Semantically-enhanced Ubiquitous User Modeling

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Abstract. Semantically-enhanced Ubiquitous User Modeling aims at the management of distributed user models and the integration into ontologies to share user information amongst adaptive applications for personalization purposes. To reach this goal, different problems have to be solved. The collection of implicit user information by observing the user behavior on dynamic web applications is important to better understand the user interests and needs. The aggregation of different user models is essential to combine all available user information to one big knowledge repository. Additionally, the Semantic Web offers new possibilities to enhance the knowledge about the user for better personalization.

1 Introduction

With the advent of the Web 2.0 and the growing impact of the Internet on our every day life, people use more and more different web applications. Thereby, they generate and distribute personal information like interests, preferences and goals. This distributed and heterogeneous collection of user information, stored in the user model (UM) of each application, is a valuable source of knowledge for adaptive systems. Current adaptive systems take into account user features like interest, plans and context such as the context of interaction, the device, etc. The modeling of the user is usually done in the design phase of the system, and therefore changes to the model, to adapt to changing requirements or user characteristics, can not be implemented without major changes to the system. Also the representation of the user model is in most cases strongly application dependent and therefore not understandable and usable by other applications. That implies that the knowledge about the users, which is buried deeply in the databases of one adaptive system, cannot be shared with other systems to provide better personalization and adaptation results.

In my dissertation, I focus on the combination of Semantic Web technologies with adaptive systems and the use of shared ontologies to describe and model knowledge about users. A UM that is based on shared and open ontologies can be used to share the knowledge with other systems and moreover it can be extended easily using additional ontologies.

2 Identified Problems and Related Work

I focus on two major aspects of the user modeling process. Firstly, obtaining implicit information about user needs and interests by collecting information about the user behavior using semantic technologies. Secondly, managing the UMs, which includes the aggregation of models from UMs from different applications, taking care of the heterogeneity of the information, and representing the information about a user based on an ontology. An extension which I consider, is the enrichment if this ontology-based UM with data from the Semantic Web.

User Behavior Collection and Management Web applications become more and more dynamic, and the way users can interact with them change. Therefore, the techniques to track the user behavior have to cope with these new challenges and have to be extended to collect fine-grained data from user interactions to provide better information for adaptive systems. Additionally, the collected data must be managed in ontologies to share user behavior information with other adaptive systems. Zhou et al. [1] focus on mining client-side access logs of a single user or client and then incorporate fuzzy logic to generate a usage ontology. Schmidt et al. [2] embed concepts into a portal which provide the context for JavaScript events, which are collected and used to adjust the portal. All relevant UI elements are linked to a concept ontology containing semantic information about the element. None of these approaches make full use of semantic technologies. First steps in the direction of semantic technologies are done but they still cannot be applied across applications and lack the necessary extensibility and dynamism.

User Model Management and Aggregation Applications typically store their user information in a proprietary format. This leads to a distributed web model of a user with several partial UMs in different applications potentially duplicating information. Therefore, the challenge is to solve the heterogeneity of the user models. Current research on user model management and aggregation emphasizes two different strategies [3]. The first strategy introduced in [4] uses a generic user model mediation framework with the goal of improving the quality of recommendations. The actual UM mediation in the framework is done by specialized mediator components which translate the data between different models using inference and reasoning mechanisms. The second strategy focuses on the standardization of user models to allow data sharing between applications. Heckmann [5] proposes an ontological approach, the General User Model Ontology (GUMO), as a top level ontology for user models and suggest the ontology to be the standard model for user modeling tasks. Another standardization approach is to define a centralized user modeling system that is used and updated by all connected applications [6]. The shortcomings of the mediation layer approach is the effort needed to aggregate such heterogeneous user models, while standardized user models suffer from the lack of a common standard. As long as different application providers pursue different goals with strong commercial interest, a global standard for user model does not seem likely in the near future.

3 Open Research Questions & Proposed Solutions

The identified problems lead to open research questions, that I want to solve in my dissertation:

- How can I merge and manage user profiles from different applications?
- How can I use the collected user information to enrich the user profile?
- How can user data acquisition benefit from Semantic Web standards?
- How can I model and share the collected user behavior data between applications and different domains?

To solve these problems it is necessary to develop a user tracking mechanism which collects implicit user feedback from dynamic websites and to manage the data in a user behavior ontology which allows the collected information to be shared. Furthermore, the development of an ontology based user profile management framework is required. This framework should combine the presented ideas of UM management and aggregation presented here. The aggregation has to be done by specialized mediators focusing on automatic ontology matching approaches and fuzzy logic techniques to address the uncertainty of this process. The framework also has to support the goals of generality and extensibility to enable adaptive systems to manage and share user knowledge.

4 Work Done & Future Work Schedule

User Behavoir Collection and Management A user tracking component which used Microformats was already implemented and presented in [7]. The usage of Microformats allows to add semantic information to web pages and, because it is an open standard, the semantic information can be used by other applications, too. The next steps are to extend the already existing user tracking component to support RDFa, and to evaluate the level of information that can be collected and its impact on adaptive systems. I'm currently working on an a user behavior ontology that manages the collected data and can be used to share information about the common behavior of a user between adaptive systems. Thus, applications are able to adapt to the user right from the start. A first version of the ontology exists already, and I expect to publish information in the near future.

User Model Management and Aggregation A lot of work is done, most of it yet unpublished. We have implemented a framework (see Figure 1), presented in [6], that manages user models from different applications. This framework was extended to support ontologies, using the JENA framework and open ontologies like FOAF. I developed a meta-ontology that allows connecting information from different applications. The framework also consists of a component which collects information from the Semantic Web and uses it to enrich the user models. My current work concentrates on merging the models of different applications. The main focus here is the usage of ontology matching approaches to automatically aggregate the models. A main open challenge is the evaluation of these methods

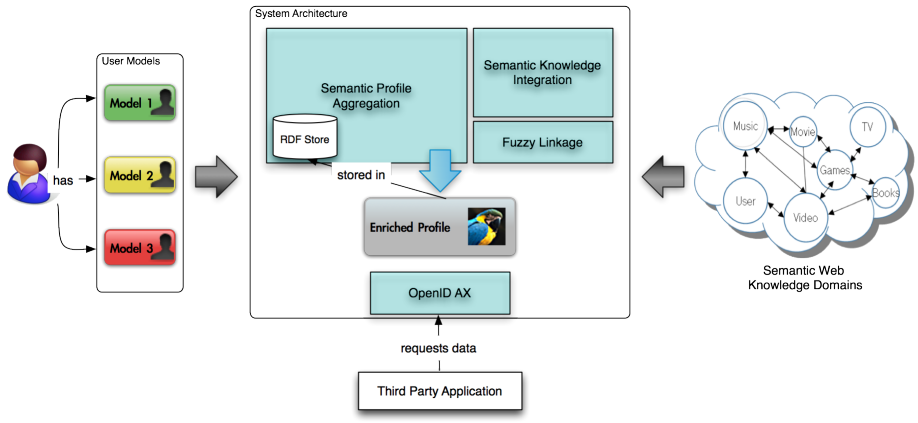

Fig. 1. System overview with components and the OpenID interface for data privacy.

due to fact that no corpus exists to measure the quality of the developed methods, as stated in [4]. Therefore, I plan to build such a corpus that can be used to measure the quality of these approaches.

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