POSITION PAPER:

Designing a Hierarchy of User Models for Context-Aware Applications

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Abstract. *Research in Ubiquitous Computing and Wearable Computing yielded several types of context-aware applications, dramatically changing the way to interact with computers. User Modelling is a key concern for these types of applications in order to accomplish personalization. In most cases each user model is specific to a certain application and opaque to others. System design could be improved if common data structures could be communicated between different user models. Therefore we propose the organisation of user models in a hierarchical structure relating different user models to each other.*

Introduction

Work in Ubiquitous Computing [1], Augmented Reality [2], Smart Rooms [10], Reactive Environments [3] enabled the vision of a *computer-augmented environment*, electronic systems are merged into the physical world to provide computer functionality to everyday objects. The technology should be distributed (ubiquitous), yet invisible, or transparent, since the full potential of the computer can only be realized when the machine itself is hidden from the user. This concept marks a dramatic shift from the status quo in which interaction with the computer interferes with our activities rather than enhancing them. This vision is often enabled by putting sensors in the environment (e.g. rooms).

Another approach to ease human-computer interaction is tackled by work on Wearable Computing [8,9,10]. In opposite to Ubiquitous Computing[1] Wearable Computing does not necessarily require any environmental infrastructure at all. In the purest form, the wearable user would do all detection and sensing on her body [11].

Both the pure Ubiquitous Computing and the pure Wearable Computing paradigms may be applied to context-aware applications. As described in [4], context-aware applications may embed arbitrary context information (e.g. location, collection nearby objects/persons, accessible devices and services) in a flexible way.

[1] Ubiquitous Computing = {Augmented Reality, Reactive Environment, Smart Space}

Here, we want to focus on personalization of services taking in account contextual information and *user models*. In general a user model contains the system's assumptions about the user [5]. Assumptions may be constantly refined by monitoring user activities or explicit by user feedback (e.g. [6]). User modelling is common to several contextual applications (list below).

Separating Concerns in User Modelling for Context-Aware Systems

The following list states general examples where user models enhance usability of applications by embedding user related information.

- Message Filtering [7]
- Location-based information services, e.g. [12]
- Service/Resource discovery [13] and selection (Service/Resource Discovery is a key concern given the enormous amount of information potentially available in the environment)
- User-adapted interpretation of context information
- Adaption of Interface Agents
- Environment configuration [10]
- Process Activation/Deactivation in dependence of context, e.g. [14]

The listed examples clarify the difficulty to introduce a single user model for context-aware systems, because eventual personalization covers several areas of use and there is no common model that fits to all of them. For this reason we propose to separate concerns in user modelling for context-aware systems. This would result in multiple user models each being specialized on a certain context of use. Still there is information common to all of them e.g. superior settings regarding security or privacy issues. This information should be propagated to the other user model (modules).

A Hierarchy of User Models

We suggest a hierarchy of user models in order to organize user-centric data in context-aware systems. Figure 1 states an example.

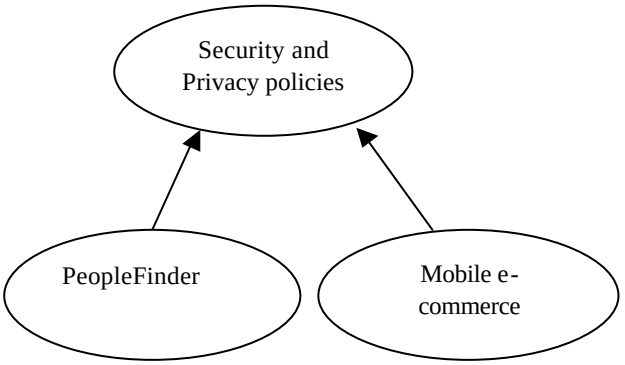

Figure 1

The Figure shows two different user models for two context-aware applications (PeopleFinder and Mobile e-commerce). Both should obey to settings in the user model

for security and privacy policies. Hence, if a user changes these policies, information about this should be *propagated* to the user models associated (the PeopleFinder and the Mobile e-commerce application). If the user selects a "high" privacy level he should neither being locatable nor being annoyed by messages that announce offers to buy.

Figure 2 depicts another example for distributing user model data on a hierarchy of entities, each entity representing a certain subset of the user model data. This example takes in account spatial concerns and provides a higher degree of granularity in comparison to the previous example.

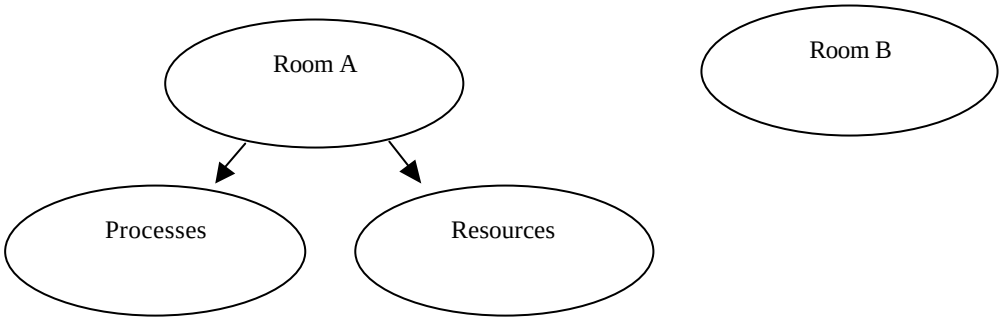

Figure 2

The left side of the figure (Room A) shows the user model for a room; it mainly includes processes which a triggered by certain user actions [14], and references to resources the user normally uses. Now the same user wants to have the same settings ("look & feel") in room B[2] as in room A, he would ask the system to do so. The system would automatically *transfer* all settings related to room A (including the associated entities) to room B. (The set of candidates for transfer operation could be determined by referential integrity constraints.) Transfer is not always trivial; in the given example it is not sure that room B supports everything specified in the user model for room A. This could lead to partial transfer or intelligently adapting functions.

In order to implement this design we could associate an agent with each entity managing it. These agents could co-operatively implement *transfer* and *propagate* operations.

The following points require further studies:

- Interactions schemes to manipulate/browse the hierarchy
- Further Operations
- …

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[2] "Room X" means the physical room and the entity modelling related user data for this room. Sorry.

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