# Multi-Device, Ambient-Aware Information Delivery

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**Abstract.** Today, a huge number of wearable devices enable users to access information from any place at any time. There are even devices that supply users with peripheral information. However, these ubiquitous devices have different I/O capabilities that lead to new problems in the development of information services because service developers have to take the diversity of devices into account. Additionally, the service usage might be spread across multiple devices. Besides of these aspects, it is very important to avoid a high cognitive load of the user. In order to realize multi-device, ambient-aware information delivery, we propose a service adaptation framework that addresses personalization, user interface adaptation, ambient awareness, session aspects and different user interaction modes.

## Introduction

Nowadays, most people are equipped with more than one mobile device. Emerging network technologies like UMTS or public WLAN hotspots offer Internet access anywhere, at any time, and with a considerable bandwidth. At least from a technological point of view, the vision of individual information which is always at your fingertips is on the verge of becoming a reality for the broad public. Nevertheless, there are many different technological and socio-economic issues which still need to be addressed in order for a realization of this vision to be widely accepted. One of the key issues to be solved is how users can be addressed according to their individual interests and immediate needs, and therefore decreasing the omnipresent information overload.

The trend towards personalization is similar to the replacement of undifferentiated mass marketing approaches with the practice of market segmentation techniques in traditional commerce. Market segmentation techniques allow the subdivision of a broad and hence heterogonous customer base into several smaller and homogenous groups. Users can be addressed according to their individual needs. This increases the quality of these services and leads to a higher degree of satisfaction.

Modern mobile devices have different capabilities for presenting service user interfaces and for interacting with the user. A user interface adaptation framework enables the creation of services that may be accessed via arbitrary terminal devices and utilize the media presentation possibilities heterogeneous terminal devices offer to a full extend.

Besides user interface adaptation and personalization, ambient-awareness, an extensive session model, and different user interaction modes have to be addressed in a multi-device, ambient-aware information delivery framework.

## Our Approach of a Service Adaptation Framework

To enable multi-device ambient-aware information delivery, certain research issues have to be addressed:

**Personalization.** In ubiquitous computing there is a strong relation between user device capabilities *and* user preferences. Each device stores its own capabilities. Preferences have to be accessible for service customization, i.e. for adaptation of service behaviour and data, regardless of the actual used device(s). They are usually valid only for a particular situation. This means that there are conditions, here denoted as *activation context*, that specify which preferences should be used. Only the combination of user preferences and device capabilities allows to take different human demands, interests, goals, and therefore different preferences into account for multi-device, ambient-aware information delivery. Consequently a valid personalization model has to consider the distributed nature of user preferences and device capabilities. Moreover, it has to incorporate several standards for the exchange of personalization data (e.g. GUP [2] or CC/PP [3]) into a single preference description language [1]. According to the selected exchange format suitable adapters with adequate transformations have to be used.
The personalization model itself has to be user-friendly and reliable. Although, users might profit from the personalized behaviour of the complete system, they do not want to be confronted with technical details of the realization. The preferences management system has to ensure privacy in order to be accepted as a being trustworthy. Beside technical concerns, these issues are the most relevant and critical ones in today's systems. Our personalization model approach is depicted in figure 1.

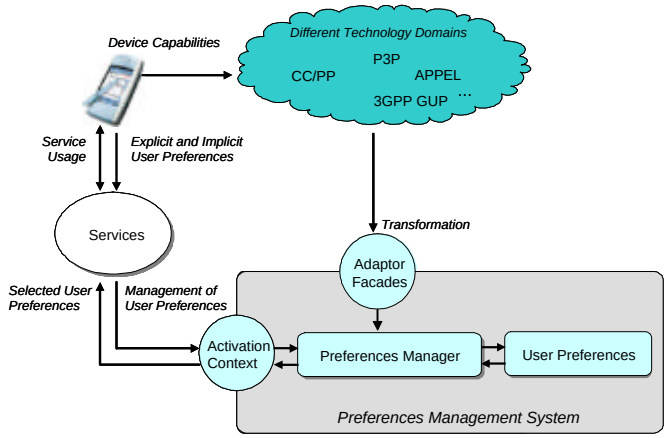


**Fig. 1.** Proposed Personalization Model For Multi-Device, Ambient-Aware Information Delivery

Our approach allows the management (i.e. creation, modification, deletion) and retrieval of implicitly and explicitly gathered user preferences and interests in regard with the user's current context. On a request capabilities and preferences are first merged by the preferences manager and then the compiled result is sent back to the service. The adaptation of service behavior and data according to the selected preferences is done by the service itself.

**User Interface Adaptation.** Devices in ubiquitous computing are extremely heterogeneous and offer a wide range of I/O capabilities. These differences need to be addressed by an automatic user interface adaptation, so that the service could be used from a broad range of devices. In order to minimize multi-device service creation time, developers are urged to create services in a device-independent manner, whereas actual device constraints have to be considered when the service is finally delivered to the user. Our user interface adaptation framework provides the basic infrastructure for a device independent service delivery by adapting a generic user interaction description language to device specific formats. Through the combination of different W3C language profiles, like XHTML Basic, XForms Basic and SMIL, and the addition of Cascading Style Sheets, service developers are able to create services that are accessibly with arbitrary devices. XHTML Basic is the host language for the description of user interface documents. XForms Basic allows a generic description of dialogs. Media elements are embedded via SMIL, whereas the developer may further describe them and has the possibility to provide alternatives. With such an explicit user interface description, the adaptation framework is able to optimize the service delivery in regard to device capabilities and user preferences. Additionally, the automatic adaptation enables all ubiquitous devices to access services homogenously. A wristwatch computer has the same point of service access as a PDA. However, it gets a short text message in reply that is displayed to the user, whereas the PDA may get a complex multimedia document. This single authoring approach [5] and the single point of service access make it possible to distribute service usage among different devices.

**Ambient Awareness.** We think that information about the user's environment (so-called ambient information) has to be considered in order to be able to adapt service behavior and data to the user's needs to the full extent. Ambient information (aka as the user's context) describes the environment of the user at a certain moment in time. This includes physical measurable data, such as temperature, humidity, loudness, etc., but also relevant items residing in the environment, such as devices and other objects [4]. This information is taken into account when a service queries particular user preferences. The preferences management systems selects the preferences to be returned according to the provided ambient information, denoted as activation context in figure 1. The user interface adaptation framework relies also on the gathered ambient information and user preferences for the service delivery. Ambient information is gathered from various sources, e.g. from sensors networks and from user devices themselves.

**Session Model.** To realize multi-modal user interaction, i.e. that the service usage is divided across different devices, a specific session model is needed. The relationship between user and the service is characterized through a user session. The user session has to consist of two parts: An access session and the actual service session. The access session describes the connection of the user's device to the system and is therefore very specific to the type of communication service used, e.g. WWW or speech. There can be multiple access sessions for each terminal. When the user is interacting with a service, there is one service session describing the state of this interaction dialog. This means, the user can have multiple access sessions, which are assigned to the same service session. Furthermore, the user can interact with different services, i.e. multiple service sessions, through one terminal, i.e. one access session.

**User Interaction Modes.** Users employ different devices to access services explicitly, i.e. they *pull* information. However, surrounding the user, ubiquitous devices may not be used actively. They may rather provide some services to the user depending on the user's actual needs. To support this kind of service delivery, it is necessary to *push* information to the user. In this way, wristwatches or ambient displays enable peripheral awareness. Our approach not only supports the *asynchronous* push model, i.e. a notification, but also a *synchronous* push model, whereas the service starts an interaction with the user. Thus, when a piece of information arrives that is of importance for users, they can explicitly access more of this information. Therefore, they can use any other device to access this information. This is possible due to our session model and the single point of service access. When a user accesses the news service, that previously delivered a message to his wristwatch, with a PDA, he resumes the service usage at the same point and is able to access the latest news.

## What we have learned

Combining the previously discussed aspects we developed a service adaptation framework for multi-device, ambient-aware information delivery at Fraunhofer FOKUS. This systems reduces the cognitive load of the user and enables comfortable and user-friendly delivery of relevant information across different devices.

## References


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## Biographies

**Bernd Mrohs** is a scientist at the Competence Center for Open Communication Systems at the Fraunhofer Institute FOKUS. He studied computer science at the TU Berlin and received his MS in January 2003. His current research activities lay in the field of ubiquitous computing, ad hoc networks and peer-to-peer networking.

**Christian Räck** received his MS from the TU Berlin in January 2003. He started working on his PhD thesis in the context of peer-to-peer networking in July 2003 at the Fraunhofer Institute FOKUS lead by Prof. Dr. Dr. h.c. Radu Popescu-Zeletin.