

# A Multi-Agent System for Handling Adaptive E-Services

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## INTRODUCTION

An Electronic-Service (E-Service) can be defined as a collection of network-resident software programs that collaborate for supporting users in both accessing and selecting data and services of their interest present in a provider site. Examples of e-services are e-commerce, e-learning, e-government, e-recruitment and e-health applications. E-Services are undoubtedly one of the engines presently supporting the Internet Revolution. Indeed, nowadays, a large number and a great variety of providers offer their services also or exclusively via the Internet.

## BACKGROUND

In spite of their spectacular development and present relevance, E-Services are far to be considered a stable technology and various improvements could be thought for them. Many of the present suggestions for improving them are based on the concept of adaptivity, i.e., on the capability to make them more flexible in such a way as to adapt their offers and behaviour to the “environment” they are operating in. In this context, systems capable of constructing, maintaining and exploiting suitable profiles for users accessing E-Services appear capable of playing a key role in the future (Kobsa, 2007).

Both in the past and in the present, various E-Service providers exploit (usually rough) user profiles for proposing personalized offers. However, in most cases, the profile construction methodology adopted by them

presents some problems. In fact, it often requires a user to spend a certain amount of time for constructing and updating his profile; in addition, the profile of a user stores only information about the proposals which he claims to be interested in, without considering other ones, somehow related to those just provided, possibly interesting him in the future and that he disregarded to take into account in the past.

In spite of present user profile handlers, generally, when accessing an E-Service, a user must personally search the proposals of his interest through it. We argue that, for improving the effectiveness of E-Services, it is necessary to increase the interaction between the provider and the user, on one hand, and to construct a rich profile of the user, taking his interests, needs and past behaviour into account, on the other hand.

In addition, a further important factor must be taken into account. Nowadays, electronic and telecommunications technology is rapidly evolving in such a way as to allow cell phones, palmtops and wireless PDAs to navigate on the Web. These mobile devices do not have the same display or bandwidth capabilities as their desktop counterparts; nonetheless, present E-Service providers deliver the same contents to all device typologies (Communications of the ACM, 2002; ; Smith, Cotter & Oman, 2007).

In the past, various approaches have been proposed for handling E-Service activities; some of them are agent-based. As an example:

- In (Anand, Kearney & Shapcott, 2007) an approach to helping users looking for relevant items

is described. In order to generate its recommendations, this approach integrates user ratings with an ontology describing involved items. This approach is particularly suited for the e-commerce domain.

- In (Mahmood & Ricci, 2007) a travel recommender system, based on the Intelligent Agent technology, is presented. This system builds user profiles by exploiting Reinforcement Learning techniques, and models the recommendation process as a Markov Decision Process.
- In (Medjahed & Bouguettaya, 2005) the Authors propose WebSenior, a system using ontologies to automatically generate Web Services customized to senior citizen needs and government laws. WebSenior is able to manage both simple and composite services. In order to generate these last, it defines a graph, called dependency diagram, in which each vertex is associated with a simple service and each edge denotes a dependency relationship between a pair of services. The problem of computing composite services is, then, regarded as the problem of computing paths in the dependency diagram; this last problem is solved by applying the Floyd-Warshall dynamic programming algorithm.
- In (Ahn, Brusilovsky, Grady, He & Syn, 2007) YourNews, a system capable of helping users in accessing news located on the Web, is proposed. YourNews relies on a user profile built by unobtrusively monitoring user behaviour; this profile is open, in the sense that the corresponding user can interactively provide feedbacks that will be exploited by YourNews to enhance its accuracy.
- In (De Meo, Quattrone, Terracina & Ursino, 2007) a XML-based multi-agent recommender system for supporting online recruitment services is presented. This system handles user profiles for supporting a personalized job search over the Internet. In order to perform its recommendations, it exploits some advanced techniques (e.g., least square error and Pavlovian learning).
- In (Fang & Sheng, 2005) ServiceFinder, a system conceived for supporting citizens in their selection of relevant e-government services, is proposed. ServiceFinder uses Web Mining techniques to discover the  $N$  services best matching user needs

and modifies the home page of an institutional e-government portal by adding to it  $N$  hyperlinks pointing to these services.

- In (Srivihok & Sukonmanee, 2005) a system capable of supporting e-tourism activities is proposed. This system analyzes past user behaviours and applies the Q-Learning algorithm to build a user profile. After this, it applies a reinforcement algorithm on both user and trip profiles in such a way as to associate a score with each trip proposal. These last are, then, ranked on the basis of their scores and only the top five are presented to the user.

All these systems construct, maintain and use rich data structures regarding both user needs and behaviours; therefore, we can consider them adaptive w.r.t. the user; however, none of them is adaptive w.r.t. the device.

On the other side, in many areas of computer science research, a large variety of approaches that adapt their behaviour on the basis of the device the user is exploiting, has been proposed. As an example:

- In (Samaras & Panayiotou, 2004) the system mPERSONA, aiming to support users equipped with wireless devices to access information sources located on the Web, is proposed. mPERSONA relies on a mobile multi-agent architecture; it associates a user profile (consisting of a set of keywords) with each user and represents the contents of an information source as a hierarchy (called metadata tree). Each time a user submits a query to an information source, mPERSONA isolates the portion of hierarchy (and the corresponding information objects) best fitting his requests; after this, it considers the features of the device he is currently exploiting and adapts the selected contents to them.
- In (Lee, Kang, Choi & Yang, 2006) an approach to Web content adaptation for mobile users is presented. This approach stores user preferences in a suitable profile. When a user is involved in Web browsing activities, it partitions a Web page into blocks, filters out those judged unnecessary and sorts the other ones on the basis of their relevance to the user. Finally, it presents sorted blocks to the user.

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