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Razmerita, Liana; Nabeth, Thierry; Kirchner, Kathrin

## *Document Version*

Final published version

## *Publication date:*

2012

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## *Citation for published version (APA):*

Razmerita, L., Nabeth, T., & Kirchner, K. (2012). *User Modeling and Attention Support: Towards a Framework of Personalization Techniques*. Paper presented at The Fifth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services. 2012, Lisbon, Portugal.

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## User Modeling and Attention Support: Towards a Framework of Personalization Techniques

Liana Razmerita  
Copenhagen Business School  
Frederiksberg, Denmark  
lr.ibr@cbs.dk

Thierry Nabeth  
ORT France  
Paris, France  
thierry.nabeth@ort.asso.fr

Kathrin Kirchner  
Universital Hospital Jena  
Jena, Germany  
kathrin.kirchner@uni-jena.de

**Abstract**— This paper aims to elaborate on the role of user modelling for personalization and enhanced attention support. User modelling is an important element in the management of personal profiles and identity of users, but also a key element for providing adaptive features and personalized interaction. In this paper, we present personalization as the process consisting on the customization, and the adaptation of the interaction along the structure, the content, the modality, the presentation and the level of attention required. The paper surveys personalization techniques and provides concrete examples of personalized interaction. In particular, the paper focuses on the role of user modeling for enhanced, personalized user support within interactive applications. The key contribution of the paper is to propose a framework of personalization techniques and to identify new forms of personalization that aim at taking into account human cognitive capabilities and emotions.

**Keywords** *personalization; user modeling; attention support; persuasion; social networks; personalization techniques.*

### I. INTRODUCTION

User modelling is a way to bypass the lack of information provided by the users and personalize the interaction with applications that adapt to their users' needs and accommodate their preferences. Personalization, contextualization and more recently attention support [1, 2] represent key elements for achieving intelligent features in advanced interactive applications. Personalization will also be a defining characteristic for a next generation of web applications and services, a defining characteristic of a new generation of services and applications on the Web. Such applications develop deeper relationships with their users, provide more value to users who return more often and ultimately offer more targeted experiences for each user according to her/his personal need [3]. Personalization may be defined as the process that enables interface customization, adaptations of the functionality via the structure, content, modality and presentation in the interaction in order to increase its relevance for its individual users [4]. Personalization may also take into account the limited human cognitive capacities (e.g., quantity of information that the brain can process, or its limited multitasking capabilities), emotions and cultural differences to provide an interface that is more attention effective.

In general, the goal of personalization is to improve the efficiency of the interaction with users, to simplify the interaction, and to make complex systems more usable [5]. Personalization is a way to overcome “one size fits all” type of applications. Personalized recommendation systems will feed us with news, new music, new products, targeted advertisements, according to preferences, moods and interests of the users [6].

A first step in achieving personalized interaction is the elicitation of the user model's characteristics (preferences, habits, needs). User models data can be created either: (1) by people explicitly specifying it (setting their preferences); (2) by automatic extraction (profiling) or (3) through a combination of the two methods. User modeling processes are a complex task, and the whole process of collecting personal data is subject to legal regulations in many countries and states. Furthermore, users are more careful about the disclosure and use of their personal information. A number of issues including the lack of reliability of the information “declared” in the profile, or its incompleteness due to several reasons including privacy concerns have to be handled in the construction of the user profiles and the associated personalization techniques. Both user concerns about the use of personal data and privacy regulations frequently impact on what personalization methods can be used [7].

The paper surveys personalization techniques and provides concrete examples of personalized interaction. This paper aims to elaborate on the role of user modeling for personalization and enhanced attention support. In particular, the paper focuses on the role of user modeling for enhanced, personalized user support within interactive applications. This article argues that user modeling may represent a key component for providing attention support (e.g., in supporting users allocating and better focusing their cognitive resources in learning or working). The key contribution of the paper is to discuss the different types of personalization and to propose a framework of personalization techniques. Furthermore the framework includes attention support and persuasion as emerging new forms of personalization.

The second section provides an overview of related work in the area of personalization and attention support. The third section is dedicated to the presentation of the different elements of the taxonomy. The fourth section gives real-case

usage scenarios and discusses future personalization mechanisms. The last section concludes and presents future related work.

## II. LITERATURE REVIEW

Personalization brings a utility as well as a conviviality function with “high-touch” impact for the users. From the utility perspective, personalization is important as significant differences between users can be observed and furthermore, users have different needs, goals and tasks at hand. An important form of personalization is interface customization, usually initiated by the user. However, studies conducted by Yahoo reveal that most often people do not take time to personalize or customize their experience [8]. Their study revealed that most often users use the default web page and mainstream users do not take time to customize or personalise their experience. Generally, users do not like to provide information and only the most experience users, “the power users”, take the time to personalise or customize and they can “do amazing things” that truly reflects their personal interests and are of great benefit for them. Furthermore, the study suggests that no matter how well designed a tool is, users may find unexpected ways to use it.

User modeling associated with personalization techniques enable changes in the structure, content and modality of applications in order to match the needs and preferences of users. In contrast to customization, where users specify their preferences manually, personalization means automatic adaptation according to user profiles. Personalization can be seen as a prediction problem: the system tries to predict the user’s level of interest in, or the utility of, specific content categories, pages, or items, and rank these according to their predicted values [9]. A large variety of personalization techniques [10, 11] are proposed in the literature and automatic personalization can be classified as: content-based, collaborative filtering and rule-based filtering systems. A comprehensive overview of data mining algorithms for user modelling and personalization techniques can be found in [9, 12, 13]. Web mining, the application of data mining techniques to discover patterns from the Web, can help to define such user profiles on the basis of the history and current actions of the user and his/her interactions with the application or with other users [9]. While collecting large amount of data for analysing user profiles, privacy concerns have to be considered [6] and the field of privacy-enhanced personalization has recently developed [7]. Furthermore, user models can be mapped to the context and generate a personalized structure, content or modality according to the context. Contextualization refers to an adaptation of the interface taking into account the user’s context and thus creating context-aware systems [14]. Context-aware systems represent the type personalization that create an interaction that is relevant to user’s context, which can include their current work process (what there are working on), the current location, people personal preferences, type of device, or current activity.

Personalization may take into account the cognitive capabilities of users, and address problems such as information overload, interaction “burnout”, the difficulty to

manage too many tasks at the same time, or other psychological aspects (e.g., boredom). In that case, the user model may incorporate elements such as mental states (e.g., bored, overwhelmed, aroused, etc.) that will be taken into account in the personalization for instance by “tuning” the cognitive effort required in the interaction (e.g., reducing the complexity of the interface and the flux of solicitations), or by providing stimulation to the user (for instance when an attention dropout has been identified).

A number of taxonomies for personalization have already been proposed in literature [10, 15-17]; however they are neither complete, nor they reflect the current state of the art of actual applications.

## III. TOWARDS A CLASSIFICATION OF PERSONALIZATION TECHNIQUES

As described in the previous section, personalization has many facets and uses many different techniques. These very different approaches of personalization techniques are classified in a taxonomy, which can guide both researchers and practitioners in future developments of personalization domain.

Based on the literature review presented in the previous section, the article proposes a taxonomy of personalization techniques, extending the basic types of personalization presented in [10], that spans three dimensions, see Fig. 1:

- Types of personalization: What is personalized?
- Elements of personalization: Which elements are used for personalization?
- Methods of personalization: How the personalization is done? (customization or user-driven personalization, automatic or system-initiated personalization)

Additionally to the four basic types of personalization (structure, content, modality and presentation) presented in [10], we added attention support and persuasion as new dimensions that have recently been discussed in the literature. Attention support considers the human cognitive limitations such as the human limited absorbing and processing capabilities. Persuasive personalization takes into account the time and strategies that are necessary for humans to change and adopt new behaviors or beliefs. In our framework, personalization or adaptation techniques can be therefore classified in six main categories: personalization of structure, content, modality, presentation, attention support and persuasion (see Fig. 1).

According to the information used for personalization, one can distinguish the characteristics of the user and the context in which the user is situated. Furthermore, personalization can be classified in two ways: user-driven (customization), automatic or agent-based (semi-automatic).

### A. Types of Personalization

1) *Personalization of structure* refers to the way in which the hypermedia space is structured and presented to the different groups of users. Personalization of the structure of an application or website means altering the location of

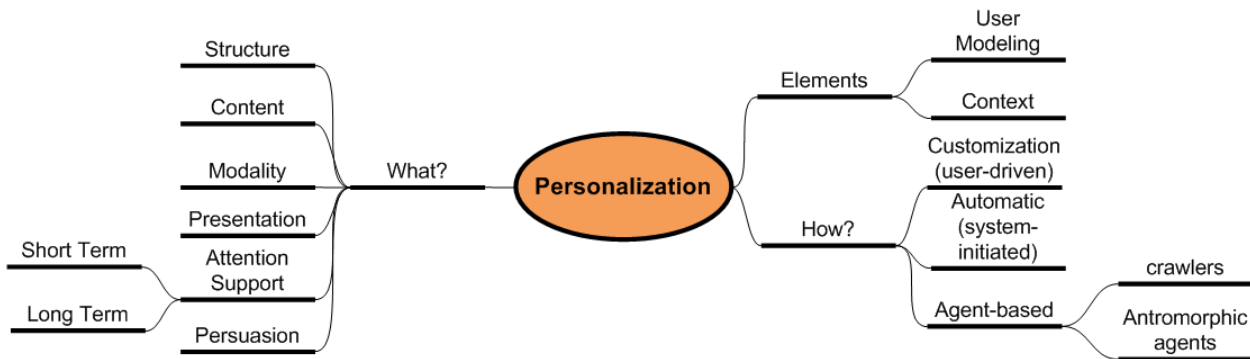


Figure 1. A taxonomy of personalization techniques

content including text, images and the location of available links. This aspect of personalization involves placing the links and content where they are more relevant for the user. Different users may see different layouts. This structuring can help the identification of the important information (putting important information at the top), but also can facilitate navigation through personalized navigation or “adaptive navigation support” [18] enabling a number of actions such as: creating shortcuts on more frequent actions, adaptive ordering, direct guidance or alternative actions). When a user navigates from one item to another, the system can manipulate the links (hide, sort, annotate) to provide adaptive navigation support [19].

The personalization of structure guides the user in his interactions in a non-intrusive manner by making more accessible the more likely actions to be followed or disables certain functions and therefore narrowing down the space of possibilities in order to increase efficiency and usability.

2) *Personalization of content* refers to the process of dynamic tailoring the information that is presented to the different users according to their profiles (e.g., needs, interests, level of expertise, etc). The adaptation of content facilitates the process of filtering and retrieval of relevant information. The content can be selected to be relevant to the specific characteristics of users, and the location or context of the activities in which they are engaged at a given time. These techniques of adaptations enable users to spend less time to search and retrieve relevant knowledge/information or products. On the web, personalized content can take the form of recommended links or products, targeted advertisements, or text and graphics according to the user’s preferences [11].

A traditional approach to personalization of content, especially in web applications, is collaborative filtering used by Amazon [20] or Google News [21]. The current user’s ratings of certain objects are matched with the ratings of similar users to give recommendations for objects the current user has not ranked. Another example of the personalization of content is personalized search. Personal preferences according search results that are stored over longer periods of time integrated into the search process [22]. Data about users search history have to be collected (e.g., with Google

Web History or via cookies on the user’s computer). The search history data are later used for ranking or filtering search results. The “filter bubble” [23] warns us about the potential downside of personalized search. It is argued that through personalized search we limit the exposure to new information, new points of view which could be detrimental for the users on long term.

The personalization of content enables to select the content that is more likely to be relevant to the user and help users to deal with the information overload problem.

3) *Personalization of modality* empowers the users to choose between different modalities of information visualization. New modalities of information visualization have recently emerged. These new forms of information visualization go beyond a text or tree based view of documents or information. Intelligent information portal bring a new designs of the user interface with a graphical view representation (e.g., Kartoo, Brain, ClusterMap, 3D representations). The personalization of modality enables changes from text to other types of media to present the information to the user (image, video, animations or audio) if they are available in the system based on various criteria such as: cognitive style, learning style, preferences, physical disabilities, type of display or device, etc. The selection of the modality can be done according to the user characteristics, culture, context, type of device in use but also according to the nature of the content (some modality can be more adapted to the delivery of some particular content). Numerous studies reported in [24] have emphasized that cultural differences are important for the selection of image modality, colour selection, and information presentation in general.

4) *Personalization of presentation* empowers the users to choose between: different presentation styles such as: different layouts, skins or size of fonts. Other preferences can include the presence or absence of anthropomorphic interface agents, the preferred languages, etc. Different types of sortings, bookmarking, shortcuts can also be included in an advanced hypermedia system. Cultural adaptation is another element that differentiates the personalisation of presentation taking into consideration

significant cultural differences (e.g. Western versus Chinese style). Cultural differences are important for website design, visual representation and information organisation [24]. According to [25] personalization of appearance through customization gives the possibility to express oneself and is correlated with both cognitive and emotional effects.

5) *Personalization of attention* (or attention supporting personalization) refers to the process aiming at making the interaction more attention effective, and in particular at reducing the cognitive effort. The support for the management of attention can be done at four levels: perceptual (filtering information); deliberative (help in reasoning and decision making); operative (reduce the cognitive effort necessary to complete a task); and metacognitive (learn how to be more effective at managing attention). Attention support is important because our attention can be easily diverged by various interruptions and because information of all types and qualities abounds [1].

Attention support is a particular form of personalization, aiming at personalizing the interaction in order to support users in being more effective and attentive on the main tasks or in relation with the tasks or goals they need to perform. In cognitive science, attention represents a very broad concept that includes a variety of aspects such as perception, information overload, and interruption, multi-tasking to name just a few. Attention can be supported both in the short term and in the long term. In the first case, it consists in helping reducing the cognitive load during human computer interaction, by reducing the amount of information displayed, by displaying it at a right level of prominence, or by notifying information (e.g., reminders) in a way that minimize the level of distraction. In the second case, it consists in assisting users in allocating their cognitive processes in a way that is the more effective over longer period of time. For instance, the support of long term attention may consist in helping users in allocating their time, and at selecting the types of actions that are the more effective so as to accomplish an objective. Attentive user interfaces [26] are designed to reduce the cognitive effort by reducing the amount of information presented to the user, by limiting the interruptions or by helping this user to recover after an interruption by restoring the previous context of his work [27].

The personalization of attention considers the human cognitive limitations such as the human limited absorbing and "processing" capabilities. This is in particular relevant for teaching and learning. Learning analytics is an area which has recently emerged that aims to manage the attention of learners based on their activities and interaction traces.

6) *Persuasion*. Persuasive technologies aim to shape, reinforce or change the behavior, feelings or thoughts of users, e.g., to maintain a healthy lifestyle or to purchase products. Usually, persuasion is not tailored to specific user groups with wide-ranging goals and needs [28]. A fusion of personalization and persuasion, e.g., by providing

personalized messages or adapting the user interface, leverages the effect of persuasion [29].

#### IV. ELEMENTS OF PERSONALIZATION

Personalization is a data-intensive process and can be based on two main kinds of information that is evaluated:

- User modelling, the characteristics of the user (user data and usage data)
- The user's context or state (e.g., location of the user, current activity)

##### A. User modeling

User models or user profiles include user related data such as user's name, address, interests, preferences, skills, etc. This information can be collected explicitly via forms or questionnaires, but also implicitly via various user modeling techniques of usage data. The explicit data can be enriched/complemented by usage data, directly observed or implicitly recorded from user actions. An overview of the various types user modeling techniques and characteristics of the models can be found in [6]. Usage data includes information about clicking on links, session length, or articles watched and purchased [30]. Usage information is available via the Web server logs, but is also increasingly made available by Web tools such as online social networking systems via the exportation of the activity streams. This information is then processed by applying data mining techniques such as clustering, association rules discovery, classification, and sequential pattern discovery, in order to reveal useful patterns that can be further analyzed and exploited in order to generate a more personalized experience.

##### B. User's context

Adaptation to context refers to the dynamic adaptation process to a changing environment in which the user operates or works. Context-aware systems represent the type of systems that create an interaction that is relevant to user's context, e.g., location, current work process (what they are working on), the current organizational settings (culture of the organization), personal characteristics or mental states (e.g., boredom). Context aware systems have been proposed also for the design of more effective e-learning systems [31].

##### C. Forms of personalization

One can distinguish between different methods of personalization:

- Customization, initiated by the user who set up his own preferences
- System-initiated or automatic through adaptive interfaces, services, or more recently attentive user interfaces
- Proactive personalization via agent-based or semi-automatic personalization through crawlers or anthropomorphic agents

1) *Personalization through customization*: is the process of creating a customized user experience taking into account users preferences and/or specific characteristics of

the user. When customizing, the user is in control in specifying his own preferences and requirements manually, and is able to adapt the interface in a way that is the most fitted to his particular needs. At this level customization process may consist of setting preferences that will be taken into account to parameterize the interface, but it may also consist in allowing users to literally design the interface itself by assembling the different components. Examples of the latest category can be found in information portals such as: iGoogle, MyGoogle or NetVibes.

2) *Automatic personalization or system-initiated personalization*: personalization can also be achieved in more sophisticated manner through automatic personalization or adaptive interfaces. In this later case, the interface and the interaction are dynamically generated, in a way that is expected to fit to each specific user. Practically, adaptive user interface rely of a user model that includes the most important characteristics of the user. Adaptive systems may make use of data from the user model/profile, his usage data and/or context. This data can be processed, analyzed and predictions about user's future behavior, intentions or goals are made. Automatic personalization relies on various types of algorithms and in particular data-mining algorithms as presented in section II.

3) *Agent-based personalization*: may include adaptive focused crawling [32] to help locate resources about particular topics of interest for a user or through the use of various agents including anthropomorphic characters [33]. Agents-based have been designed with the purpose of personalization of interaction or providing enhanced user support through a dialogue with the user in domains such e-learning or e-commerce [32]. Anthropomorphic characters try to mimic and behave like a human and they can play different roles (e.g., guide a user is searching, help, discuss, entertain).

## V. DISCUSSION AND USE CASES OF PERSONALIZATION

Online social networks provide a fast-developing application domain of different methods of personalization. The different personalization mechanisms contribute to improved effectiveness attention by reducing the amount of information processed and reducing the level of interruption and distraction.

At the level of **content personalization**, a typical personalization mechanism consists of friends' recommendations that are likely to be friends or acquaintances. These recommendations are typically done using collaboration filtering technique, and are inferred by mining the social network of the member. Furthermore, the disclosure of information can be parameterized taking into account the social proximity (close friends have access to more information than acquaintances or complete strangers). The social network is notified of changes of other members' profile or with information that are relevant to a given member (such as common friends or groups affiliation).

As an example of **personalization of presentation**, users can select the number of items to be displays in the suggestion box for possible new contacts and the location of this suggestion box in the web page. Users can select to have more or less information from a specific person in their list.

A user can decide how to get informed about news in his/her network – via mail or via sms on the mobile phone. These mechanisms are a form of **personalization of modality** as described in the previous section. As web notification, suggestions boxes can provide a non-disruptive means of notifying users of an event or to indicate a suggestion what other people might be interesting. Social navigation is also a new form of navigation support that has developed with the context of social network applications. Few attention support mechanisms are also included. Such mechanisms include notifications of birthdays, applications advertisements or events that might be of interest.

Personalization in online social networks makes use of both individual characteristics (e.g., all the personal information such as age, position) as well as of user-generated content (list of favorites, ratings), the context (such as the recent activity of the members in his/her social network). Personalization in these systems is specified **both explicitly** by members (for instance when they select the level of notification or set their privacy preference) or **automatically generated** by the system (when they provide relevant recommendations).

An analysis of common features and current limitations of social networks applications have been described in [34]. Such limitations can be addressed through advanced personalized features enabled by Semantic Web technology. Personalization in social networks using Semantic Web technologies will enable more up-to date and relevant content and stronger social connection through semantic browsers and semantic mashups [34]. Semantic Web technology and advanced data models will enable to integrate different data sources and facilitate dynamic data integration from different data sources through semantic mashups. Thus a busy user will spend less time to find relevant events and share them with his/her friends in case she /he wants to.

Finally, attention-aware systems are taking into account the cognitive effort in the interaction for short term or for longer period of time. This is particularly relevant to application that support teaching, training and learning. More specifically, (short term) attentive user interfaces [24] are able to make the graphic user interaction more attention friendly, by displaying information at the right level of prominence, or by managing interruptions (e.g., prioritizing or delaying them). Long term attention management systems offer assisting users in managing their attention over longer period of time (weeks, or month), via the capture, analysis and visualization of activities and the provision of guidance. Such systems has been proposed in the context of online social interaction [2], learning [35] or work, and typically consists in providing an analytic component (e.g., learning analytics dashboard) and a recommendation system.

## VI. CONCLUSIONS AND FUTURE WORK

Personalization techniques represent a way to enhance the user experience, to help users cope with increased information overload, to support attention management with the ultimate scope of helping users to be more effective, help users in the decision making process or persuade the users and customers. However personalization is a challenging, broad area of research that overlaps several research fields and it poses a complex set of both usability studies [36], trust [23] and privacy concerns. With system-initiated personalization which is the more advanced form of personalization the users are less in control and therefore trust and privacy concerns are important.

This paper examines the different forms of personalization and proposes a classification of the different existing personalization techniques according to three dimensions: types of personalization, elements of personalization and methods of personalization. In addition to the four forms of personalization (structure, content, modality, presentation) discussed in the literature, this article introduces two new forms of personalization: attention support and persuasion. In particular, we elaborate on the management of attention or attention support.

This framework can be applied in the different application domains and it may be further developed and may enable researcher and practitioners achieve an overall understanding of personalization methods, techniques and elements. Further research on attention support, collective intelligence and personalization mechanisms will enable application to provide more value to the users who return more often or targeted experiences for each user according to his/her needs, capabilities, interests or preferences.

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