

Application of Multi-Agent Technology in Decision Supporting

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Abstract

In the study, the development course and present situation of decision support technology is analyzed, and now decision support technology is lack and it is need to solved, it should combine the benefits of artificial intelligence as in the people's way of thinking to solve practical problems. In addition it also needs to have the ability to identify problems, and skills of dealing with distributed collaboration. The Multi-Agent technology in decision support research is introduced, the decision support is based on the Multi-Agent technology, and in order to demonstrate it can meet the specific needs of today's decision support, it analyzes the process of its implementation applying agent modeling theory, the behavior of the agent coordination mechanism and communication mechanism between the agents and so on, and puts forward the corresponding implementation scheme. Finally the effectiveness of the proposed technology and feasibility are analyzed, related results show that it can be applied in the actual decision support.

Keywords: Multi-Agent, decision supporting, computer technology, application

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1. Introduction

Computer technology is one of the most rapid developing science and technology today. It almost has been deeply into all areas of human activity and life, and it greatly improved the social productive forces, and cause the profound changes to the economic structure, the social structure and the way of production. Computer science and technology is a great comprehensive subject, and it crosses with many other science and technology, and in turn it combines with other science and technology, and it promotes the development of them [1-3]. Computer science and other crossover subjects have produced many new subjects, and lead the development of science and technology to a wide area. With the development of computer and related technology, all kinds of information technology in the related field has been developed and improved. Decision support technology is an important computer application field, which is put forward by M.S.S cott Morton in the early 1970s. Decision support system (DSS) shows that the concept of computer application and research in information has entered a new period. Then on this basis, the researchers of decision support system make efforts to continuous improvement and gain proposes all kinds of decision system, its purpose is to solve the computer how to perform assisted decisions [4-7].

However, modern enterprises are facing the changing and unpredictable environment, previous static structure, and isolation technology, now the adopted structured decision support technology can not adapt to modern enterprise business process and it is an urgent problem need to be solved. In essence, the decision process itself is a kind of human intelligence activity; today's decision support technology is still not able to maximize the scheme of simulation human intelligence to make the decisions scientifically. What it needs is a new type of intelligent decision support technology which is the combination of the existing decision support technology and artificial intelligence technology.

Based on human mental activity and the parallelism between the brain cells, it is difficult to solve complex problems through isolating the intelligent unit, so the methods through imitating human intelligence activity and establishing intelligent collaboration between units have become an important way to solve the complex problem. In recent years, the development of artificial intelligence is one of the important marks of the rapid development of agent technology, and the agent technology has the characteristics of the autonomy, interactivity,

reactivity, and so on. So the agent technology provides the new way of the decision support technology realization.

Agent is originated from artificial intelligence technology; its core concept has been put forward in the 1960s. Agent theory and its technology provide a new way in the analysis, design, and implementation of open system, which now are called as a major breakthrough in software or the software revolution. The Multi-Agents is the relatively loose consortium of multiple agents, the agent members relies on each other and complete the specific task together. As the characteristics of multi-agent technology, it can be applied to the development of collaborative learning system, the different modules can use different agent to realize its function, and they also can strengthen the collaboration and communication of the groups. Above all it can simplify the learning process, intelligence, and provides a new train of thought in solving the problems and in the development of collaborative learning system.

The collaborative science (cross subject, technical integration, organizational cooperation), under the guidance of using modern information technology, including artificial intelligence, network technology, database technology; computer supported cooperative work (CSCW, computer supported cooperative Work). The integrated management science, cognitive science, decision theory, such as achievement, research based on the Multi-Agent decision support (Multi-Agent Based Decision Supporting, MABDS) technology, which are the inevitable trend of information age with fast decision, accurate and high quality of decision support, its working process is as shown in the Figure 1.

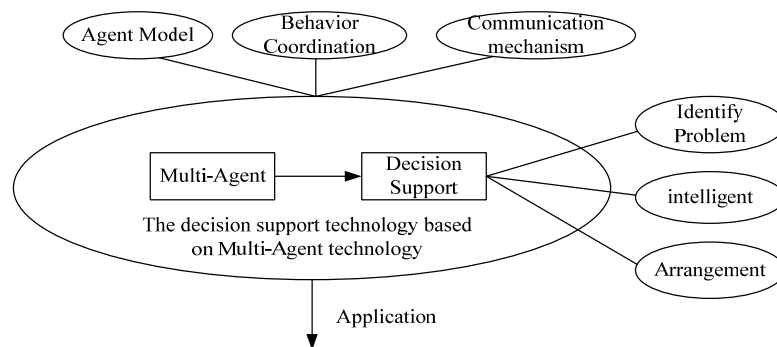


Figure 1. Research Route Graph

Good decision support technology should have the ability of effective decision making for various respects support activities in time. From the perspective of aid decision making, decision support technology has experienced the period of data aided decision, aid decision making in the form of models and methods, and multi-model combination decision-making and so on. It has been able to solve the problem of all kinds of conventional decision-making, but as for the actual application need, we need a method which is close to the human way of thinking to solve the problem of decision-making. The technology should integrate the advantages of all kinds of artificial intelligence, and form a more powerful support technology.

2. Decision Support Based on MULTI-AGENT Technology

Agent and Multi-Agent technology appeared in the field of distributed artificial intelligence firstly, now they have become a hot focus in the field of artificial intelligence and computer. From the characteristics and advantages of Agent and Multi-Agent, if we put them into decision-making activities, it will bring a certain degree of improvement in the process of decision support technology. And the understanding of the basic theory of Agent and Multi-Agent technology and its implementation method can provide us much enlightenment in improving existing decision support technology.

2.1. Agent and Multi-Agent Technology

As for the agent, what is agent? This problem has not yet been a unified definition so far. It is generally believed that the agent runs on a dynamic environment with intelligence, sense the environment, and it can perform planning, reasoning and decision making according to their own resources, status, behaviour, ability, knowledge, rules and the external environment of information. It also can achieve the intended target and has a high degree of autonomy ability. From the perspective of knowledge processing, the agent has certain knowledge and ability of using knowledge in solving the problem of unit for specific target.

R.J. Aldag [7] thinks that the agent is the one who has control ability in solving mechanism of the cell. According to the definition of Shoham, the agent is an entity, which includes knowledge, such as commitment, capability, mental state. A.A. Angehrn [8] thinks that the agent is an abstract entity; they are self-governing in their own environment, operating environment, climate change action. Despite many definitions of agent, but most researchers have approved all the agent has the same basic features, the agent is an entity, it can be sustained, autonomous, its environment including the other process and the coexistence with other agent.

The agent usually has the following characteristics:

(1) Autonomy

Agent belongs to its own computing resources and behavior control mechanisms, it can able to directly manipulate according to its internal state and perceived environmental information, decisions and control their own behavior.

(2) Interactive

Agent can communicate with other agent including people, the implementation of flexible interaction with the agent communication language, and it can work effectively with other agents.

(3) Reactive

Agent can sense the environment they are facing, it may be the real physical world, manipulate graphical user interface, or the other agent, etc. and it can make response to the relevant events in time.

(4) Initiative

Agent can follow the commitment to take the initiative action, and perform the goal-oriented behaviour.

(5) Social

Agent can exchange information and knowledge with other agents. It can interact with other agent, in coordination and cooperation.

In the characteristics mentioned above, the first three characteristics are essential. The robustness of the agent makes the agent responses for those unexpected changes with the appropriate reaction, etc. It has rich knowledge and powerful function, so in Multi-Agent system, each agent is autonomous, independent, its behavior and the target is not restricted by other agents, through competition, negotiation, collaboration between them, they can complete the targets set by the system.

The combination of Multi-Agent and the individual agents have the following characteristics:

(1) The agent may be composed of multiple agents, the agent may have other agent information and knowledge, and it can be able to use the agent language to implement flexible and varied interaction and communication, and achieve cooperation consultation, competition with other agent, etc. in order to achieve problem solving or help other agent to complete the relevant activities.

(2) Autonomy in multi-agent system, after sending the service request agent, it has the ability to provide these services and interests, and therefore, another agent cannot provide same mandatory service.

(3) Collaborative cooperation mechanism is the constraint specification standard of each agent. Each agent's behavior limits the behavior of the other agent. So the agent cooperation problem is mainly about how to regulate agent behavior, and it should be consistence with the whole behavior of the system, local sub-target should be accordance with global targets.

2.2. Key Technology in MABDS

As the today's enterprise need is the decision support technique, so we should perform a detailed analysis of the technology to achieve needs of enterprises. And we should take it as the key technologies in the application.

(1) How to describe the problem formally, decomposition, allocation of tasks and the comprehensive results in group agent system.

The modeling problem of the agent involved, the agent modeling method is directly in the field of artificial intelligence development, this kind of method is to simulate the adaptability of the basic unit of the main body, the modeler's mission is to define the main body, giving them the necessary behaviour rules and suitable parameters, which can be performed to find countermeasures to make them in a system. The macroscopic phenomenon of the whole system is in the main body behaviour rules, parameters, reflected the basis of the learning process definition.

In the model, the economic roles or social roles are not the variable mathematic parameters, but they will be inversely in the web interactions and agent accident. Take the consumers as an example, the model of consumer propensity to consume behaviour is not based on precise mathematical formulas, their strategy is likely to be improper, but they can learn from lessons and to remember the past strategy for themselves, and then their strategy will be improved.

(2) How to make agent to understand the behaviour of the other agent, planning and knowledge, reasoning and coordinate with other agent.

In order to solve the problems, they are mainly the coordination problems between the agents. Behaviour coordination problem of each agent in the agent system is a hot in related academic research field; many of the techniques are also put into the applications. Methods can be divided into: organizational structure, negotiation, contract, the agent planning. In the organizational structure, the pre-defined social structure is used to coordinate the agent behaviors; social structure here refers to the role of the different agents in the system and their relationships. More typical example is the client server model system.

Contract with the coordination mechanism, the most typical example is the contract or protocol, a management agent announces a contract and receives bids from other interested agent, after evaluation of bids and contract authorization are obtained by the win bidding agent.

In Multi-Agents planning, each agent adopts the classical artificial intelligence programming techniques to plan their own behavior, in order to solve these foreseeable conflicts, the rule can be usually divided into two kinds of mode, centralized and decentralized planning. Centralized planning refers to the agent which represents the view of whole interest. Decentralized planning refers to the agent in exchange for preferred auxiliary to each other, and then it gradually eliminates conflicts, and creates a whole system action plan. Each agent involved in dialogue can exchange ideas with each other, evaluate each other's opinions, and change their opinions in time, until all the agents reach the state of satisfaction with the opinion collection. Typical consultation mechanism is based on the game theory, the other form of planning or human consultation mechanisms are also on the basis of these [9-12].

(3) How to make each agent have a clear and definite semantic expression, make each agent can understand the thoughts of other agent.

Though the agent can adopt common languages to describe the problem, but if agents in the system use different words to represent the common concepts together, they can not communicate with each other too. Therefore, they should use the uniform vocabulary to express the same concept or idea. We can use general ontology or create the specific domain ontology, and then through the ontology inference engine, the agents can communicate with each other. As the general ontology theory cannot express all the ideas of problem, at the same time, for most applications, general ontology appears too large and cumbersome.

(4) How to realize communication and interaction of the agent.

The independent agent communication language is very necessary, most of the agent communication language does not specify the syntax or semantics of information content, the reason is that the different applications might require different information expression language. There are many general information expression language, many languages have been developed out, take the K.I F (Knowledge Interchange Format) for example, it is widely used in KQML and FIPA-ACL adopts the more popular SL language. It can be seen that, the agent based decision support technology is a complex technology; its implementation is based on a

series of existing technology. Therefore, we need some specific link analysis of core technology, and provide technical guarantee for the realization of the whole system.

3. Core Problem of MABDS Technology

In order to understand the multi-agent technology in decision support, we should make the analysis of the application of the core technology, and select agent modeling technology, mechanism of coordination and its core technologies such as agent communication mechanism in the detailed analysis.

3.1. Design Tasks of the Agent

When we adopt Multi-Agent technology in the application technology of decision support, the first task is to analyze the abstract agent model. Here according to the specific needs and different methods, such as the use cases or conceptual description. In the paper, we will use role modeling technology in the agent modeling technology, as the role modeling method is independent of finally realizing method, so that we can use many construction tool of agent to realize it.

When we make the design of the agent, we should know the specific needs of agent, which responsibility they should take. Therefore, this stage of the work should involve these responsibilities which can be reflected in the specific agent in certain way. When we make the design of the agent, we need to know how many agents are needed, which responsibility they have.

3.2. Role Modeling

Agent role and role model provide us the way of description the agent problem. Every role in a role model has its own position and function; at the same time it also undertakes certain responsibility, which can encourage the developers to think about problems from the implement need of this technology and the corresponding task, the role modeling and decision support are based on the Multi-Agent technology, and the process of each stage are closely linked. Needs identification, analysis, design, maintenance and so on, all the works are based on role models.

Role model at the same time is a kind of method to analyze the problems and solve the problem in a straightforward way. Although role modeling is mainly associated with demand recognition and problem analysis, but its influence is produced in the design period.

One agent may play many roles, so during the design stage; the roles defined in advance will be reflected in the specific agent entities. Finally, combined with the characters of working, the mechanism will be implemented.

Role model elements should be expressed through the role model, as shown in Figure 2. Figure role model in the symbols is from the UML class diagram. The core concept of class role in figure is the role not the class, the gathering and inheritance are described in the same way.

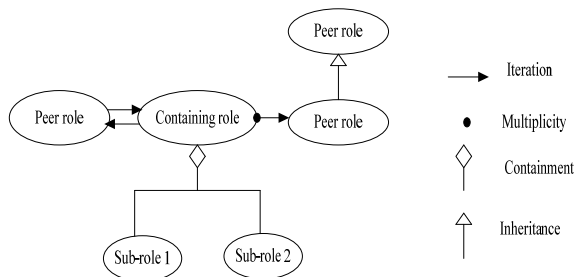


Figure 2. Role Diagram

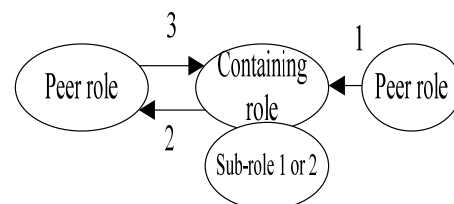


Figure 3. Collaboration Diagram

In the role model, another important figure is the collaboration diagrams, it should abstract the specific role relationships, and in the role figure, it cares about the interactions between each character, and it is shown in Figure 3.

As we can find that, the role model is a model which is the definitely simple solution of the specific application.

3.3. Mechanism of Coordination and Solving the Behavior of Agent

Agent behavior mechanism of coordination and solving the purpose are proposed to control their own behavior in the solving problem, especially those who need multiple agents in the cooperation behavior. In addition to the statement of general demand, action mechanism of coordination and solving the design are also need to make the individual agent to participate in multiple tasks at the same time. It means that it compromises with this kind of behavior coordination mechanism and it should be able to support some form of multitasking. However, due to some factors of system, it will be not appropriate if we take the multithread method to achieve this propose, because the number of separate tasks can be hundreds or thousands. Therefore, a better method is to adopt recursive state transition network diagram to solve the related problem, the network diagram can be explained by the recursive step finite state reasoning machine. On the other hand, as the agent can use mathematical calculation or rule reasoning to achieve autonomous behavior and the specific operation task, it also can adopt the message passing mechanism and the interact environment condition to complete information transmission and coordination, and it should be adapted to the changing of circumstances quickly. Therefore, in order to carry on effective control of the behaviors, the agent process scheduling should be dynamic.

According to the needs of dynamic scheduling and unit behavior concept, we should provide the agent with the control mechanism, according to its internal state and the change of environment.

(1) Representation and Reasoning Solution Behavior

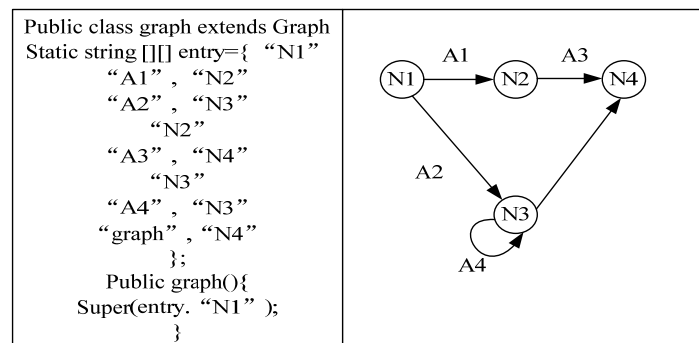


Figure 4. Behavior Graph Representation

From the above analysis, we can use the state transition network diagram to represent the actions of solving the problems, which is as shown in Figure 4. The behavior can be described through state diagram associated with other nodes of the network structure. So in the process, we can use a two-dimensional array of strings to represent the state diagram, each string expressed as nodes and arcs are defined as the name of the class.

The figure reasoning process is controlled by a specified starting node, if we want to try to traverse the entire diagram, until it reaches the target nodes. State diagram of the node execution behavior reasoning, state graph of arc performed inspection work can determine whether a node is correct from one node to another. Each node and arc can receive input parameters of the outside world, and also can return the output parameters. Therefore, the information in the picture is along the state's transformation path, which is passed from the node to the arc. In order to allow the recursive call, the figure itself can also be used as arc, as shown in the Figure 3, the arc of N3 to N4 is a recursive interchange named as the graph diagram.

All the nodes in the Figure 4 must be able to perform two operations; i.e., the perform operations and reset operation. Perform operations is to complete the core reasoning work of the node, and returns success, failure, or waiting for the information. Success and failure information represents a work in the nodes of the reasoning of success or failure. Waiting

information must be with an expiry date or the associated return key, the reasoning work must be suspended until the expiration date, or get the return key information.

Reset operation should undo all changes in the input data produced by performing actions; it is also in order to be able to support back to operate. On the other hand, the arc must complete a test operation, the operation returns to a Boolean value to judge whether the arc state transitions is correct.

(2) Agent Communication Mechanism

In the communications part of the agent, we adopt the peer-to-peer TCP/IP sockets methods, each statement is represented by a series of ASCII character. It is achieved by message box and manager to cooperate. As long as the agent of the life cycle exists, the persistent thread will be kept running.

(a) Message box

Message box is responsible for the creation and parsing the TCP/IP socket for sending and receiving messages. It maintains two active functions in a parsing process, continuous monitoring to read incoming socket connection. When a connection is monitored, it will create a temporary thread to read the information and sends the information to the message manager; news of information will be send to the manager for further processing. This method will read the information of the work assigned to a new connection thread, and it keep the "into the box" in the idle state, so as to get more monitor the input information. When the message is read after the connection thread is terminated. Another message box of threading is "out of the box" state. When a thread receives the distributing information, it will generate a temporary thread and open a socket for the recipient. If the connection has been established, the message will be turned into the socket, when the writer thread is terminated; this approach means that the agent can be able to get more information once again at the same time. Message box threads can continuously check the message queue, as to choose the right messages in distributed processing. Distributed for each waiting for the news, it will need to find the message receiving object and its address. If address can be found out, the autotype thread will be opened for the agent in the location of the specified network socket. Next, the message object will be serialized for ASCII character sequences which can be transmitted on the network. If the receiver address is not found, facsimile process object will be stored in the storage buffer, the information of the naming service and the agent address will be queried as requirements. The inner query will be recursive function of the same message box and message manager. Once the message receiver address is found, polygraph information will be removed from the reservoir to distribute information. As we could not find the failure of address or network communication. It will generate the error message, and it will be put it into a message queue as the normal message.

(b) Communication language

Most Agent communication language (ACL) is based on language theory. Language behavior theory, the daily events of the behavior of human language can be looked as a kind of behavior. So the ACL can standard the information types, the information will be transferred from one agent to another agent according to their respective properties, in the receiving agent, the information will affect the performance behavior of agent. Only when all the agents use a common communication language, the compatibility problem of the internal agent can be solved, while this kind of standard ACL does exist.

Standard 1381 of the FIPA ACL 1997 can be applied. The ACL news can be divided into three layers: content, communication and message layer. In content layer, FIPA standard is not mandatory provisions on adopting what kind of content language. The agent can choose the language of KIF, Prolog, and sL to encode content. Different agent groups can choose consultation between the content of the language, through the intermediary translation to ensure the normal communication between the groups of the agents. Message communication layer describes a feature set, the parameters of the key words, sender, receiver, in reply-to-reply with logo, they are all technical parameters of communication. Message layer is to provide the sender content of the speech ACTS or CA, which is identified with first element of the logo message.

(c) Message handler

Message handler is used for checking the new information in the message queue, and it can transmit them to the agent of the other related components. Its behavior will be subject to two elements control. First, whether the new information represents a new round of dialogue or it's a part of the ongoing dialogue. Second, the other components of the agent registered the

message handler inference rules. The whole communication mechanisms are shown as Figure 5 below.

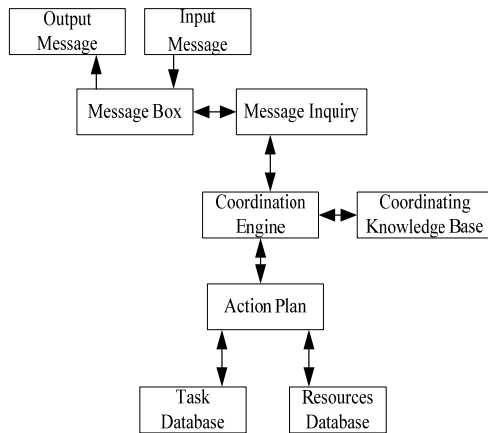


Figure 5. Communication Mechanism

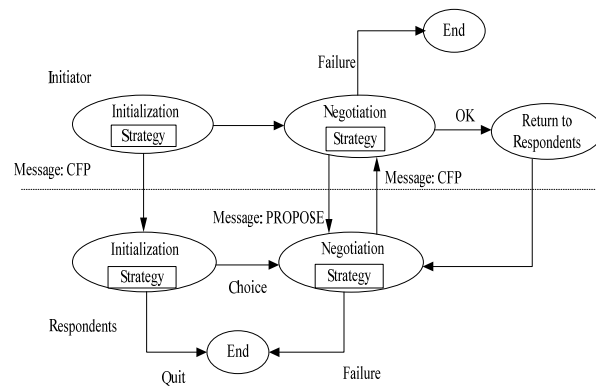


Figure 6. State-transition Diagram

Among them, act the role of the planner is to build the desired target sequence of actions. Action plan is under the domination of the engine running, it can affect the program behavior. And it can arrange the behavior of agent which does not reach the target.

3.4. Operation Mechanism of MABDS Technology

After research of the key technical problems of the agent, we can find that the Multi-Agent is based integrated decision support technology of operation mechanism. Due to the decision support technology based on Multi-Agent as a whole, so it is based on the interaction between multiple agents to complete a given task of decision-making. Therefore the whole operation mechanism can be summarized as shown in the Figure 6.

What described in the Figure 6 is agent interactions between each other, what kind of information should be exchanged between the agents, and a special meaning of the message will affect the whole decision-making activities. Due to interactions of the originators of the role of the agent, in the interactive role of different state, so we can describe interaction behavior from two angles. As it can see from Figure 6, the decision making work is needed in every phase of the agent behavior.

In the agent of receiving index information, the CFP message will make it go into the initialization state. If it decides to respond to this message, it will enter into the negotiation stage. Then indicator information agent will apply its own strategy to produce a piece of advice message to the agent of ranking. After that, the index information will entered the stage of waiting for the agent. If in the final limit range of time, it has not received any feedback information, index information, the agent will stop the interactive activities [13, 14].

When hierarchy agent receives recommended news, it will apply its own strategy to analyze it, the results could be three possible situations:

- (1) If the proposal is acceptable, then the interaction will be stopped.
- (2) If it does not accept the advice, the hierarchy agent think there is no need to negotiate again; it will immediately terminate the interaction activities.
- (3) If you don't to accept advice, hierarchy agent will give out the information using their strategies.

Agent will send a CFP message of requesting to get the new proposal, at the same time hierarchy agent will entered the stage of waiting until getting new advices or there occurs timeout. The complete interactive activity is completed.

4. Conclusion

The research on several key technical problems of the Multi-Agent are discussed in this paper, we put forward the corresponding technical implementation scheme, but as for the agent mechanism of negotiation, negotiation strategies and countermeasures, security problem, the in-depth explorations of the theory are necessary. And it will play an active role in MABDS technology, and it will get more widely applications, it needs to be researched during the process of application in the future.

The application of decision support technology based on the Multi-Agent is still in the exploratory stage, the accuracy of reason for accident gradation results also need to be verified in a real emergency response process and the further improvement in view of the problems are also needed. MABDS technology is a very useful technology, the many famous laboratories around world have the research direction about the agent, and agent does have the necessity of the study. It is believed that there will be more and more researchers and technicians to join in the research; and the MABDS technology will have its own broad application prospects.

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