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A flexible architecture for distributed knowledge based systems with nomadic access through handheld devices

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Abstract

Nowadays any Knowledge Based System (KBS) realization needs of intercommunication among distributed components and to use non-connected and distributed data sources, which poses several challenges to the classical Artificial Intelligence field of KBS.

The multiagent paradigm and the use of ontologies are considered to be suitable tools to face the problems of designing and developing today KBS. On the other hand, using such networked KBS through handheld devices makes more efficient exploitation and interaction with the system.

This paper presents an open and flexible architecture for a distributed KBS and an application of it to construct a system for Psychological Disorders consulting, the so called PDA^2 (Psychological Disorder Assistant through PDA). We analyze the main features of the architecture as well as the agent tools we may use to construct it. Additionally, we present a support ontology for Psychological Disorders.

Keywords: Knowledge based systems; Handheld devices; Nomadic computing; Ontologies

1. Introduction

The growing of the public and private networks, especially the omnipresent Internet, is an indubitable fact in the last decades. Net technologies have contributed to fast information delivering in several scenarios, as education, business, entertainment or information retrieval. Artificial Intelligence has also been influenced by this trend giving raise to the so called Distributed Artificial Intelligence (DAI)–defined as the study, construction, and application of multiagent systems, that is, systems in which several interacting, intelligent agents pursue some set of goals or perform some set of tasks (Weiss, 1999)-, which has become a very interesting research field to success with the building of this kind of systems.

In order to develop a Knowledge Based System (KBS), i.e. a computational system to perform knowledge processing to help users find quality solutions to complex problems (Hayes-Roth & Jacobstein, 1994), DAI must face several challenges. For instance, the need of intercommunication among independent components and use of a increasing amount of non-connected and distributed data sources available in networks (Li, Shilane, Noy, & Musen, 2000) are two of the most important. The multiagent paradigm and the ontology formalism are agreed to be suitable tools to overcome these problems.

A Multiagent System (MAS) is a complex system where multiple independent agents coordinate to accomplish a task (Stone & Veloso, 2000). The main advantage of the use of the MAS paradigm is that agents provide a high level of abstraction to conceptualise the relationships and the communications in the KBS (Shaalan, El-Badry, & Rafea, 2004), which results in an easier block-building process. From a practical perspective, there exist several frameworks to build MAS, like FIPA standard (FIPA, 2000) (implemented in JADE platform (Bellifimine, Caire, Poggi, & Rimassa, 2003)), and multi-tiered software development tools, as Web Services technologies (Booth, Haas, McCabe, Newcomer, Champion, Ferris & Orchard, 2003) (supported by J2EE or.NET platforms).

Ontologies are the Knowledge Representation (KR) formalism proposed to be used in MAS. An ontology, defined as a formal, explicit specification of

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a shared conceptualisation (Studer, Richard Benjamins, & Fensel, 1998), promotes the interrelation with another models, so it is appropriate to code the underlying knowledge in such KBS. In fact, ontologies are an essential building block in the layered architecture of the Semantic Web, the extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee, Hendler, & Lassila, 2001).

It is obvious that a networked KBS can be better exploited by enabling mobile interaction with the system. With mobile interaction we refer to the use of handheld devices, especially Personal Digital Assistants (PDAs) but also cell phones and other hybrid ones, to manage and consult the knowledge in the system. By 2003, there were about 30 million of PDA and 1.300 million of mobile phones in use worldwide; the predictions for US state that PDA sales will increase from 6.9 million in 2003 to 17.1 million in 2007 and the smart phone market will rise from 8.5 to 35 percent of the whole mobile phone segment in the same period (Brad & Beigl, 2003). With these numbers and considering the synergy between the two technologies, we can foresee that handheld computing will be crucial in the future of information society.

Nevertheless, there are not yet many intelligent applications running on mobile computing devices. The main reason to this absence is the constrained CPU performance, small memory size and low bandwidth of these devices, which seriously makes difficult the development of complex processing software. But this situation has changed in the last years and the emerging wireless communication technologies (Wi–Fi, Bluetooth), the increasing computational power and the extended use of common develop and execution platforms in handheld devices (J2ME) are expected nowadays to be the support to this new full KBS-integrated applications.

To avoid this absence of applications, in this paper we propose a flexible multiagent architecture and a framework for the development of knowledge based applications with ubiquitous access through a wide variety of devices, specially handheld and mobile ones. The KBS schema presented relies on an ontology which models the domain specific knowledge and which may be related to other information repositories. Agents and services in the system communicate among them to carry out the users tasks. As an example of the potential capabilities of this system we show an implemented prototype to support diagnosis of psychological disorders through information retrieval from a suitable semantic web.

The proposed multiagent architecture and the associated framework are described in Section 2. We present a schema from a separated-component perspective and then we explain how the parts of the model are connected. Also, we enumerate and evaluate some of the several existing technologies to implement the modules (what is called the framework). Section 3 shows an example implementation of the architecture, the Psychological Disorders Assistant for PDA (PDA^2) application, which leads us to the final conclusions of Section 4.

2. System architecture and framework

2.1. System architecture

The proposed architecture is inspired in the standard given by the World Wide Web Consortium (W3C, the main organization in Internet standards) for interoperating between different software applications, running on a variety of platforms and/or frameworks: the Web Services Architecture (Booth, Haas, McCabe, Newcomer, Champion, Terris, & Orchard, 2003). W3C Architecture does not constrain the implementation or combination of the services, so we can extend it to our particular requirements.

Our approximation is based on the Service Oriented Model in W3C specification. The relying idea to the model is that a service, implemented by an agent, is invoked by another agent and carried through by mean of the messages exchanged between them (and, maybe, among other third-party supporting agents). Thus, Service Oriented Model describes a landscape where distributed software agents communicate to complete a task. The Service Oriented Model focuses on services and actions, rather than message-passing or resource location issues. A consequent architecture is defined from this basis.

Our adaptation of the general W3C specification is summarized in the architecture schema depicted in Fig. 1. It shows how services are distributed across the network and how clients can query and access them. If necessary, a service will communicate with other service in order to satisfy an user request. Therefore, the services are potentially active entities and can be viewed from an agent perspective. In fact, W3C defines an agent as the concrete software implementation of a service, whereas the service definition is similar to classical agent ones (Russell & Norvig, 1995). Thus, MAS are used as a design metaphor to organize the architecture (encapsulating the processing and the implementation) and as a technology source (agent software can be used in the implementation).

The figure depicts the several Service Providers, each of them offering an access point to a piece of the whole KBS. The servers may be running on different distributed machines in a public or private network. The Ontology Server is a specialized one that supports the management of the ontological knowledge source and the integration with other information sources, like external data repositories. To accomplish a task, a Service Provider may interact with another service server or the Ontology Server via a previously established protocol, from simple HTTP to formal FIPA standard.

A provider can be implemented as a proactive agent or a passive service, depending on the processing it has to do.