Agents for the web

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Biographical notes: Juan Pavón obtained a PhD degree in Computer Science from Universidad Politécnica Madrid in 1988. Then, he worked for ten years in research centres in Alcatel in Spain, France and Belgium, and in Bellcore (USA), especially in the development of component-based architectures for distributed systems, and their application to multimedia services on broadband networks and UMTS. In 1997 he move to the Universidad Complutense Madrid, in Spain, where he leads the Agent Research Group (grasia!), with participation in several projects of applications of multi-agent systems for personalisation (IST-PSI3), workflow management systems (Eurescom P815), democratic discussion and decision making in internet (IST-DEMOS), and multimedia information management (SIMBA, TIC-2000-0737-C03-02). The main research line is the definition of a methodology for the development of multi-agent systems, following the work in the project MESSAGE (Eurescom P907), which has been extended in INGENIAS (TIC2002-04516-C03-03) and the release of the INGENIAS Development Kit (http://grasia.fdi.ucm.es/ingenias).

Juan M. Corchado (PhD) received a PhD in Computer Science from the University of Salamanca in 1998 and a PhD in Artificial Intelligence from the University of Paisley (UK) in 2000. At present he is Profesor Titular de Universidad at the University of Salamanca (Spain), previously he was Sub-director of the Escuela Superior de Ingeniería Informática of the University of Vigo (Spain, 1998-00) and Researcher at the University of Paisley (UK, 1995–98). He has been a research collaborator with the Plymouth Marine Laboratory (UK) since 1993. He has worked on several Artificial Intelligence (AI) Research projects sponsored by Spanish and European public and private Institutions. He is the co-author of over 120 books, book chapters, journal papers, technical reports, etc. published by organisations such us IEEE, IEE, ACM, AAAI, Springer Verlag, Elsevier, Morgan Kaufmann, etc, most of these present practical and theoretical achievements of Hybrid AI Systems. He is the head of the Intelligent Information Systems Group (http://gsii.usal.es)

Introduction

The web has been successful in enabling people to access diverse information in different formats. This success has been so great that, since the early days, the volume and the

sources of information have grown in unpredictable ways. This has led to the development of tools to assist users to locate and manage information on the web. Among these tools, the most successful have been search engines. But the current situation is that they do not completely fulfil users' expectations, as they tend to offer too many results for each single request, so that users find it difficult to access the information that is really relevant for their particular query. Further, users are discovering new needs so that there is a demand for diverse services. Electronic services have become more popular at all levels (e-business, e-government, e-society, etc.) so that there is a need for further processing of information. There are some attempts to facilitate the emergence of a new generation of tools for processing such huge and diverse information, and providing such services. The most relevant tool in this context is the Semantic Web, a framework for structuring and describing the information in the web, and providing a superior support for building information and service processing tools. It is in this environment that agent technology, which has been running for more than a decade, sees its natural application field. And from this perspective, as 'web agents', we are presenting multi-agent systems in this special issue.

The notion of 'web agent', as the notion of agent, is rather fuzzy and depends on the authors. So, for the special issue, we have selected representatives of different applications, which may allow the reader to get an understanding of the way agents work, and their usefulness. As a starting point, we can consider that the term 'web agent' which refers to an autonomous entity, with processing capabilities, and supporting web services. By 'supporting' we mean that usually web services exist already, and the agents just increase their functionality, for instance, by providing personalisation (e.g., an agent is assigned to one user, and will assist the user to perform repetitive tasks, or will anticipate the user's wishes). This does not exclude the possibility of creating new web services only with agents, or as a combination of web services and agents. But the idea is that agents should have capabilities to interact and adapt to the changing environment that the web represents: an agent may have to face, dynamically, during its existence, new services, new providers, or the disappearance/absence of some known sevices or providers. And this capability to adapt to a dynamic environment is one of the main reasons to consider this technology suitable for building web services.

Another capability that makes agents distinct from other paradigms is their social ability. Agents do not work alone, but in communities. In order to achieve a higher degree of intelligence, agents collaborate with other agents, whose experiences and capabilities can be put together to improve the quality of services and information the user gets. The notion of sociability among agents is assumed to be crucial. Agents are autonomous, but social entities, and they get most of their potential from working together to satisfy their goals.

The first paper, by Sviatoslav Braynov, on 'Coalitions of malicious intelligent agents', addresses the problems that the collaborative aspect of multi-agent systems may provoke. This is a well-known topic in the context of internet where organised cyber-attacks are frequent, with unpleasant consequences for everybody. Recently, these attacks become better coordinated and increasingly difficult to discover. Agents have been already used to detect intruders, but in this paper the problem is addressed from another perspective: modelling malicious agents in coordinated distributed attacks, in order to know better (and also to be able to prevent, detect and respond to) the coordination patterns, strategies, and tactics of intelligent distributed attacks. Apart from this concrete application, the paper provides an interesting characterisation of agents

according to their social attitudes. Agents can be considered to be prosocial or anti-social, and three basic types are defined: benevolent, self-interested, and malevolent. The social structure of coalitions will be determined by the links established after taking into account the different types of agents. And this will be the basis for analysing pro-social and antisocial behaviour within and between agent coalitions.

Another direct application of the collaborative nature of multi-agent systems is the system presented by Javier Carbo and José M. Molina, 'Agent-based collaborative filtering based on fuzzy recommendations'. Recommender systems, which attempt to provide suggestions based on the opinion of several sources of information (e.g., user ratings), have been one of the first applications of agents in internet. Basically, the problem consists of filtering from a set of elements those which may be of interest to the user, taking into account the matching of attributes of the user and the type of information (*content-based filtering*) or the experience from other users with similar profile (*collaborative filtering*). Collaborative filtering implies the classification and combination of preferences and opinions from users to determine groups of users with certain similarity. Then, the information of interest for a specific user can be derived from what is rated well in the groups to which the user is associated. The difference with content based filtering is that the answer of the system is determined by the behaviour of the group, instead of a simple matching for a user profile with item attributes. For this reason, collaborative filtering techniques are used where there is a significant degree of subjectivity in the user's choice, and can be found in many book and music stores in the web. The paper by Carbo and Molina introduces the readers to the issues of building an efficient and scalable recommender system, and proposes a novel solution by combining agent technology and fuzzy logic computations. This is evaluated against its predecessors in order to show improvements in the hit-rate and false-alarm rate, and better global performance in cost analysis.

The paper by Emilio S. Corchado, Donald MacDonald and Colin Fyfe, 'Internet agents who structure concept formation using kernel self-organising maps', addresses the problem of managing the huge quantity of documents in internet from another perspective. Most of the interesting information stored in the web is in the form of text and this is likely to continue given the length of the time most people spend in acquiring the skills to create and access such information. This paper proposes a method for constructing agents endowed with some capability for understanding human text. The authors assume that most of the information that is present on the internet has text-free form and for that reason they have developed a connectionist agent model, based onself-organising maps, capable of dealing with such difficulty. They develop agents that can cluster web documents in such a way that it is useful for humans. The authors presents a Kernel space based self-organising maps architecture that allows the agent to learn very fast, in a very robust way and an architecture that is based on the same properties that the human has.

A similar problem of managing a diversity of documents, but considering a particular community, (in this case, a company), is addressed by José R. Villar, Carmen Benavides, Isaías García, Ángel Alonso, and Francisco Rodríguez, in 'A web-based multi-agent system approach to document engineering'. This paper presents a web-based multi-agent system developed to assist a documental department of a company in the gathering, storing, retrieving and generation of articles and documents, and also in the distribution of these documents. The presented system provides a flexible and scalable solution that

not only automates the process but also improves the initial manual work. The developed platform can be distributed across machines and its configuration can be changed at execution time. The authors have identified a well-defined multi-agent hierarchical structure composed by agents of different type and functionality.

The application, 'Connecting web applications with interface agents', by A. Amandi and M. Armentano, presents another important line of applications of agents, as personal assistants, or as interface agents that facilitate the way users interact with the applications. Interface agents are one of the most relevant applications of agent technology to assist humans in using computer software. However, the development of agents assisting users working on the web, using multiple applications to browse information, represents a challenging task. Particularly, when these agents need to act on standard web applications whose source code is not available. Developers have one additional requirement, which is the complete independence between the web application and the agent. The work presented by the authors proposes a method that enables web applications to be connected with interface agents without any changes in the source code of the base application. The software architecture AGUSINA defines the main abstract component of an interface agent and, based on it, a method and the tools for materialising those components under the relevant constraint of independence between application and agent.

Next we address the development of multi-agent systems for the web from a more methodological perspective. The paper 'Agent oriented software engineering with web applications', by Jorge Gómez-Sanz and Rubén Fuentes, uses agents as a convenient modelling abstraction to design web applications. The agent system is finally implemented using standard components such as EJBs and servlets. This is specially interesting for analysing interactions among system components and the users, as interactions is one of the issues which has been studied intensively in agent theory. The paper describes the role of interaction in analysis and design, identifies the elements that are required for the specification of interactions in a system, and illustrates the whole process with an example of a web application for report management, involving several users playing different roles.

The last work, 'Modelling web service composition with UML 2.0', by Bernhard Bauer and Marc Philippe Huget presents some work that has called the attention of the agent community recently. 'Web agents' can support the provision of web services. Because of the cooperative nature of multi-agent systems, it is advisable to consider the effects of combining several web services in order to be able to offer new ones. The ability to model and exploit web service choreographies is the subject of this paper, by using well-known standard modelling and implementation technologies, which are extended to facilitate this task.

We hope that by showing working agent systems, as those presented in this special issue, the reader will have a better understanding of the capabilities that agent technology has to offer. Given the continuous evolution of the web, development of software with capabilities to adapt to changing environment, offering more friendly interfaces to users, and with a sense of social behaviour, is the way to provide those new services that users look for as they get progressively experienced in the use of the web.