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A Market-Based Information Resource Management Approach in Information Grid

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ABSTRACT

The information grid is made up of autonomous systems linked together by a network technology substrate. Based on the Agent-Based Information Resource Management Model (ABIRMM), we advance a novel Market-Based information resource management approach, MBIRMA for short. It develops a market model to predict performance. Agents, which are created to receive consumers' requests and preferences, make the information services plan correspondingly and bid for required information resources through hybrid auction. And utility function depicts consumers' preference under the direction of the global information management. The working mechanisms and the information resource management approach of the model are thoroughly illustrated. At final, the applications of ABIRMM are briefly discussed and an example is given.

INTRODUCTION

The information grid is made up of autonomous systems linked together by a network technology substrate. The information grid is heterogeneous, the architecture and the information resource of individual nodes differ, and the information services provided by the information grid are diverse —01,20.

The main service provided by the information grid is the information service. Hence, information resource management is playing a more and more important role in the information grid. We put forward the Agent-Based Information Resource Management Model (ABIRMM) according to the characters of information resource management in the information grid environment and the advantages of Agent-Based architectures—03‰. Since significant benefits can often be realized by sharing these information resources among the distributed agents, a principal challenge is the development of efficient and robust resources allocation and access mechanisms. In this paper we address the problem of information resource management in the ABIRMM.

In general, there are two kinds of information resource management strategy: plan-based and market-based —02,40. Plan-based information resource management strategy is efficient, which construct an action serial according to goals, solution techniques, resource and environment constraints. However, it is hard to know such in details in the information grid environments—060. Market-based mechanism provides an effective solution.

Modern economies generally allocate resources in systems whose complexity overwhelms any algorithm or technique developed for computer systems. Elegant normative models have been developed describing how resources in an economy may be optimally shared in informationally and computationally decentralized ways. These algorithms are shown to have several attractive features including their simplicity, distributed nature, provable (and rapid) convergence, and the computation of successively better resource allocations at each step. The numerous similarities between economic systems and distributed computer systems suggest that models and methods previously developed within the field of economics can serve as blueprints for engineering similar mechanisms in distributed computer systems—0110. A market-based approach is presented in —050 to allocate grid resources in the computational grids, which is based on equilibrium theory and which realizes the optimal allocation of grid resources by the market mechanism. But the initial price is adjusted with a parameter, and the parameter must be set with experience. Usually it will affect the time and accuracy of solution.

This paper advances a new kind information resource management strategy based on market mechanism in ABIRMM, which develop a market model to predict performance. Agents bid for required information resources through hybrid auction. And utility function depicts consumers' preference under the direction of the global information management.

This paper is organized as follows: in section 2, ABIRMM is analyzed. In section 3, a market-based information resource management approach, MBIRMA for short, is developed. The analytical model is carefully examined and evaluated. In Section 4, applications of MBIRMA are introduced. Finally, conclusions are given in Section 5.

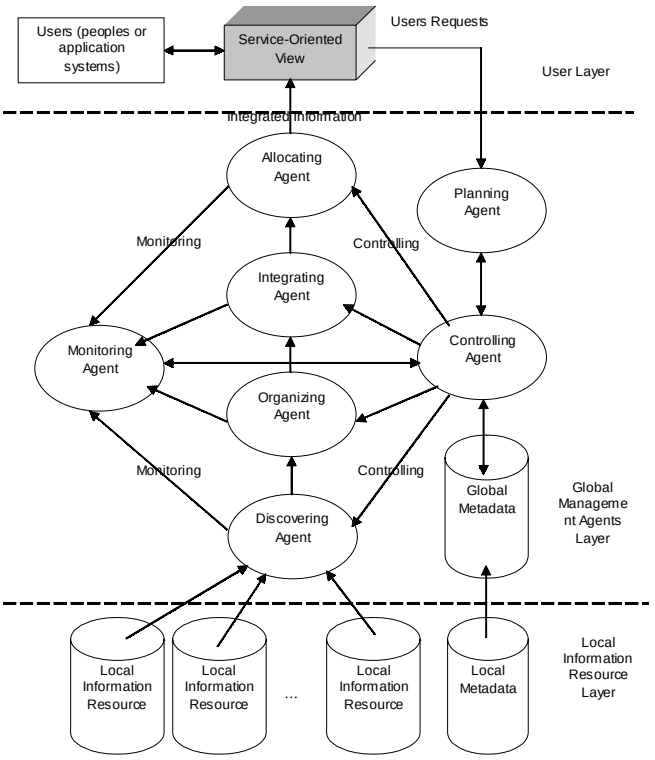
Agent-Based Information Resource Management Model

Figure 1 depicts the ABIRMM architecture which is a three-layer architecture consisting of a User Layer, a Global Management Agents Layer, and a Local Information Resource Layer —04,7,80.

At the User Layer requesting users, which are peoples or application systems, access the system through a service-oriented view. The service-oriented view then submits user requests to the Planning Agent residing at the Global Management Agents Layer, which is aware of the current state of the system including all applicable constraints. The Planning Agent then makes information services plan according to the user requests and its privilege, after which it routes both the information services plan and the user requests to the Controlling Agent. The Controlling Agent coordinates the information services plan on the basis of the system status known from the Global Information Resource Metadata, and then decomposes the requests into a collection of activities and workflows to be handled by other agents residing at the Global Management Agents Layer.

Under the control of the Controlling Agent, the Discovering Agent locates the right information resource from the Local Information Resource Layer with the aid of the Local Information Resource Metadata and transports it to the Organizing Agent —09,100, then the Organizing Agent organizes the information resource collected from the Discovering Agent and sends it to the Integrating Agent, and then the Integrating Agent accepts the information resource sent by the Organizing Agent and integrates all the information resource so as to provide

Figure 1. Agent-based information resource management model architecture



information services, finally the Allocating Agent obtains the integrated information resource from the Integrating Agent and distributes it to the users through the service-oriented view. The Monitoring Agent monitors these Agents' working status from the beginning to the end and reports which to the Controlling Agent in real time.

All these agents residing at the Global Management Agents Layer, such as the Planning Agent, the Controlling Agent, and the Integrating Agent, are intelligent agents, which have intelligence and social ability, and can fulfill high-level tasks directly or through cooperation with other agents. Both the Global Information Resource Metadata and the Local Information Resource Metadata play a very important role in the ABIRMM, which are responsible for knowing about the system status, the agents working status, the available information resources and services.

MARKET-BASED INFORMATION RESOURCE MANAGEMENT APPROACH IN ABIRMM

A novel Market-Based information resource management approach, MBIRMA for short, is proposed. It develops a market model to predict performance. Agents, which are created to receive consumers' requests and preferences, make the information services plan correspondingly and bid for required information resources through hybrid auction. And utility function depicts consumers' preference under the direction of the global information management.

Market Model

The market model in ABIRMM includes $<A,R,P,U,S>$, where $A=\{a_1,a_2,\ldots,a_n\}$ is the set of consumer agents who require the use of certain information resources in order to perform their assigned tasks, $R=\{r_1,r_2,\ldots,r_m\}$ is the set of available information resources, $P=\{p_{ij}\}_{nxm}$ is a matrix in which p_{Ij} represents the price of agent a_i bidding for information resource r_j . $U(.)$ is the utility function which describes the satisfaction of consumers in terms of the price of information resources, and $S=\{s_{ij}\}_{nxm}$ is a matrix in which s_{Ij} represents the percent of resource r_j allocated to agent a_i. An agent prefers some allocation to others. Agent preferences are typically represented by utility functions. $U(.)$ maps the resource vector space to a real number. An agent prefers $x \succ y$, when $U(x)>U(y)$.

In an economic model of a computer system, the consumers are applications such as transactions, computational jobs, file allocation applications, multimedia teleconferences and new distribution.

Utility Function

Allocation of files (or data objects) in a complex distributed computer system has been considered by (11). It provides a utility function known to all *n* consumer agents as follows, which optimization criteria included communication cost and average processing delay.

$$U = -\sum_{i \in N}\left(C_i + \frac{K}{\mu - \lambda x_i}\right)x_i$$

Where xi is the probability that an access (from anywhere in the grid) being directed at the fraction of file resources stored at node *i* for processing. C_i is the average (system-wide) communication cost of accessing the file object at node *i*. ›is the system wide arrival rate.

Then the optimal allocation is computed to solve the global optimization problem in a distributed fashion. This is done by trading appropriate amounts of resources iteratively among themselves till they reach a point where the marginal rate of substitution of resources is equal. The allocation at this point is pareto optimal.

Pricing Mechanism

The pricing mechanism in the economy is based on auctions held by information resources and bidding by agents. There are four types of auctions. The first is an English auction where the price of resource is gradually increased with the bidding. The highest bidder obtains the resources. The second is the Dutch auction, where prices are gradually lowered by the seller till one of the buyers claims the resource. The third is the hybrid auction, where the asking price of a resource is increased if a bid is submitted, and decreased if no bid is submitted. The hybrid auction attempts to find the highest price using this process. The fourth is the Sealed Bid auction, where sealed bids are submitted by the agents and the highest bid is given access to the resource. In this auction model, agents are not aware of the amounts bid by the other consumers. Hybrid-auction economy performs the best at all utilizations (12).

A market mechanism is any kind of auction; an auction is a competitive equilibration protocol. The essential feature of an auction is that it adjusts the price of a resource in response to the demand for it, so that the price rises or falls to the point where demand at that price just matches supply. Equilibrium prices determine the ratios in which resources are to be allocated among the consumers so as to realize a Pareto optimal distribution (13).

The price matrix is created during hybrid-auction: consumer agents who require certain information resources bid for them, the price of such resources increase; the price of some others decrease if no bid is submitted. So *n* consumer agents bidding for *m* resources create the price matrix $P=\{p_{ij}\}_{nxm}$, in which p_{Ij} represents the price of agent a_i bidding for information resource r_j.

After a bidding, the controlling agent evaluates all the bids, and assigns the task to the best bidder according to utility function.

APPLICATIONS OF MBIRMA

The information resource management has been widely studied in E-government, Supply Chains, and Virtual Enterprises to provide high-

performance information services—0150, such as decision-supporting. We will illustrate the application of MBIRMA through an example of decision support in E-government.

In E-government, electronic dissemination of government documents offers the opportunity to reduce the costs of dissemination and make government information more usable and accessible—016-170. However, to move to an environment in which documents are accessed freely and conveniently in electronic format, a number of challenges would need to be overcome. One of these challenges is how to provide foundational optimize service for large-scale file allocation and information access efficiently, considering the effect of information resource access and communication cost to end-users.

To make sure customers getting their required information in a timely manner, the information resource can be managed on its global information system using MBIRMA. In such way, an agent is created for a consumer, which receives the consumer requests and preferences, and makes the information services plan correspondingly. Then the agents bid for required resources by trading appropriate amounts of resources iteratively among themselves till they reach a point where the marginal rate of substitution of resources is equal.

As a new kind of information resource management approach, MBIRMA, which is advanced on the basis of thorough investigation to the information resource management in the information grid environment and the advantages of Agent-Based architectures, can be used to manage information resource in large-scale information system to provide information services efficiently and effectively.

We have used the MBIRMA in the Hunan Province E-government Project to manage the information resource that the government deals with, which is heterogeneous and of large amount—0180. The results show that the system can provide high-performance information services.

CONCLUSIONS AND FUTURE WORK

The information grid calls for innovative approaches and models to the management of information resource. This paper has presented a novel and efficient Market-Based information resource management approach named MBIRMA to the management of information resource on the basis of thorough investigation to the information resource management and the information grid environment. The MBIRMA advances a novel information resource management strategy based on market mechanism in ABIRMM, which develop a market model to predict performance. Agents bid for required information resources through hybrid auction. And utility function depicts consumers' preference under the direction of the global information management.

Favorable information resource management of the information grid will benefit the critical information services provided by the information grid greatly, which are the backbones of many information application domains, such as E-commerce, Virtual Enterprise and military missions —02,4,80. In this paper, an example of decision support in E-commerce has been given to illustrate the application of MBIRMA, and the results show that information resource management system founded on ABIRMM can provide high-performance information services.

The information resource management in the information grid environments is very different to which is in the traditional distributed information system —01,2,100. Future work will involve Agent-Based intelligent integration of information (I**3), intelligent agents, interoperability at the collaboration level of knowledge and meta-model level interchange.

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