply analysis, determines supply plan according to the ordering information.

(2) Related service by agent

a) Storage Analysis Agent: It provides inventory analysis service, which is in need of ordering analysis service.

b) Order Analysis Agent: It provides ordering analysis service, which is in need of the delivery of goods by supplier

c) Supply Analysis Agent: It provides delivery service of goods.

5. Construction of supply chain management decision support system

The most important for enhancing supply chain management is to keep the smoothness of information flow, capital flow, material flow and value flow between all the supply chain members; at the same time, enterprises need to forecast the market trend on the basis of the market change, then adjust their development strategy according to their internal information. In the latest few years of rapid development of information technology, the new achievements of information technology has provided technological tools to supply chain management, which we have applied into supply chain management practice to set up our supply chain management decision support system, in order to realize the integration between enterprises within the whole supply chain and keep an elastic and stable demand-supply relationship, so as to solve the issue of globalizing manufacturing and supply, cross organizational supply and exchange, optimization of customer service and delivery timeliness etc.

We have introduced agent technique in order to meet the design needs and to realize this decision support system, where SCM-DSS is designed into four levels: user’s level, performance level, coordination level and system level [7].

(1)The user’s level is used for the management of participating departments of related enterprises in the supply chain, e.g. supplier, planning department, production department, supply department, transportation department and customer etc. (2)Problem analysis and solving MAS is to analyze and process the information from all the user interfaces. (3)Coordination agent is to coordinate and diminish the possible conflicts between agents at the performance level. This includes email system, electronic conferencing system and team consensus system etc. (4) the system level is where data is stored with the decision support system, in which different types of data are managed by different agents.

In addition, every storekeeper in supply chain system is a thorough independent agent, at the same time it is a complex adaptive system which is made up of multiple sub agents with their simple functions. And every sub agent could either be a solid existence or be non-solid existence. Manufacturers are the core of the whole supply chain system, which is made up of five sub agents: order management, supply chain dispatch, processing and manufacturing, production planning and inventory management.

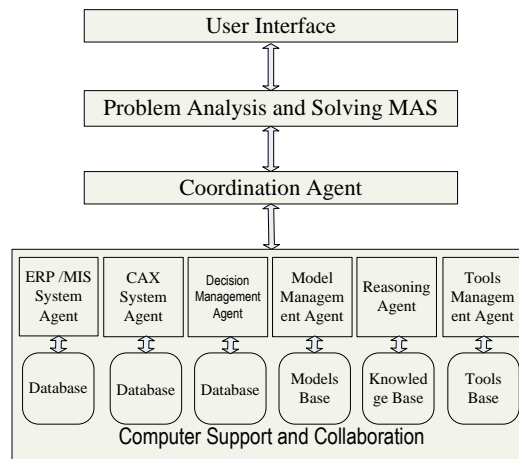


Fig. 3 The decision support system

Order management agent is responsible for processing the orders from other intelligent agents at the internal part of manufacturer or storekeeper. Its main task is to estimate the end date of order according to the available inventory and the production capability. It generates order and send it to supplier when inventory level touches a certain threshold; supply chain dispatch agent is responsible for interaction with suppliers, it has certain decision making mechanism to select appropriate suppliers for manufacturers; inventory management agent is responsible for incoming and outgoing management to and from the inventory, it provides inventory information to other agents; production planning agent receives order from order management agent, makes production plan according to the end date of order and to the inventory information, which is for the use by production agent; production agent simulates the production according to the progress plan, and delivers products to the assembly organization at the end. At the same time, manufacturer can take the order-driven demand management strategy: MTO (make to order), or it can take the safety stock strategy and supplement its inventory timely.

Suppliers are responsible for making components for manufacturers, a supplier is made up of order management, supply chain dispatch, production and inventory management agents. Order management agent is responsible for receiving and managing the orders from manufacturers; supply chain dispatch agent is responsible for interaction and bidding with manufacturer’s supply chain dispatch agent; inventory management agent is responsible for incoming and outgoing management of materials to and from the inventory, and for timely delivery to manufacturers. Manufacturer can take the demand management strategy on the basis of inventory: MTS (make to stock), when the inventory touches a certain threshold level, it is for the production agent to supplement the inventory

by assuming that there are adequate raw materials needed by the production agent. The assembly organization plays the role of customer in the whole system, it has order management, inventory management and assembly sub agents. Order management agent is responsible for receiving and managing customer's order, and transferring the order to manufacturer according to the inventory information provided by inventory management agent; inventory management agent is responsible for the incoming and outgoing management of goods to and from inventory, while assembly agent is responsible for retrieving products for final assembly and distribution of goods. The assembly organization takes safety stock strategy, when inventory touches a certain threshold level, it is necessary to send order to manufacturer in time; it can also take the management strategy on the basis of the assembly demand: ATO (assemble to order) to manage orders[8].

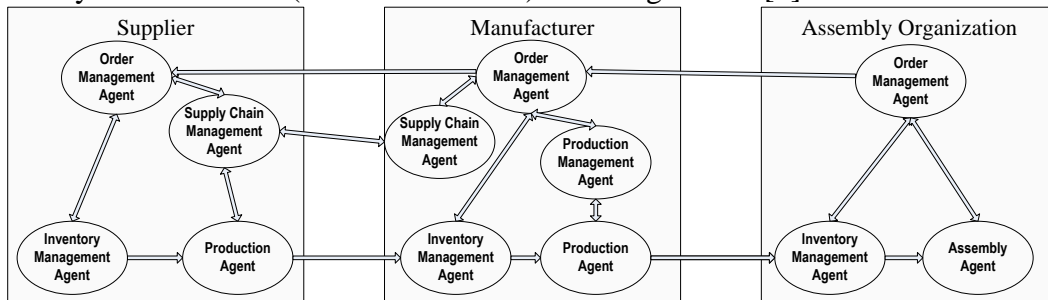


Fig. 4 The working procedure of agent based supply chain system

6. Improvement directions for the decision support system of supply chain management information

Supply chain management decision support system is the product of the latest internet technology combined with intelligent decision making technique and supply chain management philosophy. It is highly pragmatic for agile application into manufacturing enterprise. This has effective performance in shortening production cycle, optimizing demand and supply structure and minimizing inventory level [9].

Following the increasing maturity of agent technique, the supply chain management decision support system could be improved in the following aspects:

(1) Modeling technique: in order to analyze the relationship between supply chain members and simulate the operation process of supply chain to help members make rational decisions, a model has to be made of it. The simulation model of supply chain is very complicated, it has multiple objectives, multiple phases, multiple variables, uncertainties and non-linear relations etc., it is quite difficult to optimize this model. The conventional method does not meet the needs anymore, there has to be a new approach to optimization.

(2) Intelligent decision making technique: this technique is to combine the artificial intelligence which is limited to reasoning technique with the basic DSS module in an organic way, to pursue the solutions to the problems. There has to be new solutions to production forecast and optimization.

7. Conclusion

While the competition of enterprises are turning from the singular competition into supply chain competition, the supply chain management decision support system is acquiring the attention of all the supply chain members.

Based on the manufacturing supply chain background, this article is targeted at complex adaptive supply chain system to design a multi-agent based model of manufacturing supply chain. This multi-agent based manufacturing supply chain system has upgraded the collaboration efficiency of the supply chain to some extent. At present, software engineering study of agent application is still at its beginning stage; but the concept of agent, as an emerging efficient approach, is going into wide application in the future.

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