Research on the Key Technology of Group Decision Support System Based on Multi-Agent

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Abstract

Using the features Agent has, according to the needs of the Group Decision Support System (GDSS), a new Group Decision Support System framework based on Multi-Agent is presented; the communication mechanism, the cooperation, negotiation and coordination of Multi-Agent in GDSS is studied and analyzed.

Keywords: Agent; GDSS; Framework; Communication Mechanism; Cooperation; Negotiation; Coordination

1. Introduction

With the rapid development of information technology, the problems people face are getting bigger and more complex, and is far from being resolved by the individual decision-making, various decisions are often made by a coordinated and cooperated decision group[1,2]. Group Decision Support System has become the most active area in the research and application of Decision Support System. Group Decision Support System is an information system based on Decision Support System, it utilizes computer network and communication technology for multiple decision-makers for a common goal to explore the solutions of the semi-structured or non-structured decision-making problems collaboratively through some rule. It can help decision-makers understand complex problems and environment, promote interaction among decision-makers and enhance mutual trust, and get better results.

Agent is a computer (hardware or software) system that meets the specific design needs, it is located in a specific environment, and highly flexible and autonomous[3,4]. Multi-Agent System is an important research direction of artificial intelligence, it is a relatively loose Multi-Agent Federal composed of multiple interacted and interrelated autonomous Agents. These agents can coordinate and serve mutually to complete a task together. The Multi-Agent is guided by synergistic science and based on distributed artificial intelligence, it is widely used in data mining, information filtering, etc.

Multi-Agent System and the computer supported cooperative work, provides a powerful information theory foundation for GDSS. In GDSS, the use of the distributed artificial intelligence theory in the research of Intelligent Agent Technology can solve a series of problems such as information distribution,
processing distribution and decision-making distribution caused by the new generation of human-machine interface and human network interface. With the rapid development of Internet and the gradual improvement of Agent technology, to integrate Agent technology into GDSS and to extend it to the Internet is an inevitable trend for GDSS. The use and the integration of Agents in the GDSS provide an automated, cost-effective means for making decisions[5], and the complex decision-making problems can be better solved. This article will study GDSS based on Multi-Agent.

2. Group Decision Support System Framework Based on Multi-Agent

Group Decision Support System based on Multi-Agent needs to go through a decision-making process from distributing decision-making task, selecting participant decision-making experts until getting the final decision results [6,7]. As shown in Fig.1, a Group Decision Support System framework based on Multi-Agent is presented. We can see that the system is divided into three levels: Decision-making Front-end Level, Application Server Level (WEB) and Data Server Level.

![Fig.1 Group Decision Support System Framework Based on Multi-Agent](image)

(1) Decision-making Front-end Level

Decision-making Front-end Level consists of the various Clients distributed in the Internet environment. Client is the major place for participants to analyze and solve problems. Decision-making Front-end Level mainly completes the interaction between the system and decision-making participants, and provides
communication support among participants. Participants can call different models and different data according to their own characteristics and the needs of problems to make decision analysis. They can also discuss with other participants by means of “Study Room”, “E-mail” or calling other Agent function modules, and make the final decision. The specific function structure is shown in Fig.2.

![Client Structure](image)

**Fig.2 Client Structure**

Assistant Agent, Resource Agent and Plan Agent are defined as follows.

**Assistant Agent.** It is used to assist the users to accomplish the decision-making process and achieve scheduled goals. It usually includes a friendly interactive interface, a description file that reflects user roles, tasks and background, a set of actions to complete specific tasks and the communication protocols among Agents.

**Resource Agent.** It provides information and knowledge services to decision-making participants, and also provides intelligent access of varied heterogeneous data sources. The resources existing in Group decision-making process generally includes three types: communication resources, such as Email, news group and so on; information resources, such as Database, Model Base, Method Base, Knowledge Base and so on; group decision-making tools, such as voting, Brainstorming and so on.

**Plan Agent.** It is in charge of coordinating each action of decision-making process, including the definition and distribution of decision-making problems, the arrangement, monitoring and coordination of decision-making process.

(2) Application Server Level

Application Server Level is the communication center of the whole system. It includes Computing Level, Negotiation Level and Alternative Evaluation Level. The distribution of decision task, the downloading of model data, the communication among experts and the delivering of the final decision are all accomplished in this level. What’s more, it is in charge of the participants’ communication settings and the connection with Database, Method Base, Knowledge Base and Model Base. The structure of each level is shown in Fig.3.
Computing Level is the start of the entire decision-making, Alternative Evaluation is the end. They are jointly responsible for generating decision-making tasks, selecting participant decision-making experts, dynamically understanding the decision-making process of various experts, coordinating the views of the experts and structuring the views, selecting the optimal decision from the experts’ decisions, and storing the formed new model and method in Data Base, Method Base, Model Base and Knowledge Base according to the specified format. They are also responsible for the management of Data Base, Method Base, Model Base and Knowledge Base.

(3) Data Server Level

Data Server Level is an important part of the system. It stores and manages all the models, datas and methods for decision-making. Data Base Server is used to manage the datas of the system. Datas can be stored in one or more machines. It does data interaction with the outside world through OLAP (On-Line Access and Processing) and Application Server.

3. The Communication Mechanism of Multi-Agent in GDSS

In Multi-Agent System, the communication among Agents is very important because of the distribution of knowledge, information and data, and the requirement of cooperation and coordination among Agents. The behavior of decision-makers need to keep in step in GDSS, therefore, there should be a good communication mechanism among Agents to support the activities of decision-makers.

(1) The communication method of Multi-Agent

There are two main communication methods of Multi-Agent: blackboard system and message/dialogue system.

Blackboard system uses suitable framework to support distributed problem solving. In Multi-Agent System, the blackboard provides public work area for Agents to exchange information, data and knowledge. In the blackboard system, Agent doesn’t communicate directly, each Agent solves the promised subproblems independently. This method is suitable for low-frequency, high-capacity communications.

Message/dialogue communication is the basis of flexible and complex coordination strategy, it is the direct communication among Agents. In message/dialogue communication, Agents use stated protocol to exchange information to establish communication and coordination mechanisms. This method provides
flexible communications, it is suitable for high-frequency and low-capacity communications.

In GDSS, the generation of decision-making alternatives needs a higher flexibility, therefore, it usually uses message/dialogue system as the communication method for Multi-Agent.

(2) Basic communication behaviors among Multi-Agent in GDSS

Communication behavior is a class of behavior that passes messages, it affects the internal states and behaviors of the interactive Agents. Communication behavior can occur between two or among more Agents, they use message/dialogue method to communicate directly.

The basic communication behaviors among Multi-Agent in GDSS are generally divided into three categories: request, promise and inform. With the combination of specific passing messages, these basic behaviors can form complex communication behaviors among Agents.

The description of the basic behaviors among Multi-Agent in GDSS is shown in Fig.4. First, Agent 1 (the message sender) makes task request to Agent 2 (the message receiver), and asks Agent 2 to provide service; after receiving the request from Agent 1, Agent 2 promises (or refuses) the request; and Agent 2 informs Agent 1 the result it needs.

![Fig.4 The Description of the Basic Behaviors Among Multi-Agent in GDSS](image)

(3) Agent Communication Language

Generally speaking, Agent Communication Language (ACL) is a high-level language that includes communication commands and related structures specifically used to support the cooperation, negotiation and coordination among Multi-Agent. The commonly used ACL are mainly as follows: Knowledge Query and Manipulation Language (KQML), FIPA-ACL, Knowledge Interchange Format (KIF) and so on. Here we focus on KQML. KQML is a descriptive language for exchanging knowledge and information, it defines the format of passing messages and protocols of handling messages among Agents. KQML implements exchange of information and knowledge sharing among Agents by providing a set of standard communication primitives. It is both a message format and a message-handling protocol.

KQML can be viewed as being divided into three layers: the content layer, the message layer and the communication layer.

The content layer is used to describe the message contents of the interactions among Agents, these contents can be expressed with appropriate programming languages. The content layer is independent of the implementation of KQML, that is to say, the specific implementation of KQML doesn’t care about the specific meaning of the message content.

The message layer is the core of KQML, it is used to describe the message types of the interactions among Agents, it mainly ascertains the messaging protocol. The message sender provides a
connotation-related primitive pointing out that the connotations of the message are ascertaining, inquiring, ordering or other primitive operations.

The communication layer describes a set of attribute parameters that is related to message communication, including lower-level communication parameters, the identity of the message sender and receiver, and a identifier associated with the communication.

The syntax of KQML is simple, it consists of communication primitive types, parameter names and parameters. The type of communication primitive determines the type of communication operation; parameter names are keywords beginning with “:”; it shows the meaning of the subsequent data; parameters are meaningful dates, and are usually marked by keywords. KQML defines a kind of standard syntax for message passing among Agents and some extensible primitive acts. These acts are mainly from the evolution of speech act theory, and can do various operations to knowledge and goal, we can develop higher level communication models on the basis of them.

4. Multi-Agent Cooperation, Negotiation and Coordination in GDSS

Multi-Agent cooperation, negotiation and coordination means that Agents do reasonable arrangements to their resources, goals and so on. They are dynamic behaviors, and are Agent adaptations to the environment and other Agents. Multi-Agent cooperation, negotiation and coordination is one of the core issues of Distributed Artificial Intelligence research[8].

Agent in GDSS complete decision-making tasks by cooperation, negotiation and coordination. Multi-Agent cooperation, negotiation and coordination is the key point to ensure the tasks commonly completed by Multi-Agent, it is also one of the major features that differ Multi-Agent System from other systems. In GDSS, cooperation, negotiation and coordination among Agents can improve system performance, enhance the system’s ability to solve problems, and can make the system more flexible. Decision-making participants form a consistent view by exchanging related structured information. The success of decision-making largely depends on Multi-Agent cooperation, negotiation and coordination, therefore, Multi-Agent cooperation, negotiation and coordination is one of the key point in GDSS.

(1) Cooperation mechanism of Multi-Agent

Strategies and learning are the cooperation mechanisms of Multi-Agent. The Agent action selection is on the basis of understanding the environment and the actions of other Agents, so there’s need to keep learning to establish and revise beliefs about other Agents. The idea of strategies and learning follows through the cooperation among Agents.

The methods of cooperation among Agents are mainly as follows:

- Decision network and recursive modeling;
- Markov measures;
- Agent learning method;
- Decision tree and game tree.

(2) Negotiation technology of Multi-Agent

Negotiation technology of Multi-Agent consists of three parts: negotiation protocol, negotiation strategy and negotiation handling.

- Negotiation protocol: used for the definition, expression, handling and semantic interpretation of Agent Communication Language.
• Negotiation strategy: used for Agent to select negotiation protocol and communication messages.
• Negotiation handling: used to describe, analyze and evaluate Agent actions in the negotiation process.

Generally speaking, negotiation protocol and negotiation strategy are the micro aspects of Multi-Agent negotiation, they reflect the internal states of Agent; negotiation handling is the macro aspect of Multi-Agent negotiation, it reflects the external behaviors of Agent.

(3) Multi-Agent coordination method

Coordination is mainly used for conflict resolution, the basic content of coordination includes goal coordination, resource allocation, process coordination, result coordination and so on. There are many Multi-Agent coordination methods, the common classification of Multi-Agent coordination methods is shown in Fig.5.

![Fig.5 The Classification of Multi-Agent Coordination Methods](image)

5. Conclusions

In this article, we presented a Group Decision Support System Framework combined with Multi-Agent technology, studied and analyzed the communication mechanism, the cooperation, the negotiation and the coordination of Multi-Agent in GDSS. With the development of network and the maturing of Agent technology, Group Decision Support System will get a longer-term development. Group Decision Support System based on Multi-Agent will become more and more important in Decision Support System field.

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References


