Available online at www.sciencedirect.com
SCIENCE DIRECT
Information and Software Technology 48 (2006) 107–120
INFORMATION AND SOFTWARE TECHNOLOGY
www.elsevier.com/locate/infsof

MAPIS, a multi-agent system for information personalization

Christelle Petit-Rozé*, Emmanuelle Grislin-Le Strugeon

LAMIH-UMR CNRS 8530, University of Valenciennes, Le Mont Houy, F-59313 Valenciennes cedex, France

Received 4 June 2004; revised 4 March 2005; accepted 5 March 2005
Available online 1 June 2005

Abstract

In the domain of multi-user and agent-oriented information systems, personalized information systems aim to give specific and customized responses to individual user requests. In addition to the ability to analyze user needs and to retrieve, understand and act on distributed data that is offered by any agent-oriented system, multi-agent systems also offer interesting possibilities for interaction, particularly with regard to information sharing and task coordination. Our approach exploits these interactive possibilities in order to make the system capable of personalizing information. In addition, reusable models at both the social and individual levels were chosen for this approach in order to facilitate subsequent information system design. With these two ideas in mind, several models of agent interaction (social) and the internal activity cycles (individual) have been proposed with the aim of creating a multi-agent system for information personalization.

Keywords: Multi-agent system; Agent activity model; Interaction model; Information personalization

1. Introduction and motivation

Being able to personalize information becomes more important as the volume of the acquired data grows, or becomes more heterogeneous and/or more widely distributed. In a multi-user context, personalized information systems seek to provide specific and customized responses to individual user requests. Such information systems (IS) adapt their responses to user preferences, goals and capacities, in an effort to supply all the information required by users, and only the information required. This class of user-adaptive software systems is also called information services [4].

Thus, designing an IS for personalized information necessitates a user-centered view of the way the system manages and processes the data (e.g. the active part of the system). In addition to incorporating features that are common to all IS, the systems must also be able to adapt the results to a specific user. The relevance of the delivered results depends on several elements: the ability of the system to access and select the necessary data; the knowledge the system has about its users and its ability to learn so that this knowledge can evolve; and the pertinence of the retrieved data to the users' needs. These three elements are the primary features of information personalization.

The agent domain can provide the means for adapting results to system users. Software agents have already proved their ability to offer interesting services in uncertain, dynamic and open environments [11]. For example, agents can be service providers based on artificial intelligence techniques, such as machine learning. These agents can intervene at various stages in the modeling, design and implementation of an information system, or can simply serve as 'concepts' or models for system analysis. In addition, they can be implemented jointly as a set of interacting agents, working together in what is called a multi-agent system.

In this article, we introduce MAPIS (Multi-Agent Personalized Information System), a multi-agent system for customizing information. Our objective is to provide models that can be reused for information system engineering, both at the macro level (e.g. the architecture, organization, and/or interaction between system entities) and at the micro level (e.g. knowledge representation, the agents' internal models). In the last section, these models are applied to travel planning services.

* Corresponding author.
E-mail address: christelle.roze@univ-valenciennes.fr (C. Petit-Rozé).

0950-5849/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.infsof.2005.03.004

2. Information personalization in agent-based information systems

The main functions of an information agent have been summed up by Klusch [12]: information acquisition and management, information synthesis and presentation, and intelligent user assistance. Separately, each of these functions designates one area in the design and development of the intelligent aspects of information personalization, as well as one area of application for agent abilities. Moreover, in the context of multi-user IS and distributed data sources, the interaction of the information agents can be managed in the frame of Multi-Agent Systems (MAS). The use of both IS approaches-agent and multi-agent is presented below, with a specific focus on information personalization.

2.1. Agent abilities to personalize information

Agents possess several interesting characteristics in terms of information system design, including:

- proactivity, which allows the triggering of actions that have not been explicitly requested, meaning, for example, that a warning can be activated if an agent receives information that it deems useful for some users;
- uncertainty management, which is a key feature in Artificial Intelligence that allows agents to infer from their current incomplete knowledge and past experiences, making assumptions to compensate for lack of knowledge and/or learning from previous user transactions;
- autonomy, which allows agents to deal with distributed data and knowledge or processing resources; and
- social abilities, which allow agents in multi-agent systems to perform tasks requiring interaction between distributed entities, including knowledge sharing and task coordination.

These four characteristics can provide additional functions for an IS, principally in the three areas mentioned in Section 2: information retrieval, information filtering and user assistance.

Information research and retrieval are dedicated tasks that can be performed by software agents. Such software agents make accessing information sources easier for users, for example, via request refinement [15]. In one of the most well-known personal assistance systems, Letizia [17], an agent anticipates Web searches, recommending potentially interesting pages by deducing user interests based on the content of currently accessed pages. Agents can also regularly and proactively check data sources in order to warn users of eventual modifications. Such surveillance techniques makes it possible to 'push' information, as in the case of a technological watch, for example [1].

Information filtering—the selection of relevant information in order to limit volume—is another task that can be accomplished by agents, with the selection based on user profiles defined in the filtering rules. Two key complementary methods are used: the cognitive method and the collaborative method. The first one simply analyzes document content [13]. The second one involves gathering user profiles showing similar interests (see [12] for a survey of the principal methods). The collaborative method is used, for example, to recommend new links, documents or products to users, based on statistical data about the choices of previous users (see [27,7] for more information).

User assistance draws on several different agent abilities in order to aid users in their individual tasks via an interface. This can mean adapting the hardware and software, a procedure that has become more and more important as the use of wireless information devices increases [3,18]. It can also be a question of adapting the presentation to the user's preferences, with assistant agents observing and analyzing user actions on one or more software elements in order to automate some tasks [14]. Two design trends can be distinguished, both of which aim to automate certain tasks [23]: (1) a trend towards agent specialization in order to provide a specific service, such as sorting electronic mail or managing meetings; and (2) a trend towards the association of one agent and one user whose activities are well-known, in an effort to automate or delegate some tasks.

In order to assemble all of the above functions, one approach would involve a complex design that assigns the functions to a series of very 'clever' agents possessing many skills and capacities. Another approach would be to distribute the functions to distinct agents in order to increase the flexibility and the adaptivity of the systems. In the latter approach, several (more or less) specialized agents are brought together to create a multi-agent information system.

2.2. Multi-agent information systems

The agents' ability to both analyze user needs and to retrieve, understand and act on distributed data and knowledge about users is fundamental to agent-oriented information system design. However, further agentification of the system is required in order for information to be exchanged cooperatively. This agentification, which uses agent-oriented concepts to model some parts of the system, can be done to various degrees, ranging from the simple encapsulation of existing software elements to a complete agent-oriented analysis [29]. When designing an IS as a multi-agent system, each acting element is either an agent or a group of agents, whose interaction allows the information system to function. In multi-agent IS, the agents have organizational knowledge about each other's competencies in order to answer questions, like 'Which agent can perform this task?', and to manage the data flows between agents, 'What must be done now?'. This multi-agent approach can be tricky in that it is not only necessary to manage knowledge distribution and task distribution, but also to