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A DISTRIBUTED DSS FRAMEWORK BASED ON MULTI-AGENT PARADIGM AND ITS IMPLEMENTATION SCHEMA

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Abstract

Many tasks in complex organizations require communication and coordination among interrelated decision making units. Distributed Decision Making (DDM) is oriented to such tasks. This paper proposes a Distributed Decision Support System (DDSS) framework based on multi-agent paradigm, in which Data Warehouse and Data Mining technology are applied. An implementation schema based on CORBA specification is put forward. And a prototype has been implemented for patent-information-based strategic decision, following this framework.

Keywords: Distributed decision making, DDSS, multi-agent, data mining

Introduction

In contrast to group decision made by a set of actors who work together to achieve a common purpose, there are many situations in decentralized organizations where decisions are made and implemented by various interrelated decision making units. These decisions typically require communication and coordination among the organizational units involved in the decision task, so called distributed decision (Swanson, E.B., 1990; Chung, 1993). Distributed decision making involves a set of actors who are autonomous within their sphere of concern, and who act independently based upon their own understanding of the situation they confront, but who recognize that they have interdependencies among themselves. Coordination in a distributed decision setting is more likely to emerge when the autonomous agents are able to take their interdependencies into account in deciding on their independent actions.

Conventional DSS and DDSS that are based on the data management system, the model management system and the knowledge engine, has shown its deficiencies in decision making based on large volume of data in today's application systems. One critical reason is that conventional database systems oriented to OLTP applications cannot satisfy the demand of DSS to support the analytical process. Data warehouse technique is an answer to this problem, which can well support OLAP and solve the data foundation problem of DDSS, satisfying the requirement of DDSS for sharing large volume of data (Inmon, 1993).

With the realization of the data warehouse comes the data mining (DM) technique. Using information contained within the data warehouse, data mining can provide DSS with powerful functions by discovering highly useful and informative patterns within the data that can be used to develop predictive models in a wide variety of knowledge domains.

A DDSS Framework Based on Multi-Agent Paradigm

As a computer system supported for distributed decision making with heterogeneous participants and distributed expertise, a DDSS framework can be built based on multi-agent paradigm logically naturally.

A Multi-Agent System (MAS) could be defined as “a loosely-coupled network of asynchronous problem solvers that work together to solve problems that are beyond their individual capabilities” (G. O’Hare, 1996). The “asynchronous” indicates that problem solvers operate in parallel; “loosely-coupled” means that individual problem solvers spend a great percentage of their time in computation rather than in communication.

These properties make a multi-agent paradigm suitable for the design of DDSS framework for the following reasons:

1. MAS constitutes a natural way to handle logically and physically distributed problems and to make distributed decision, which also can be easily supported by distributed component technique.
2. Agents interacting with each other can share distributed resources.
3. Agents can accomplish mechanical tasks without the direct intervention of decision makers.
4. An agent is an intelligent entity that can learn. By individual or organizational learning, the performance of the whole system is hopeful to be raised.
5. Codes of legacy systems can be encapsulated by agents, which can be implemented by component technique and promote the reusability of codes. The modularity of such systems allows their extensibility.
6. MAS enhances the overall reliability (capability to recover from the failure of individual components, with graceful degradation in performance) and robustness (tolerance to uncertainties in data and knowledge);

So we built a DDSS framework based on multi-agents paradigm, which is showed as Fig.1.

This framework composes of a Service Request Broker and several Decision Units (DUs). Each DU contains a PPA (problem process agent), a DWA (data warehouse agent), a DMA (data mining agent), a MSA (model system agent) and a KSA (knowledge system agent). DUs are correspondent to individual units of distributed decision-making, which combines the four-base infrastructure of traditional IDSS and the “DW+DM” solution.

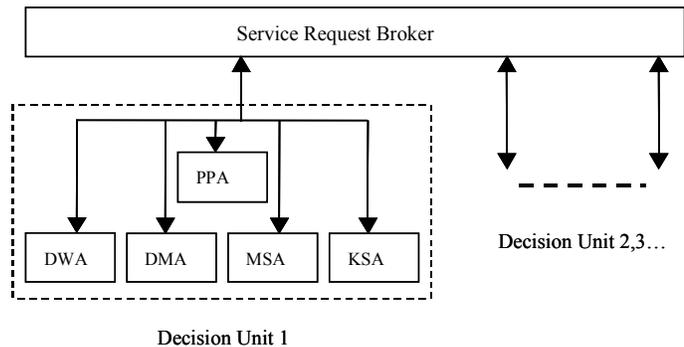


Figure 1. A DDSS Framework Based on Multi-Agent Paradigm

In this framework, PPA interacts with the decision maker, proposes approaches for problem process, supports the recognition, analysis and solution of local problem, and evaluates the result. When necessary, PPA can also request agents of other DUs for supports via the Service Request Broker. MSA is responsible for providing model process function to PPA in the same DU, and KSA for providing rule-based inference. DWA provides data resources and OLAP functions. DMA interacts with local DWA, doing knowledge discovering in the data warehouse. If satisfying the security restrictions (such as authority), all these agents can respond to requests from other DUs when necessary.

The Service Request Broker is some middleware that works as the Object Request Broker in distributed object computing, responsible for interaction of communication among all agents. This builds a flexible client/server relationship between any two agents, thus forms a three-tier mode of “Client-Agent-Server”. The agent has intelligence that can map abstract service requests from client to special server implementation. As a whole, the relationship between Service Request Broker and agents is that of software bus and soft plug-in units.

Implementation Schema and a Prototype for Patent–Information-Based Strategic Decision

The implementation work mainly lies in the implementation of Service Request Broker, agents and their relations, based on the proposed framework.

The above kinds of agents in general are designed to include several parts: a communication module, an event handler, a meta knowledge base, a state set and a method set. The communication module therein is responsible for information exchanges with external entities. The event handler responds to received messages, does actions for problem solving according to the knowledge in meta knowledge base and internal state, and invokes relevant method.

Based on the properties of agents, they can be implemented using distributed software components that have autonomous and independent functions. Also, we want to design software agents to support interoperability in heterogeneous computing systems. Distributed object computing can satisfy the requirements well, by regarding all available resources in distributed networks as commonly accessible object collection, and integrating application objects at heterogeneous platforms.

We choose OMG's CORBA (Common Object Request Broker Architecture) in several distributed object computing architectures, for its well-established specifications standardizing a platform- and programming-language- independent environment. Besides, CORBA ORB (Object Request Broker), which is corresponding to the Service Request Broker in our DDSS framework, provides efficient interoperation between distributed objects. CORBA Object Services provide fundamental functions at system level for distributed objects, which makes the implementation of agents easier.

Each kind of agent in the framework is implemented as a CORBA component, and the Service Request Broker is implemented as CORBA ORB. Each component is a module that can run independently. Components communicate with each other via CORBA ORB, forming a "Client-ORB-Server" relationship.

Following the proposed framework and implementation schema, a DDSS prototype for patent-information-based strategic decision has been developed. The goal of patent strategy is to conduct trades or companies to make technical innovation and to get the most profit by using and mining patent information.

In each single Decision Unit, we implement basic search, intelligent analysis of patent information, technical innovation and strategic decision support, and other accessorial functions. Intelligent analysis of patent information is done mainly by the Model System Agent. The Data Mining Agent and Knowledge System Agent are responsible for technical innovation and strategic decision making by data mining and knowledge inference, based on the result of intelligent analysis. We also design an Internet-based Service Request Broker using CORBA Internet Inter-ORB Protocol (IIOP), which is responsible for the communication and coordination among Decision Units as well as Decision Makers. The prototype system has shown high efficiency and good coordination capability on distributed problem solving, as well as good systematic extensibility.

Summary

A multi-agent-based DDSS framework is proposed in this paper, combining the architecture of "DW+OLAP+DM" with that of traditional DSS. MAS constitutes a natural way to handle logically and physically distributed problems and to make distributed decision, which also can be easily supported by distributed component technique. By using agents and CORBA components to encapsulate the parts of DDSS, the whole system is more flexible and extendible, and software modules are made more reusable.

There are several problems that need further research. Continual study must emphasize on the efficient implementation of DW Agent and DM Agent, the efficient coordination of distributed decision nodes, etc.

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