Ubiquitous User Modeling in Recommender Systems

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Abstract. The existing personalization services usually base on proprietary and partial user models. This work attempts at evolving inference-based mediation mechanism that will facilitate integrating user models coming from different sources, such as repositories of other service providers and user's personal devices. This will allow obtaining more information about the users and providing more accurate personalization. The efficiency of the above approach will be demonstrated using the techniques from Recommender Systems domain.

1 Better Personalization with Ubiquitous User Modeling

Nowadays, the quantity of the available information rapidly grows and exceeds our limited processing capabilities. This is regarded in the literature as the 'Information Overload' problem [5]. As a result, there is a pressing need for intelligent systems that provide services according to user's personal needs and interests, and deliver tailored information in a way that will be most appropriate and valuable to the user. The state-of-the-art personalization techniques basically overcome the Information Overload by filtering the irrelevant information reaching the user.

An essential input for every personalization technique is the model of the user [1] that is either collected by the service providers (through accumulating the information on user's preferences and interests), or imported into the system from user's personal devices (e.g., PDA, mobile phone, or personal media). For example, user's reading preferences might be stored by *Amazon* and *BarnesAndNoble* websites, and also by user's reading device. Thus, in the rest of this paper the term 'data source' refers to the repositories of service providers, and of users' devices.

Typically, the models stored by the repositories of service providers are proprietary and partial, as they fit a specific application and are limited to its domain. Since the level of personalization a system presents depends on the detailing of the input user models, different systems would improve the provided services by sharing the models stored in their repositories. However, due to the commercial competition service providers neither cooperate, nor share the data stored in their repositories.

A natural way of resolving this issue might be replicating the interactions between users and service providers also at the user side and directly accessing the models stored by users' personal devices. Hence, part of the user model and other personalization information will be obtained from the collaborating users, and combined locally by the service provider that needs it. In addition to resolving the problem of non-cooperative service providers, direct interaction between different data sources in user modeling will partially resolve privacy concerns [4].

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In this work we aim at developing an abstract mediation mechanism that will allow upgrading the existing personalization systems by integrating user models from different data sources (both users and service providers). This will facilitate obtaining more information about users and providing more accurate personalization services.

2 Integration of User Models

The principal architecture of the evolving ubiquitous user modeling platform is represented in Figure *1*. The core of the platform is the mediating mechanism that facilitates user modeling data sharing by translation and integration of user models. As each service provider stores partial user model according to its own format and representation, mediating mechanism is responsible for the following tasks:

1. Mapping from specific services to a generic representation and vice versa.
2. Providing standard language/interface for user modeling data exchange.
3. Maintaining user modeling semantic knowledge facilitating ad-hoc mapping.

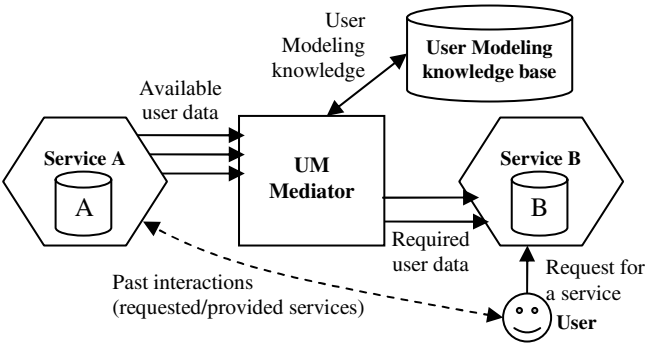

Fig. 1. Principal architecture of ubiquitous user modeling platform

We propose to cluster the data sources storing user models from similar domains in order to improve the integration task and minimize the communication overhead tied with it. Note that the structure of the clusters is highly dynamic, as they comprise user's devices (providing partial user models), whose availability is unstable.

When different data sources share a model related to the same domain (e.g., models from *Amazon* and *BarnesAndNoble*), the integration of partial user models is performed using the mediator's domain knowledge. It should support identifying semantic relations between different concepts in the domain. For example, it should integrate partial models from systems using different ontologies to model user's preferences in the same domain. Thus, the mediator should be capable of resolving conflicts and ambiguities, and facilitate obtaining accurate and expressive user model.

Another issue that should be tackled by the mediator is integrating partial models from different domains. For example, consider the repositories of books and DVDs stores. Although the domains are not identical, user's interest in a particular genre of books can be inferred from the DVDs model. This requires identifying the relation-

ships between the domains, e.g., when building a model for books domain, data from DVDs model is of some value, while data from cars domain probably gives no benefit. Knowing relationships between the domains, we plan to develop inferring mechanism from domain-specific representations to a generic user model and vice versa.

3 Major Issues and Demonstration in Recommender Systems

Evolving ubiquitous user modeling mechanism over a dynamic set of heterogeneous data sources raises three major research questions:

1. How can we evolve an organization of user modeling services and data sources using on semantic relationships and similarities between them? This requires expanding the ideas proposed in [2], inferring relationships between data sources and different domains, and defining explicit similarity metrics.
2. How can we build an accurate user model over the above distributed organization? This comprises developing a stable (to dynamic environments) protocol for combining partial user models obtained from different data sources.
3. How can we efficiently provide personalized services using the above technique for building user model? This comprises implementing a variant of a personalization technique functioning over the above organization of data sources.

We intend to demonstrate and evaluate the ideas of ubiquitous user modeling using Recommender Systems techniques [6]. For example, Collaborative Filtering [3] builds a prediction basing on the opinions of 'like-minded' users by computing a weighted average of their ratings on a given item. In this case, sparsity of information about the users might require combining their ratings from different data sources.

The proposed research contributes to the community by providing a novel technique for building user model through integrating partial models received from multiple data sources. It also suggests a novel approach for building recommendations by integrating the data stored in different repositories from different domains.

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