A Knowledge Grid Architecture Based on Mobile Agent

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Abstract

The performance of services implemented in the service-oriented knowledge grid becomes one of the most key issues that affect the development of the knowledge grid. This paper presents a knowledge grid architecture based on mobile agent and effectively utilizes mobile agent's mobility, flexibility and intelligence to implement knowledge grid services. The idea that applies MA technologies to the knowledge grid can reduce network traffic and improve the intelligence of knowledge grid services. The integration of two main distributed technologies provides a new way to develop knowledge grid.

1. Introduction

The knowledge grid is service-oriented and defined on top of grid toolkits and services. "The Grid Service Specification (Draft 2/15/02)" by Foste2, Kesselman, Tuecke, Karl Czajkowski, Jeffrey Fry and Steve Graham proposed (Open Grid Service Architecture) OGSA, which represents a long-overdue effort to define the specification for grid services and architecture. Following the Integrated Grid Architecture approach, there are many ways and models, which can implement grid tools and services in conformity to OGSA specification, such as Globus, Condor and UNICORE. Foster [1] discussed service-oriented grid architecture and the implement of grid-services in Globus. Cannataro and Talia [2] particularly described knowledge grid services and discussed a knowledge grid architecture based on the Globus Toolkit 2.0. However, these ways and models still need lots of efforts to effectively implement KB-services such as knowledge discovery services.

This paper presents an architecture based on mobile agent for service-oriented knowledge grid and combines mobile agent technologies with knowledge grid technologies to effectively develop and implement KG-services. The key feature of mobile agent is code mobility, which raises the location where an application component is executed from the status of configuration or deployment detail to that of first-class element in the application design. Besides, with the other features such as mobility, flexibility and intelligence utilizing MA technologies to implement knowledge grid services can greatly improve KG-services performance such as reducing network traffic and improving the KG-services intelligence.

2. The Knowledge Grid

With a rapid development of IT, how to manage and exploit massive data produced on internet is one of the main issues to be faced by next-generation internet. The most effective way to achieve these ambitious goals is to apply knowledge grid to the future interconnection environment [3][4]. The knowledge grid is a communication infrastructure and effectively acquires, represents and exchanges massive data and information and integrates and converts them into useful knowledge through mining and reference methods [5]. It also enables search engines to make references, answer questions, and draw conclusions from masses of data. Moreover, the knowledge grid provides an intelligent, sustainable Internet application environment that enables people or virtual roles to effectively capture, publish, share and manage explicit knowledge resources.

The architecture of the knowledge grid [2] is shown in Fig. 1.

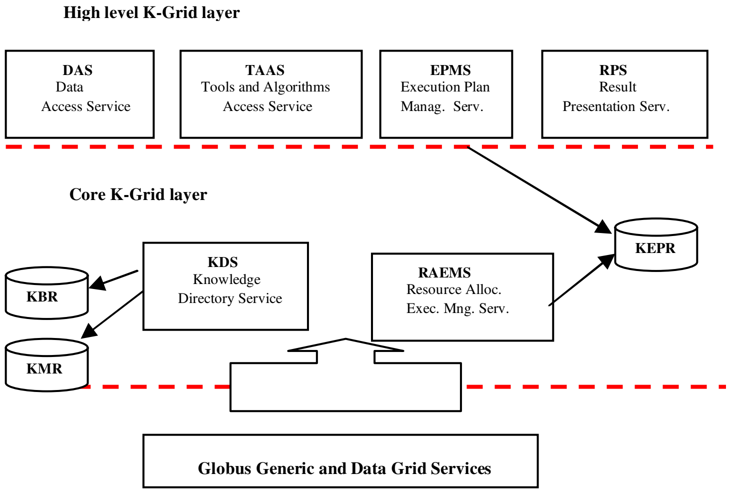

Fig. 1 The architecture of the knowledge grid

The core K-grid serves for searching, storing and managing information and services which come from basic grid and matches the application requirements on high level K-Grid layer to available basic grid resources. The high level K-Grid layer includes some application services about knowledge discovery which can synthesize knowledge from data through mining and reference methods, enabling search engines to make references, answer questions and draw conclusions from masses of data. Ontology knowledge services are described in metadata and exist in the format of XML which is machine-understandable and is converted to human-understandable knowledge through XSL [6].

3. A knowledge grid architecture based on mobile agent

In this section, we introduced our MA-based architecture for service-oriented knowledge grid which has been implemented on the previous work [7][8]. We used the conception and thought of architecture in [2] and designed MA-services and MA API for the implementation of KG-services. This paper presented a model which gave a solution to optimize the KG-services performance by implementing the KG-services based on mobile agent.

3.1. Mobile Agent technology

Mobile agents are computer programs that can migrate from one server site to another in a computer network to perform a task on behalf of a user autonomously and more efficiently. Mobile agent technology is expected to reduce network traffic and to enhance efficiency of information retrieval by moving code to remote data centers. Mobile agent technologies have the following advantages:

1) Reduce network load
2) Overcome network latency
3) Encapsulate protocol
4) Execute asynchronously and autonomously
5) Adapt dynamically and naturally
6) Robustness
7) Fault tolerance

Because of their good features, we would like to make full use of mobile agent in implementing KG-services in the knowledge grid.

3.2. Utilizing MA to Implement KG-Services

We utilize MA technology to improve the architecture in the knowledge grid and add MA-services in the knowledge grid. MA-services can optimize the performance of KG-Services and MA-based architecture for service-oriented knowledge grid is showed in Fig.2.

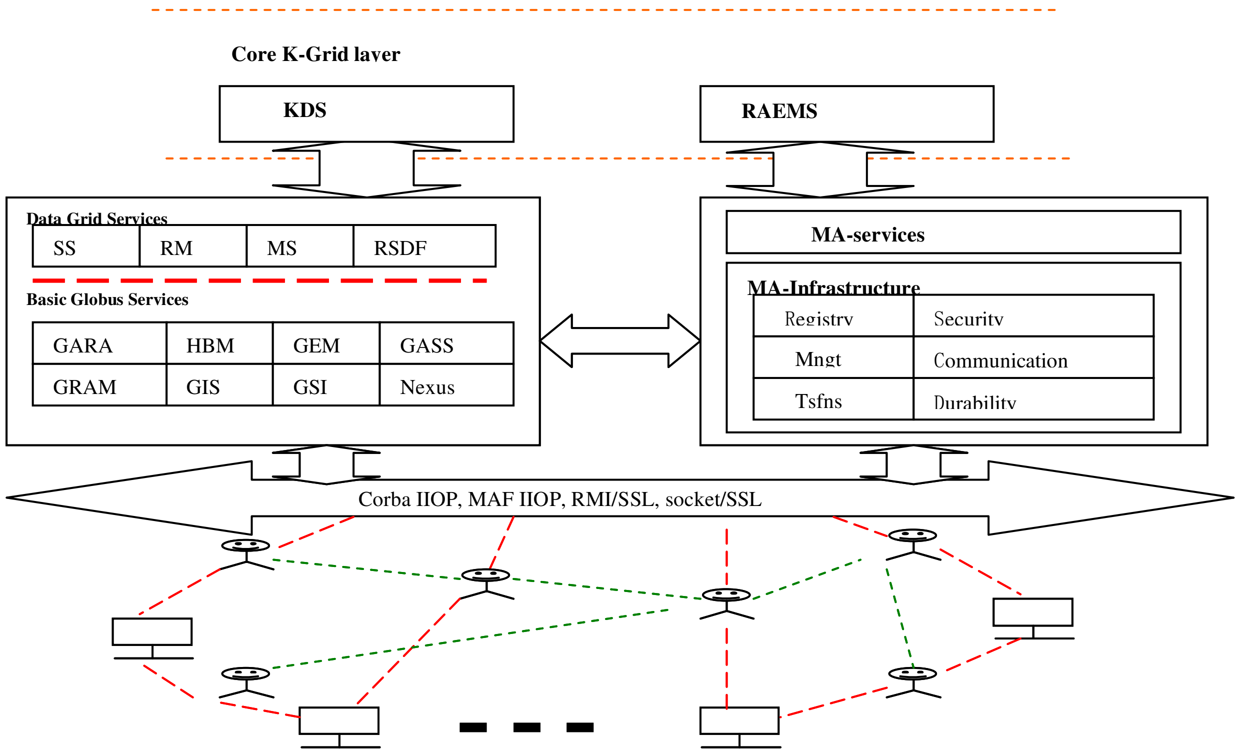

Fig. 2 A knowledge grid architecture based on mobile agent

As follows we describe the work mechanism of the MA-services:

1. The ontology KG-services acting on the user's behalf are described in the format of XML and communicate with MA-services for making MA-services serve for the request of KG-services.

2. MA-services communicate with the basic-grid and get the grid resources information from basic-grid such as CPU

time, storage and network performance.

3. MA-services according to the request of KG-services and the information from basic-grid independently and intelligently move to the services providers who can provide the required data mining and knowledge discovery services.

4. The multi-MAs dispatched by MA system during the execution communicate and contact with each other for getting the information about services providers. They also intelligently negotiate and choose an optimal services provider.

5. KG-services communicate with local host in the format of XML and use the KG-services resources of this host such as algorithm, database and the rule of knowledge discovery to execute the program for achieving the request of KG-services.

6. If the host is offline or collapses during the execution, MAs carrying the statement of the tasks and temporary executing result move to another optimal services provider to continue to execute the tasks.

7. After achieving the tasks mobile agents autonomously return the results requested by KG-services to host and MA-service recalls and kills the outside agents.

3.3. The Implementation of the MA-services

We implement the KG-services by integrating MA technologies and KG technologies. The following toy example introduces the implementation of curing illness by combining ontology knowledge with MA technology.

```
<ontology: illness>
<ontology: name>cardiopathy</ontology: name>
<ontology: symptom>faint…</ontology: symptom>
<ontology: cure >medication…</ontology: cure >
……………
<ontology: name>cancer</ontology: name>
……………
</ ontology: illness>
public interface Diagnose extends Aglet
{
public String find (String symptom);
public String send(String medicine);
Boolean call ( );
Boolean dispatch ( );
Void clone ( );
  ……………
}
public void doDiagnose ( ) throws IOException{
Diagnose diagnose = (Diagnose) jndicontext.lookup
("ma:ontology/ Diagnose");
String cureWay = diagnose.find ( );
……………
}
```

The MA-services API designed by us include (MA API for XML Registries) MAAXR, (KGS with Attachment API for MA) KGSAAMA, (BGS with Attachment API for MA) BGSAAMA and (MA API for XML Processing) MAAXP in the MA, which can implement the function of MA-services.

MAAXP is used to implement DOM2 (Document Object Model, Level 2) and SAX2 (Simple API for XML version2) and provide an architecture for standard MA API used for reading, writing and modifying XML Document.

MAAXR provides API which is used for visiting registered resources in RAEMS (e.g. performance, available computing power) and registered KG-services resources in high level K-Grid layer (e.g. data mining tools and algorithms).

KGSAAMA provides API used to communicate between KG-services and MA-services in the format of XML and get the KG-services request or return the results (e.g. search services, selection services, downloading services of data mining tools and algorithms).

The difference between KGSAAMA and BGSAAMA is the latter is implemented to conform to OGSA and is used to communicate with basic grid for getting and returning the BG-services resources.

Globus project is one of the most eminent grid projects in the world. The source code of gt4.0 released in 2005 is open and everyone can download the source code of gt4.0 and research and improve it. At the same time we research the Aglet developed by IBM, so we developed our MA-based architecture for service-oriented knowledge grid on the top of Globus and Aglet.

The advantages of integrating the MA technology into the knowledge grid in KGBMA are follows:

1. MA-services can independently migrate from one node to another node which is regionally distributed in the heterogeneous grid environment and communicate with other mobile agents for implementing KG-services and self-adaptation.

2. MA-services can migrate to other nodes or servers and highly-speed achieve KG-services in local host, so the quantities of network transmission have been reduced and the usage efficiency of network resource has been improved.

3. MA-services can enhance the ability to concurrently achieve the KG-services because users or nodes can create several MAs and execute them on one or more nodes.

4. MA-services can intelligently decide how to handle the KG-Services according to the information of achieved knowledge grid services. Consequently MA-services greatly improve the performance of KG system and enhance reliability and intelligence of KG-Services.

5. Because of MA-services' good collaboration, mobility and object-oriented, we can have more space in implementing KG security.

4. Related work

The mobile agents paradigm was popular as a natural and flexible way to manage latency and bandwidth in the distributed systems over the network and the emergence of autonomous agents technology solved the issues of distributed, dynamic and heterogeneous faced by grid. There were already some researches on the integration between grid and mobile agent. Tianfield [9] presented an agent based framework for grid resource management. A consumer agent, a resource provider agent and a domain scheduler agent accomplish cooperatively the tasks of schedule and administration of grid resources. NetSolve [10] provided the user with a variety of interfaces that afford direct access to preinstalled, freely available numerical libraries. NetSolve uses NetSolve agent to manage the coherency of the computational servers and enhance flexibility and performance of grid platform. CoABS (control of agent based system) [11] integrates heterogeneous agent-based systems, object-based applications and legacy systems. CoABS grid provides support for mobile agent systems by allowing the creation of CoABS grid agents that may be transported across the network, resuming operation in a new location. Overeinder et al [12] proposed an agent-based approach to resource management in grid environment and described an agent infrastructure that could be integrated with the grid middleware layer. The agent infrastructure provides support for mobile agents and is scalable in the number of agents and the number of resources.

5. Conclusion

To more effectively implement the KG-services is one of the most key issues to be faced in the development of knowledge grid. This paper proposed a MA-based architecture for service-oriented knowledge grid to implement KG-services by utilizing MA technology. The proposed architecture integrates MA technology and knowledge grid technology and improves the performance of knowledge grid such as reducing network traffic and enhancing reliability and intelligence of KG-Services. At the same time, the integration of two main distributed technologies provides a new way to develop knowledge grid technologies.

Ongoing works include deeply researching and implementing the integration between MA and knowledge grid in detail and solving the security of MA-services and KG-services. Another further work is to research the theory of ontology and perfect the knowledge grid.

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