Building a Platform for Pervasive Personalization in a Ubiquitous Computing World

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ABSTRACT
We propose a platform with the goal of helping developers when they need to apply personalization to ubiquitous computing applications, ranging from simple mobile apps to rich multimodal systems. The platform's core is a general personalization model, which provides the orientation and required tools to simplify and accelerate the creation of personalized applications. It also includes a context-aware clustering module fed by user data and context data in order to obtain users profiles for each personalization.

Author Keywords
Personalization, ubiquitous, adaptive HCI, user modeling, cloud-based platform, personalization as a service.

ACM Classification Keywords
H.5.m. [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

General Terms
Algorithms, Design, Human Factors, Standardization.

INTRODUCTION
We present a cloud-based Personalization Platform for Multimodal Ubiquitous Computing Applications (P^{2}MUCA), which provides tools and services to help developers in the implementation of their personalized solutions following a generalized personalization model (X-Users). The model is the guiding basis that allows applying personalization in the same way to different applications, even if they belong to different domains. On the other hand, interactions of a user with an application might be useful to personalize her experience while interacting with another one. Based on the model, a new application might get an appropriate user profile in order to automatically start adapting itself to the user's preferences. The scenario is viable due to the use of a generalized model provided by a platform such as P^{2}MUCA, which can assist developers in the implementation of both solutions.

Usually, personalization solutions are implemented towards the end-applications' specific needs, however the following are more closely related to our work. GUMO [1] is used to manage the syntactic and semantic variations between user modeling systems, modeling user attributes and their interrelationships. In [2], the user model mediation concept employs appropriate methods to transform the syntax and semantics of the user model used in one system into those of another system. A mechanism for reusing generic user modeling data with different applications called UM Toolkit [3] appeared in 1995, evolving into PersonisAD [4]. The latter was more focused on Ubicomp, providing distribution of models, where authorized applications could request access to a model in order to use its allowed parts.

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PLATFORM FOR PERVASIVE PERSONALIZATION

X-Users principles
Developers should decide beforehand, at design time, what to personalize in an application they are developing. Personas are behavioral specifications of archetypical users and they can drive design decisions at many levels of abstraction. Their careful specification can help determine what to personalize (instances of personalization, e.g., a screen or an interaction mode) and the different options for each personalization. So, in our model, each personalization instance (*Personalization*) will have a number of *Personalization Options* according to the number of identified *Personas* (Fig. 1, left sub-model).

Figure 1. X-Users: Personalization core entities.

An application developer must study which data resources the application is able of providing to select those that will be useful for personalizations. It is desirable that the representation of a persona, in an application's context, should be made through detailed combinations of different types of data resources. One or more arithmetic expressions should be defined in order to achieve it. For instance, (w_1*x+w_2*y) describes the combination of two resources, where x could be the number of logins with a weight w_1 of 0.2 and y could be the number of clicks on a menu with a weight w_2 of 0.8. This equation is a parameter. After defining the desired Personalizations and their Options, the developer should select Resources, combining and weighing them to create Parameters, which represent Personas (Fig. 2, right sub-model).

It is important to have a consistent user model to gather relevant information in order to support different (X-) users,

which may evolve over time while using diverse applications. The user sub-model of X-Users comprises the user's demographics and three main types of resources: preferences, interactions stream, and context. Context modeling and user modeling are strongly interrelated in our approach. When an application updates data on a given user (e.g., logins), there may also be data on the current context of the user (e.g., location or weather conditions). Therefore, the user's interaction data are stored and simultaneously associated to specific context conditions.

Summarizing, when using an application, a user will have a profile (can mutate) that will match one of the personas ("cluster profiles"). The user profile can be seen as the output of the *user sub-model* and it works as "input" for the *personalization sub-model*, matching a cluster profile. The two sub-models represent the global X-Users model [5].

P²MUCA Overview

X-Users is provided within a framework called Context-Aware based Personalization Environment (CAPE), which is composed of two main components: an XML-based registration service to configure personalizations for third-party applications; and a context-aware clustering module for user profiling. CAPE also provides a basic personalization API and it is made available through P²MUCA. The latter provides a set of services to registered users, which can be: 1) developers that register their client applications to use the service; 2) end-users that will be able to authorize applications to have access to their data. P²MUCA is composed of two major components (Fig. 2): 1) Website - a front-end for registering applications and configuring their personalizations based on X-Users; it is also used as a user sign-in and authorization point, allowing users to grant and revoke an application's access to their data; 2) Service - implements an HTTP-based API (Table 1 summarizes a subset of it), following a remote procedure call pattern, protected by OAuth 2.0; It uses CAPE to support all of the provided API calls to personalization.

Name	Input	Output
/validate		*clientId* and *username* for given access token
/addUser	username email	Request status
/setPreference	preference value_id	Request status
/setPreferenceValue	preference value	Request status
/setResource	resource value	Request status
/getPersonalization	personalization context (optional)	Request status and *personalization option* (if successful)

Table 1. Subset of P²MUCA's HTTP API.

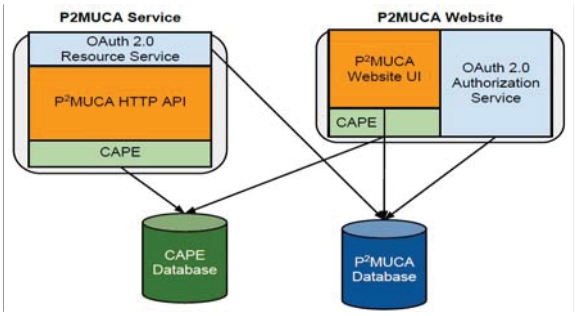

Figure 2. Platform's architecture.

Both P²MUCA's components depend on each other. For example, the P²MUCA Website allows the configuration of an application's personalization using CAPE, but that same configuration must be shared with the P²MUCA Service. Moreover, OAuth data must be shared between both since P²MUCA Website is responsible for creating applications' client credentials and access tokens, but the P²MUCA Service endpoint must use the same data to authorize each request made by third-party clients. Two databases are used: 1) one with P²MUCA's users, applications and OAuth data; 2) the CAPE repository, implementing X-Users.

CONCLUSIONS AND FUTURE WORK

We conducted a preliminary developer study focused on the evaluation of applications' personalization configurations. The results were very promising showing that every developer was able to understand the model. For future work, it will be important to provide different clustering algorithms that can be used interchangeably in the personalization process according to each specific situation. A long-term evaluation study must be conducted to further enhance the platform and its underlying model (X-Users).

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