Towards Grid Based Intelligent Information Systems

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Abstract. Multi agent systems, Grid technology, Semantic Web, and Web Intelligence paradigm are three modern approaches in information technologies, which we put together in our research effort described in this paper to create a new-generation infrastructure called the *Wisdom Grid* with the mission to maintain, share, discover, and expand knowledge in geographically distributed environments, and in this way to support development of intelligent information systems. The paper, introduces motivating ideas for this project, proposes the system architecture of an instance of the *Wisdom Grid*. The full version of the paper will also describe the *Wisdom Grid* functionality by means of a case study of one medical application.

1 Motivation

The Web has significant impacts on both academic and ordinary daily life. It revolutionizes the way in which information is gathered, stored, processed, presented, shared, and used. Moreover, the Web provides the infrastructure for the **Grid**, an emerging platform to support on-demand "virtual organizations" for coordinated resource sharing and problem solving on a global scale [10]. The Grid is sometimes heralded as the next generation of the Internet or the Web. There are strong connections between Grid, the Internet, and Web developments, as we will discuss later.

The early Grid computing efforts began with an emphasis on compute-intensive tasks, which benefit from massive parallelism for its computation needs, but are not data intensive; the data that they operate on does not scale in portion to the computation they perform. Later this focus shifted to more data-intensive applications [4], where significant processing is done on very large amounts of data, and recently several research projects also address knowledge discovery in the large databases attached to the Grid [3].

Meanwhile, "*a new generation of Web technology, called the Semantic Web, is designed to improve communications between people using different terminologies, to extend to interoperability of databases, to provide tools for interacting with multimedia collections, and to provide new mechanisms for the support of "agent-based" computing in which people and machines work more interactively.*" [2]. These ideas led Grid scientists to the notion of *Semantic Grid*, where they plan to apply Semantic Web technologies in Grid computing developments [7].

Web Intelligence (WI) is a new direction for scientific research and development that explores the fundamental roles as well as practical impacts of Artificial Intelligence (AI) and advanced Information Technology (IT) on the next generation of Web-empowered products, systems, services, and activities [11]. Our vision is that a similar research direction, correlated with the WI research, is also needed in the Grid research domain. Therefore, this paper deals with an analogous paradigm, *Grid Intelligence*, as a basis for developing a new-generation information technology infrastructure, the **Wisdom Grid** (WG), which will allow the creation of intelligent Grid applications that will help people achieve better ways of living, performing scientific work, treating patients, working, learning, etc.

2 The System Design

In this section, we describe the system architecture, outline the functionality of the components involved, and describe interactions between individual components.

1. **Architecture.** The architecture of our Wisdom Grid system is sketched in Fig 1. The agents provide distributed intelligence services, which involve communication and decision taking activities. The Grid is the basic infrastructure, which provides secure accesses to distributed data and knowledge resources.

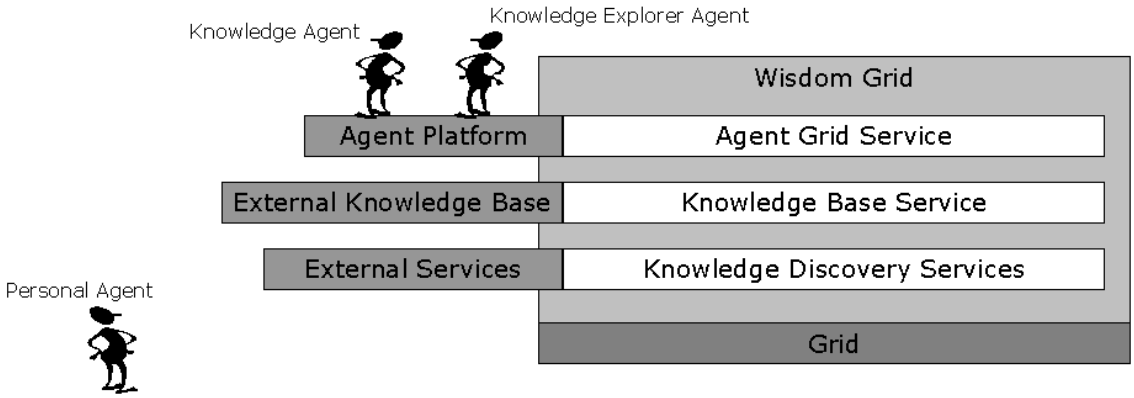

Fig. 1. System Architecture

2. **Agent Grid Service.** This service is a part of the *Wisdom Grid system* and plays the main role in the interaction of agent and Grid services, and as such, it is the mediator between the *Agent platform* and other services on the Grid. This service transforms agents' messages to exact actions and converts the results of these actions back to the messages. This service closely cooperate with the *Knowledge Base Service*, which is always queried for data and their semantics and also for information about all the services and resources, which can be used in search for knowledge.

3. **Knowledge Discovery Services.** This service is able to perform knowledge discovery (advanced data analysis like data mining, Online Analytical Processing, etc. [8]) in databases integrated into the Grid. It is based on a novel infrastructure called the *GridMiner* [3], which we are developing within another Grid-based project. The full version of the paper will present the GridMiner architecture and its functionality.

External services extend our system by the data from services outside the Wisdom Grid infrastructure, for example from Web services.

4. **Knowledge Agent** *(KA)***.** This agent represents the system to the outside world during the communication with other agents. From the software and outside world point of view, it is an intelligent software agent, but from the WG point of view it is a specific Grid application. This agent is registered on the agent platform JADE [1], which is compatible with the FIPA standards [6]. In fact, this agent works as an input and output interface to the Wisdom Grid system and in such a way, he is a mediator between knowledge demand and information resources on the other side. This agent is created and managed by the *Agent Grid Service* and communicates with other agents by messages in the ACL format [5].

5. **Knowledge Explorer Agent** *(KEA)***.** This agent is used by the Wisdom Grid to search at appropriate Grid sites when the requested information is not found in the *Knowledge Base* but the location of this information is known. This agent is registered on the agent platform and is managed by the *Agent Grid service*, which gives the agent the instructions how to ask for the desired data and also information about the location of the data. The agent is able to query other agents and also search the Semantic Web [2], which is another information and knowledge source of our system.

6. **Personal Agent** *(PA)***.** The user who asks for knowledge submits PAs. These agents are able to address questions to the Wisdom Grid and present answers to the user. The success of this activity strongly depends on understanding of the PA and KA and also on the query construction technique. PA is not part of the system because it is created by the user and is not registered on our agent platform. It can ask the KA for the list of domains, about which it has knowledge, or PA can inform the KA about the ontology, which describes its domain and merge it together with KA's ontology to select one common domain.

6. **Knowledge Base *(KB).*** Our KB is a database which stores particular data about real objects and relations between these objects and their properties. KB consists of two parts; the first one is a well-prepared ontology and the second one are instances of this ontology.

3 Conclusions

This paper outlines our vision of the Wisdom Grid as a future infrastructure for advanced applications. The full version of the paper will also present an instance architecture of the Wisdom Grid, describe its main components, and the structure of their communication, and the concepts of the Wisdom Grid knowledge base in the context of an example medical application. The prototype implementation of the knowledge discovery services is currently in progress.

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