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A User Meta-model for Context-Aware Recommender Systems

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ABSTRACT
User profiles are increasingly used for sharing standard information about users among context-aware agents. User profiles allow agents to offer users personalized content and services. However, the entities and contextual information used by these agents must have same meaning in order to share a common understanding about user related personal information, context and preferences. The contribution of this paper is to present a general user metadata model which is integrated within a generic metadata model (CAM Meta-model) that covers altogether information about content, services, physical and technical environment. This new user profile meta-model has been designed with a view of using it in conjunction with content and service recommender systems. It brings new opportunities to reason over user context data with the main purpose of increasing user experience in ubiquitous environments and satisfying their desires depending on the circumstances.

Categories and Subject Descriptors
H.2.1 [**Database Management**]: Logical design – *schema and subschema*. H.3.7 [**Information Storage and Retrieval**]: Digital Libraries – *collection, dissemination, standards*.

General Terms
Documentation, Design, Human Factors, Standardization, Languages.

Keywords
user profile, user modeling, ontology, context, semantic web

1. INTRODUCTION
Ubiquitous computing has been introduced into human life as a new way of human-computer interaction. Computational devices are everywhere, besides these computational device capabilities are increasing day after day. For instance, nowadays it is unbelievable to think in a handheld device without an internet connection, multimedia playing capabilities, camera, and even operating systems comparable with personal computers. These new features bring to users incredible capabilities to interact with the environment, content and services provided over various access networks.

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However, users can be overloaded trying to configure ubiquitous environment systems if they want to obtain the maximum benefits from them. Afterward they could opt not to use the system, in special those users who are not very technology aware. Aiming to deal with this problem the notion of user profiling has become popular lately. User profiles focus on including user personal information [1], user context [2], and if the system wants to be adaptive to user preferences including user behavior and preferences is a must.

It is worth to mention the importance of adaptive ubiquitous environments. In other words, these environments should have capabilities to learn user preferences and routines while they monitor the environment in order to offer the most suitable services and content to users [3]. There are many possible learning methods that have potential to be applied in intelligent environments, for example, data-mining techniques [4] or simple if-then rules [5].

The paper presents a new generic user model that combines user personal information, user related context information and user preference information that can be dependant on contextual information. This new user model has been integrated within a content generic metadata model [6], which is called CAM (Collaborative Aggregated Multimedia) meta-model. It merges information about content, services, physical and technical environment. The use of both metadata models together provides to intelligent recommendation services key information for providing users with personalized content and services. The metadata uses a well known and widely use RDF[1] schema representation. It provides enough expressiveness for our purposes while it keeps the model simple to understand. The paper also presents a use case of the user model that is validated within a case study.

The paper is organized as follows. First of all, we introduce some related work that deal with the main objective of creating a generic user model for being used in context-aware environments. Then, we present briefly the CAM Meta-model lying on its main purposes providing as well some usage

[1] Resource Description Framework. http://www.w3.org/RDF/

examples. Section 4 focuses on the user meta-model that is integrated inside the CAM Meta-model as well as a possible use case. Section 5 introduces a use case for validating the CAM Meta-model and the user meta-model. Finally, we explain some conclusions and we list our future work directions with the use of the CAM meta-model.

2. RELATED WORK

Formal models to memorize user preferences are not common; in special those that try to define dependences among preferences and external factors. There are various ontology models for modeling users. It is worth to mention the relevance of the General User Model Ontology [1]. It is a top level ontology that was created with the purpose of being the base for the user modeling research community. GUMO defined good basic user dimensions; in fact, some of them have been used in the user profile model that is presented in section 4. The lack of definition for user preferences is its weak point. Golemati et al. [3] follows the same line of defining user related attribute vocabularies. They also introduced the concept of user interest or preferences without referencing them to other external factors. They only describe this user preference and interest as simple text, defined as a simple hobby description.

Ngoc et al. [7] defined a preference and behavior routine ontology for ubiquitous systems. This ontology creates a good input for user preference learning mechanism. In the paper even some learning mechanisms are proposed that could be used with their model. However, they do not take into account the user current status. In our opinion it is a key concept that might alter user preferences. Besides, this preference ontology extension was created with the intention of being used in context-aware environments. This could be the reason of why the final preference inference is focused on learning the user intentions. Our approach tries to be more general not focusing only in one possible application area.

3. CAM META-MODEL

The CAM meta-model has been created under the ITEA2-CAM4Home project. Collaborative Aggregated Multimedia (CAM) refers to aggregation and composition of individual multimedia contents into a content bundle that may include references to content based services. Besides, it can be delivered as a semantically coherent set of content and related services over various communication channels. Project's main intention is to create a metadata based content delivery framework to allow content providers and, in consequence, end users to share and process a common metadata. The CAM4Home metadata framework provides a modeled representation for different multimedia content and enables processing capabilities of that metadata. It also focuses on providing mechanisms to use other relevant standard metadata and content representation formats.

CAM meta-model makes a distinction between single objects and bundle of objects. The first is called CAM Object while CAM Bundle refers to the content bundles. CAM Object contains the metadata level representation of a single multimedia element; a video, picture, music, or even software services. The metadata may contain variety of information to enrich the user experience; e.g. community created data such as user comments, tags or ratings. This feature benefits heterogeneous services and multimedia elements share a common description structure. CAM Bundle combines two or more CAM Objects specifying in its metadata description the commonalities between them. It is also capable of receiving community user ratings, comments or tags. Figure 1 clarifies this idea showing a simple example of two CAM Objects gathered inside a CAM Bundle.

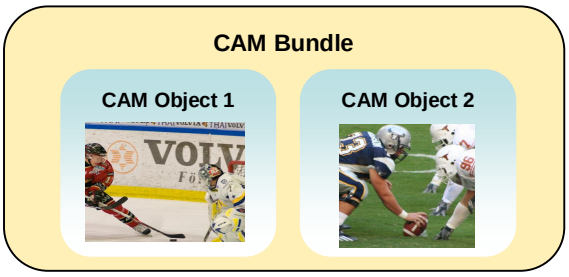

Figure 1. CAM Bundle concept

Each CAM Object contains its own information related to the multimedia content is describing. Figure 2 shows a short set of information that CAM Objects would contain for this specific example.

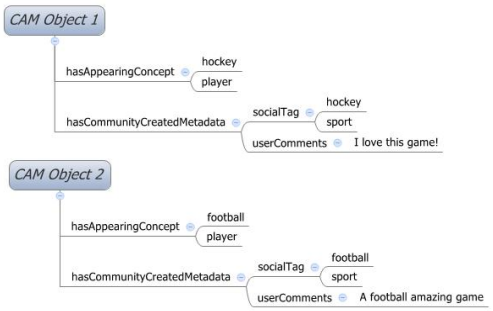

Figure 2. CAM Objects information

The resultant CAM Bundle that merges both CAM Objects would contain information related to both objects. In other words, that information should describe the common qualities of the CAM Objects. It does not matter that both objects are different media MIME types. Figure 3 shows an approach of possible information the CAM Bundle might have for this specific example among others.

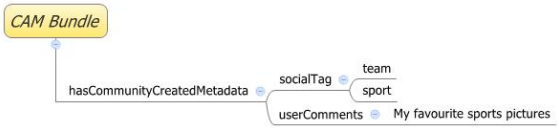

Figure 3. CAM Bundle information

CAM Meta-model uses RDF Schema representation since its capabilities are enough for encoding the required data. It also allows keeping the model as simple as possible. There were considered already existent technological alternatives such as MPEG-21, but their lack of capabilities for representing services or community created information rejected them. Amir et al [6] enlarge this CAM concept providing extended details about the capabilities of the CAM Meta-model, including as well some RDF usage examples.

4. CAM USER PROFILE

User profiles were needed in the CAM4Home platform due to the importance of supporting recommendation capabilities in this

kind of multimedia systems. After all, methods to filter multimedia content depending on user preferences is a vital feature in order to increases the final user satisfaction, and as a consequence, the system usage and success.

In many preference models only simple preferences can be modeled. For example they do not have the current user context information into account. However, having this kind of data is important since the user likes and dislikes could vary depending on contextual information as the weather, location or even his/her physiological state. The user profile model that is presented supports this kind of modeling. Recommendation services that make use of the framework can use this profile information to generate recommendations. In Figure 4 a general overview of user profile metadata is shown.

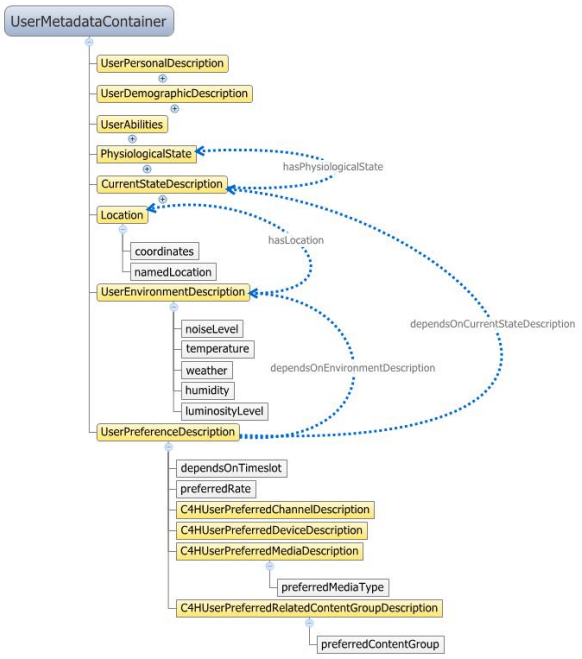

Figure 4. Structure of User Profile Data

First of all a user metadata container class is created that contains every kind of user related information attached. There are some classes that only include simple and static information about users. User Personal Description class includes personal information about the user, such as name or family name. User Demographic Description models every kind of information related to the user demography, for instance, age, date of birth or employment. User Abilities refers to user skills. This class is important for recommendation services that want to take in account user capabilities to recommend specific content or avoid offering other type of contents. Finally, the physiological state holds the information related with the physiological state a user might have. For instance, blood pressure or heart beat rate. These properties are based on the General User Model Ontology (GUMO) [1].

The most important part of the user model is the User Preference Description class. It has relationships with key classes in the model that allows specifying preferences depending on the context information such as the user environment description, the user current state description and on time. The user environment description is related with the definition of the environment description of where the user is located. For example, these properties are the noise level, temperature, weather, humidity, etc. It is also linked with the location description class for defining where that environment is located exactly. The user current state description refers to properties such as the user mood or mental state. It is also linked to the previously explained physiological state class. In turn, the User Preference Description class can be extended with several different preference types. For example, it is possible to define a preference related to the user preferred content type (Audio, Video or Image) that might be dependant on the user environment, or even in the user current status. Also it is possible to define content preferences, device preferences, etc. Finally it is worth to highlight a probability property that is included in the mentioned user preference description class. It expresses the importance or the priority of a preference. This property is useful for recommendation systems since they can take more in account the preferences with higher rate values and decrease the ones with the lowest.

4.1 Usage Example of the CAM User Profile

One possible application of the user profile would be to offer users different media content types depending on their location. It is well known that location highly affect user preferences; the content you consume at home differs from the content you may want to consume at work.

Figure 5 clearly shows how user preferences are modeled using the presented user model. In this simple case the user preference only is affected by two properties of the user environment description and the user location. Two different media type preferences are affected by that context information; one for video types and the other for audio types, both with different rates. For using this model in recommendation services, the system would read the current user status and would match it with existent preference description instances. Then, if a preference description instance matching the current user status is found, that description information would be used for knowing the user preferences in that concrete occasion in order to fulfill user likings with the recommendations.

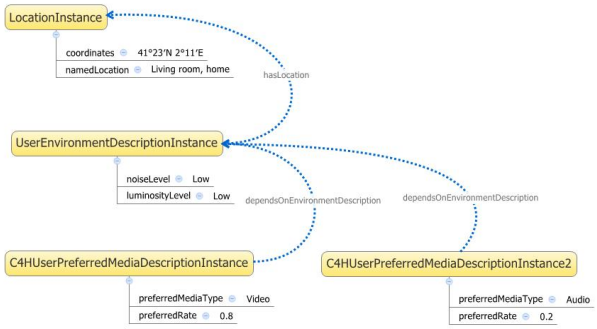

Figure 5. Example of User Profile Preference Instances

5. VALIDATION AND CASE STUDY

This section presents a case study where the described CAM user profile model and content model were used to implement a collaborative multimedia sharing application. It allows end-users to easily access, share and aggregate (i.e., bundle) their favorite multimedia content via PC and mobile terminals. The contents

that are bundled can be linked to user specific events (e.g., birthday party, class reunion, etc.) to provide additional semantics for the aggregation and they can be shared to other users as multimedia invitations. The CAM user profiles and content model were used in the application to enable creation of personalized end-user experiences and to allow dynamic cross-linking between the content and user context.

A typical use case for cross-linking of content and user information used in the application was personalized content recommendations, which refers to content recommendations made based on the user context and preferences. Implementation of the recommendations relies on the use of User Preference Descriptions described in Chapter 4. As an example of application logic, the user Alice may have different preferences linked to her home and office locations. At home Alice may want to receive recommendations of any type media types related to her hobbies but at office she may only want to receive recommendations of audio content related to her favorite artists. The application user interface showing specific recommendations for Alice is shown in Figure 6.

Figure 6. Personalized Content Recommendations

Another use case where CAM user profiles were used to personalize the user experience was the creation of multimedia invitations. As the invitation included information about the event location, the user location information was used to create personalized map showing the route from user location to the event location. As an example if the event was located in location A and the user Alice was located in location B, the application creates a map showing route from location A to location B. Other users receive different personalized maps based on their current location information. The user location information was automatically updated by the mobile terminal equipped with GPS receiver, making the updating process transparent for end-user.

As validated by the case study, the proposed CAM user preference model is suitable for recommender systems creating personalized content recommendations based on the user context information. The model enables convenient way of cross-linking the content and user context to develop highly personalized and user-centric multimedia applications.

6. CONCLUSIONS AND FUTURE WORK

In this paper we have presented a different user meta-model that can express user preferences that are dependant on the context information, which also might influence on users. This preference model has been designed to be as general as possible in order to be used in wide application areas. Moreover, we introduce briefly the CAM Meta-model concept providing also a simple example to ease its understanding. As explained before, it is a new an innovative metadata framework that serves a homogeneous deployment of content and services. We validate the usefulness of the user meta-model as an input model for recommendation systems within a case study that also makes use of the CAM Meta-model.

Our next steps will be to apply and use this general user model with machine learning techniques. They will be responsible of monitoring user activities while they create preference instances in the user model to be used by other consumer services. The CAM4home platform provides a good starting point since it offers heterogeneous content information metadata and a profile management service supporting all the required operations.

7. ACKNOWLEDGMENTS

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