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Decision Resource Management and Scheduling on the Grid

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Abstract: The Web-based Decision Support Systems (DSS) have made information sharing on the Internet possible, but they cannot meet the decision-maker’s needs in the heterogeneous, autonomic, dynamic and distributed decision support environment. However, as an advanced technology representing "the third internet revolution", Grid brings about a lot of innovative ideas and technologies for the development of DSS. In this paper, we propose a service-oriented economy model for Decision Resources Management in Grid environments, and discuss Grid Decision Resource Scheduling process based on cross-organizational workflow. We believe the support for service-oriented economy-based Decision Resources Management and Scheduling within Grid environments is essential for pushing Grid-Based Open DSS (GBODSS) into mainstream DSS.

Key-Words: Decision Resource Management; scheduling; Web services; Grid

1. Introduction

DSS have a history of more than 30 years since the beginning of 1970s. DSS are computer-based information systems that help decision-makers solve half-structured or non-structured problems by using data and models. They enable decision-makers to make decisions more effectively. The Web-based DSS have made information sharing on the Internet possible, but they cannot meet the decision-maker’s needs in the heterogeneous, autonomic, dynamic and distributed decision support environment, because they only link web pages and lack global mechanism to manage and coordinate decision support resources on the Internet. However, as an advanced technology representing "the third internet revolution", Grid appears as an effective technology coupling geographically distributed resources for solving large-scale problems in wide area network, which support open standard and dynamic services. In addition, it provides highly intelligent communication between computers and human. These characteristics are very suitable for the constructing need of DSS platform. It will improve DSS greatly, and bring profound revolution to DSS theory and its application. The idea of GBODSS is becoming a reality [1]. As an application of Grid in the field of DSS, this paper puts forward an improved model of Agent Grid-based Open DSS (AGBODSS).

In general, the major problems in this domain relate to the Grid Decision Resource (GDR). However, GDR Management (GDRM), GDR Scheduling (GDRS) and usage models in these environments is a complex undertaking. This is due to the geographic distribution of GDR that are owned by different organizations or peers. The owners of each of these GDR have different usage or access policies and cost models, and varying loads and availability. In order to address complex GDRM issues, we have proposed a service-oriented economy model for GDRM and GDRS in Grid environments. This model provides mechanisms for optimizing GDR provider and consumer objective functions through trading and brokering services.

2. Agent Grid-based Open DSS

The concept of Grid system can be divided to different technological layers of computer system for an in-depth study. Agent Grid layer plays a very important role in whole Grid system. On one hand, it is this layer that interoperates directly with users. It includes agent and the agent system that perform the main system functions and sub-functions. On the other hand, Agent Grid layer needs to connect the three Grid layers beneath it and manages the corresponding layers and resources. It facilitates the coordination between the different layers to accomplish concrete tasks.

In order to elaborate on the GBODSS, we have improved the model of the GBODSS with the above Grid hierarchy framework based on the Agent Grid. We have established an Agent Grid based open DSS model (AGBODSS) in figure 1 [1]. The improved model characterizes the relationship between the components and layers of the GBODSS and illustrates its openness and dynamic characteristics more clearly.

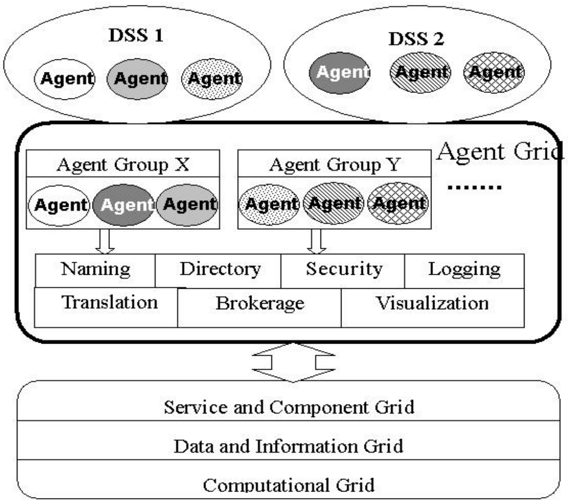

Fig. 1.Open DSS Model Based on the Agent Grid

The Agent Grid layer is the core of the AGBODSS model. This layer has direct connections and interfaces with the other components of the system. The Agent Grid layer is composed of several registered agent groups and grid services, and each agent group is composed of some agents. The Agent Grid provides many Agent Grid services to support the management, interoperation and integration of the agents in this layer. Presently, the Agent Grid services include register service, brokerage service, logging service, security service and visualization service, etc. Agents in the Agent Grid can be divided into several agent groups according to their type to facilitate the management and utilization of these agents.

Considering practical problems, the designer of the DSS can construct different DSSs easily through a quick integration of the agents in the Agent Grid layer. The designer of the DSS needs firstly to design the structure of the AGBODSS, and then chooses suitable agents in the Agent Grid to play the roles in the AGBODSS.

The three bottom layers of the Grid stack are the basis of the AGBODSS, and can be considered as the Grid infrastructure that can provide all kinds of resource on the Grid. Heterogeneous resources in these layers can be fully utilized in a transparent way with the Agent Grid layer to hide the heterogeneity of them.

3. Service-oriented Economy Models for GDRM

3.1 Service-oriented Architecture

Service-oriented architecture (SOA) is not a new concept. A SOA is essentially a collection of services, stressing on interoperability and location transparency. These services communicate with each other, and can be seen as unique tools performing different parts of a complex task. Communication can involve either simple data passing or it could involve two or more services coordinating some activity.

Web services, in the general meaning of the term, are services offered via the Web. In the Data Acquisition and Monitoring Equipment (DAME) scenario, an application sends a request to a service at a given Internet address using the Simple Object Access Protocol (SOAP) protocol over HTTP. The service receives the request, processes it, and returns a response. Based on the emerging standards such as eXtensible Markup Language (XML), SOAP, Universal Description, Discovery and Integration (UDDI), and Web Services Description Language (WSDL), web services enable a distributed environment in which any number of applications, or application components, can inter-operate seamlessly among organizations in a platform-neutral, language-neutral fashion. Web service consumers view a service simply as an endpoint that supports a particular request format or contract. Web service consumers are not concerned with how the Web service goes about executing their requests; they expect only that it will.

Grid services [2] on the other hand are based on the integration of Open Grid Services Architecture (OGSA) concepts and web service technologies. Specifically, Grid services benefit from both web service technologies as well as Grid functionality. As an example, Grid services can provide aero engine experts in any geographical location with remote access to powerful Grid computing resources, large knowledge repositories and datasets as well as diagnostic tools via a Web browser and Internet link.

3.2 Service-oriented Economic models for GDRM

Grids are emerging as a global cyber-infrastructure for solving large-scale problems in science, engineering and business. They enable the sharing, exchange, discovery, selection and aggregation of geographically distributed, heterogeneous resources—include GDR. As Grids comprise of a wide variety of GDR owned by different organizations with different goals, they present a number of challenges in managing shared distributed GDR. To address these challenges, a distributed computational economy mechanism has been proposed. This mechanism would support efficient management of distributed GDR by regulating the supply and demand through differentiated pricing strategies and promote sustained sharing of resources by providing incentive for GDR Providers. It also encourages GDR Consumers to specify their Quality-of-Service (QoS) needs based on their actual requirements [3]. Therefore, the use of Grid economy mechanism in managing shared GDR would lead to the creation of a GDR Market-Place (GDRMP).

We proposed and explored the usage of an economics-based paradigm for managing GDR allocation in Grid computing environments. The economic approach provided a fair basis in successfully managing decentralization and heterogeneity that is present in human economies. Competitive economic models provide algorithms/policies and tools for GDR sharing or allocation in Grid systems. The models can be based on bartering or prices. In the bartering-based model, all participants need to own GDR and trade GDR by exchanges. In the price-based model, the GDR have a price, based on the demand, supply, value and the wealth in the economic system [4].

Research on Economic models for GDRM suggests that GDRMP -based architecture is a good solution for managing GDR because GDRMP -based links between companies are more efficient than point-to-point links between every buyer and every supplier. We envision a future in which economically intelligent and economically motivated P2P and Grid-like software systems will play an important role in distributed service-oriented computing. Emerging Web Services and Web Services-based process definition standards provide mechanisms for formally defining GDRM that can be clearly understood and quickly deployed in a platform-independent manner. Figure 2 visually describes Service-oriented Economic Model for GDRM that satisfies the key requirements. In addition, the proposed Service-oriented Economic Model for GDRM contains the repository of shared ontology, message formats and templates.

Up until now, the idea of using Grids for solving large computationally intensive applications has been more or less restricted to the scientific community [5].

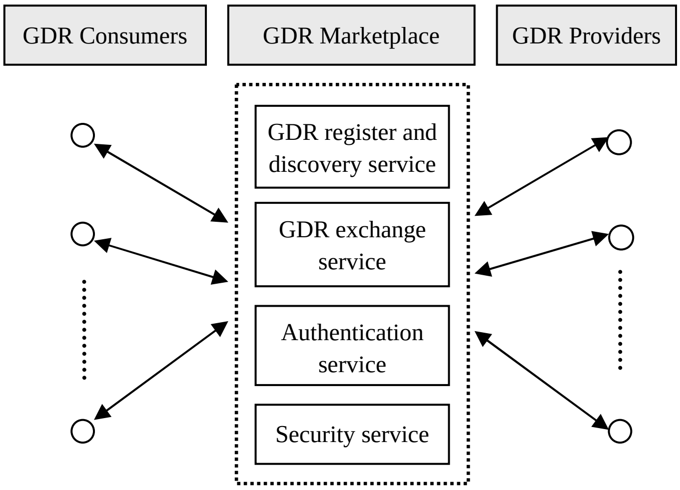

Fig. 2.Service-oriented Economic Models for GDRM

4. GDRS process Based on cross-organizational workflow

4.1 Service-oriented cross-organizational workflow

The cross-organizational workflow (SCW) environment described in this paper incorporates the interoperability of general web services. In figure 3, an example is given of a SCW environment for multiple travel-related businesses. The initiating business is the travel agency company. The Travel Agency has internal services for managing customers' accounts and credit card numbers. However, the travel agency uses other third-party vendors to realize the hotel reservation and car rental reservations. The Hotel Reservation and Car Rental companies register their offerings as web services in a distributed registry, such as a UDDI registry. The Travel Agency uses these registry services as a part of its internal workflow. In addition, the Travel Agency has a partnership with an on-line publishing company that publishes the finalized itineraries. In this case, the travel agency has a static connection with the partner organization and is able to access services directly over a shared network connection. Problems occur in this domain when the online companies update or remove their service offerings. This SCW environment requires a framework that supports a methodology for process or workflow oriented service specification. This framework would allow workflow developers to specify the process sequence and message exchange between local and distributed services [6].

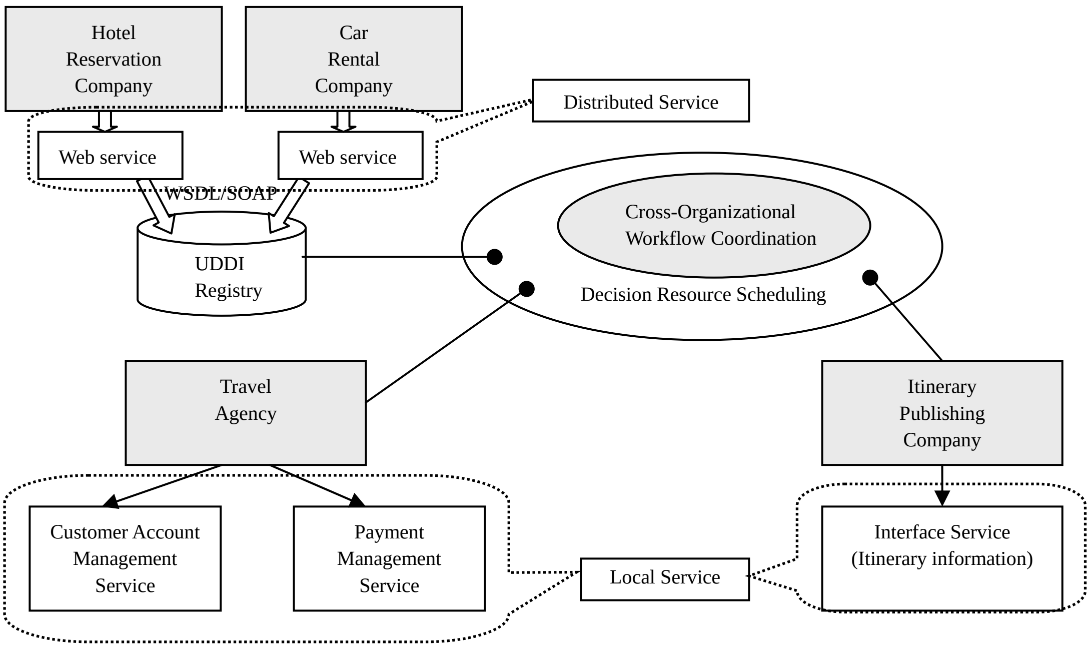

Fig. 3.an sample of service-oriented cross-organizational workflow

4.2 GDRS process based on cross-organizational workflow

GDRS process Based on cross-organizational workflow, in a general sense, consists of five steps as illustrated in figure 4.

(1) GDR Discovery: Identify characteristics, configuration, capability, and suitability of GDR. This discovery can occur on services in UDDI registry or locally registered component-based services.

(2) GDR Capturing: Save the GDR characteristics in the service-oriented data model and then interacts with GDR to establish their configuration and access cost. It creates a broker GDR list and the GDR performance data as predicted through the measurement and extrapolation methodology.

(3) Scheduling Process: The scheduling flow manager selects an appropriate scheduling algorithm for component GDR depending on the user's requirements (deadline and budget limits, and optimization strategy-cost, cost-time, time, and conservative-time).

(4) Process Capturing: When the GDR Scheduling Process has finished, the GDR returns it to the broker's receptor agent. It aids in predicting the job consumption rate for making scheduling decisions.

(5) Agent Self-Configuration and Deployment: application layer agents access the integrated data model and configure themselves for workflow enactment in the Grid environment. At the end, the agent returns updated GDR data back to the user entity.

In this process, scheduling decisions are made dynamically at runtime and are driven and directed by the end-users requirements [5]. Economy model primarily charges the end user for services that they consume based on the value they derive from it. Pricing policies are based on the demand from the users and the supply of GDR s is the main driver in the competitive, economic market model. Therefore, a user competes with other users and a GDR owner with other GDR owners.

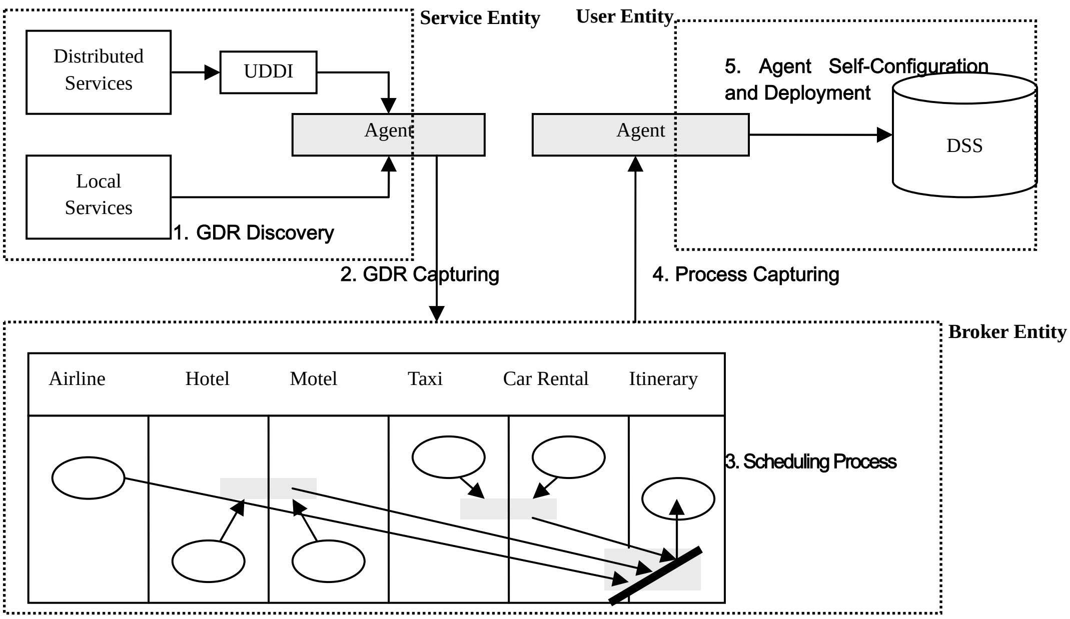

Fig. 4.GDRS process based on cross-organizational workflow

5.Security

GDR may contain potentially business-sensitive data and hence access to data and services should be restricted to authorized members within an organization. For instance, both the engine faults knowledge base and engine models contain important information on its design characteristics and operating parameters. The use of the Grid Security Infrastructure (GSI) enables secure authentication and communication over an open network. GSI consists of a number of security services including mutual authentication and single sign-on. This is based on public key encryption, X.509 certificates, and Secure Sockets Layer (SSL) communications. The implementation of GSI within the DAME decision support environment is composed of Globus Toolkit 3 (GT3) security elements conforming to the Generic Security Service API (GSS-API), which is a standard API for security systems promoted by the Internet Engineering Task Force (IETF) [2].

6. Summary and conclusion

In this paper, we proposed the use of computational economy as a metaphor for the management and regulation of supply-and-demand for GDR. It provides a decentralized GDRM capability and is adaptable to changes in the environment and user requirements. It is a scalable, controllable, measurable and easily understandable policy for management of GDR.

The paper also shows GDRS process based on cross-organizational workflow. It effectively schedules the GDR with good intelligence, scalability and adaptability. More importantly, it provides mechanisms to trade-off QoS parameters, deadline and computational cost, and offers an incentive for relaxing their requirements reduced computational cost for relaxed deadline when the time frame for earliest results delivery is not too critical.

It also raises some questions about the GRDM and GDRS. We believe the support for economy-based GDR Management and Scheduling within Grid environments is essential for pushing GBODSS into mainstream DSS.

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