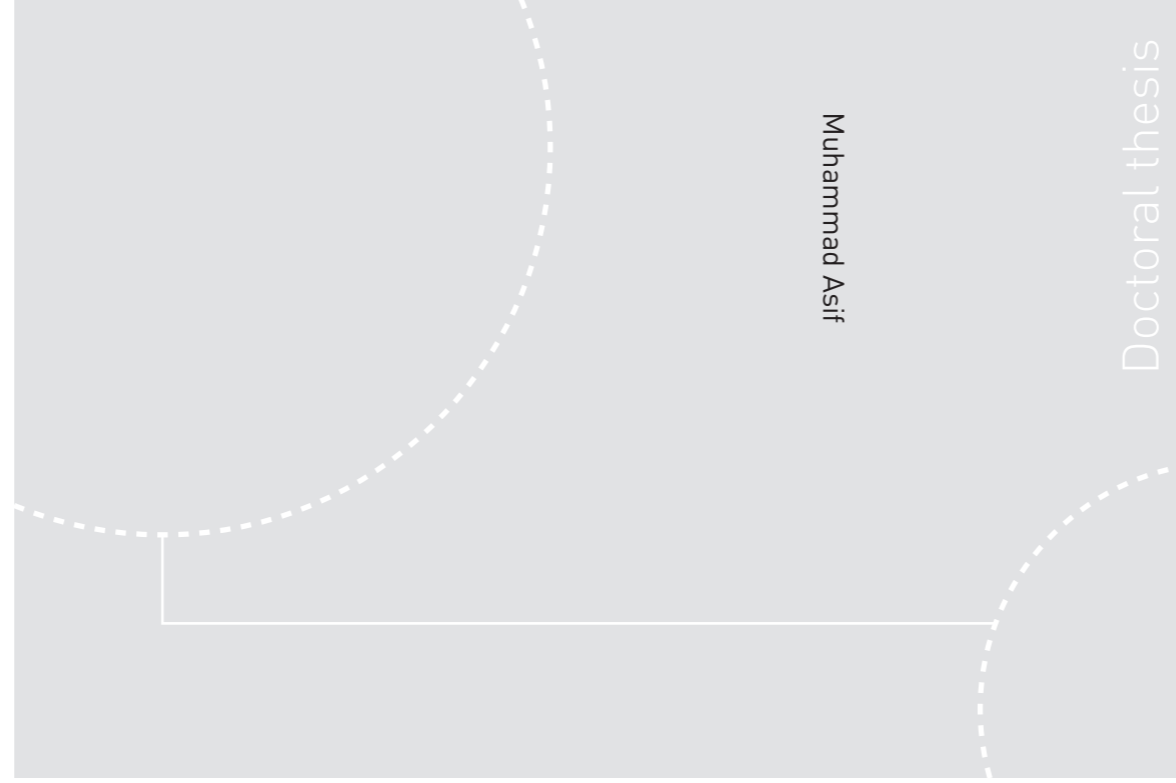


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Muhammad Asif

Personalization of Mobile Services

Muhammad Asif

Personalization of Mobile Services

Thesis for the degree of Philosophiae Doctor

Trondheim, July 2014

Norwegian University of Science and Technology
Faculty of Information Technology, Mathematics
and Electrical Engineering
Department of Computer and Information Science



NTNU – Trondheim
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*The only people who truly know your story, are the ones who help you
write it -- (unknown)*

Dedicated to my Parents, Siblings and Uncle

Abstract

The mobile era is well established and the number of smartphone users is showing exponential growth. The capability of smartphones and enabling technologies is also increasing and has opened many possibilities of personalized mobile services. The goal of personalization is to support the user by providing the right service at the right moment. Early focus of personalization was on content adaptations in different information systems. The new approaches of personalization are still needed for mobile services as it is a compelling feature of mobile communication systems for both end users and service providers.

Personalization is providing a means of fulfilling users' needs more effectively and efficiently and, consequently increasing users' satisfaction. By providing successful personalization, a high degree of user satisfaction and a pleasant user experience can be achieved. Some features of personalization can cause problems and may outweigh the benefits of personalization.

This thesis has focused on how to achieve scrutable mobile client-side personalization while keeping the user's privacy. The issue of privacy in personalization of mobile services can be reduced by shifting the control of their personal information towards the users. Our research goal is to understand and improve the personalization process and develop an architecture for scrutable mobile client-side personalization while keeping the user's privacy. Moreover, there is a need to develop an evaluation framework to measure the effectiveness of mobile services personalization. A design science research methodology is adopted in this research work. More particular contributions of the thesis are as follows:

C1: Identifications of the research issues and challenges in personalization of mobile services.

C2: An approach for delivering personalized mobile services.

C3: Development of mobile client-side personalization architecture.

C4: Development of mobile services Personalization Evaluation Model.

C5: Identification of the prospects of scrutable personalization of mobile services.

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) for partial fulfillment of the requirements for the degree of philosophiae doctor.

This doctoral work has been performed at the Department of Computer and Information Science, NTNU, Trondheim, Norway with Professor John Krogstie as the main supervisor.

The work presented in this thesis is conducted in the context of Wireless Trondheim Living Lab project. The research work is also funded by Higher Education Commission of Pakistan.

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Muhammad Asif

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1. Introduction

The mobile era is well established and the number of smartphone users is showing exponential growth. The capability of smartphones and enabling technologies is also increasing and has opened many possibilities of personalized mobile services. The goal of personalization is to support the user by providing the right service at the right moment. Providing the same contents or information to everyone at the same time may end up not serving anyone. In this respect, we have to understand real user needs before delivering a personalized service. In recent years, the focus of personalization has changed from simple system personalization to complex service oriented personalization. Both users and service providers of mobile services are facing different conceptual and technical challenges of achieving personalization. The research area is equally popular among both industrial and academic researchers.

This chapter gives an overview of the research conducted for this thesis. First, it describes problem outline and motivation for the thesis. Next, it will give a brief description of the research context and state research questions. This will be followed by a brief description of the research approach and the research contributions. Finally, the selected papers included in the thesis are listed, and a brief overview of the structure of the thesis is given.

1.1. Problem Outline

Providing the same contents or information to everyone at the same time may end up not serving anyone. Users of mobile technologies are getting exposed to information and services without being able to control the flow of services and user information. Early focus of personalization was on content adaptations in different information systems. The new approaches of personalization are still needed for mobile services as it is a compelling feature of mobile communication systems for both end users and service providers. In addition, mobile users can have different needs and focus other than traditional approaches of personalization. Mobile devices can enable context-awareness and data services which makes it an ideal tool for personalization. This can offer unique opportunities of providing personalized mobile services in different domains.

We have to understand real user needs before delivering the personalized service. User must have control over a service to personalize it; on the other hand service delivered should have the flexibility to fulfill the user's needs. Depending on the user's needs not every personalized service require real-time user context or complete user model. One challenge is to find out how to provide personalized services that leave the user in control. The challenge of privacy can be treated as a part of personalization preference

and hence should be the part of service delivery. Privacy can also be handled by shifting the control to the user's end which in turn will increase the level of trust. The aim is to achieve a market where user can share precise user model elements securely and can get lifelong personalized experience of mobile services.

Personalization is providing a means of fulfilling users' needs more effectively and efficiently and, consequently increasing users' satisfaction. By providing successful personalization, a high degree of user satisfaction and a pleasant user experience can be achieved. Some features of personalization can cause problems and may outweigh the benefits of personalization. Since personalization is becoming a key feature of mobile services, therefore there is a need to measure the effectiveness of personalization delivered to the users. Personalization is an iterative process and requires continuous monitoring and reassessment of the user's satisfaction.

1.2. Research Context

This PhD research has been conducted at the Department of Computer and Information Science at NTNU. The research work is related to Wireless Trondheim living Lab [1] in particular work related to personalization of mobile services. The main objective of the project was to offer a test bed for new products and services depending on the real user needs.

The focus of this research in terms of the objectives given above was to explore the possibilities of user centered mobile services. Personalization of mobile services is the main objective of this research. The results from this research have been published in internationally peer-reviewed conferences and journals.

1.3. Research Questions

The research in personalization of mobile services has various dimensions and focuses. The overall topic of the thesis focuses on the following:

Users with mobile devices can be viewed as user data providers, user data consumers, and user data brokers (which facilitate the user data sharing by providing mediation services e.g. semantic mediation and lookup) and the user can/should have central role in the marketplace of personalized mobile services.

Specifically, the following research questions are addressed:

RQ1. What are the research issues in personalization of mobile services?

This research question aims at finding the research issues and challenges related to the personalization of mobile services. This research question formed the basis of whole research done in this thesis. The identified challenges and research issues in different phases of personalization process helped to formulate the problem domain of the thesis.

RQ2. How to achieve privacy enhanced personalization of mobile services?

Privacy is a major concern in personalization of mobile services. This research question helped to explore the different approaches utilized so far to understand how the privacy was maintained in delivering personalized experience. This research question motivated to identify various challenges and solutions to deliver privacy-enhanced personalization.

RQ3. How to put a user in control of her/his data and overall personalization process?

This research question aims at finding how to put user in control of his/her personal data and personalization process. This research question helped to explore the possibility of delivering control to the users to achieve a desired level of privacy. This research question is tightly linked to RQ2.

RQ4. How to achieve lifelong scrutable user modeling for personalization process?

This research question aims at finding how to achieve lifelong personalization of mobile services. In addition, it was interesting to find out how the user control and scrutability of user model can help to achieve scrutable lifelong experience of personalization of mobile services.

RQ5. How to evaluate and measure the effectiveness of personalization of mobile services?

This research question targets to understand and measure the personalized experience delivered to the users. It was interesting to find out how to measure the success of personalization of mobile services particularly due to the inherited challenges of mobile devices. Moreover, this research question helped to understand various challenges related to the measure the effectiveness of personalization of mobile services.

The thesis has overall three themes. The first theme of the thesis is to find out the research issues and challenges related to personalization of mobile services. Moreover, we examined the problems and approaches used to address those issues. The second theme is to design and develop an approach that can leave the user in control of personalization process while keeping the user's privacy. The final theme is related to the measurement of the effectiveness or success of personalization in mobile services. Overall, the thesis focuses on explaining and improving different phases of delivering personalized mobile services.

1.4. Research Contributions

The main focus of this research is to improve the different phases of personalization process of mobile services. To accomplish this, different design approaches are analyzed, and the research challenges related to the personalization of mobile services are identified. The main challenge in personalization process is to evaluate the effectiveness of personalization of mobile services. There is a need to develop an evaluation model which can be used to measure the overall effectiveness of personalization. The next step is to develop privacy enhanced personalization architecture to provide of highly personalized mobile services. Further, an application will be built based on this architecture and evaluated by the personalization evaluation model.

C1: Identifications of the research issues and challenges in personalization of mobile services.

We have provided taxonomy of personalization of mobile services which reveals different dimensions and levels of personalization in the context of mobile services. It also highlighted the need of approaches needed depending on the current technological advancements and the needs of the mobile users. This contribution also consists of a definition of personalization of mobile services in P1. We have described various research issues and challenges in the domain of personalized mobile services (P2) needed to be addressed. P4 contributed to determine how the personalization was overlooked so far in mobile services adoption research and how it can be beneficial towards the acceptance of mobile services.

C2: An approach for delivering personalized mobile services.

We have analyzed various design approaches in P2 and discussed challenges / issues of personalized mobile services. It was revealed that privacy is a challenge for personalization of mobile services. Depending on the analysis of existing design approaches, we have developed an approach to deliver scrutable personalization which keeps the user in control of their personal data and privacy. P4 and P5 contributed in developing and evaluating the design approach.

C3: Development of mobile client-side personalization architecture.

We have developed a scrutable mobile client-side personalization approach that allows a single system to develop and maintain a life-long user model that can be applied to a variety of mobile services. The objective of the P4 was to introduce a mobile client-side personalization architecture that incorporates privacy and scrutability of a user model as an integrated part of the personalization process. The architecture is designed in a view to put the users in control of their personal information and able to scrutinize the user model shared with a variety of mobile services.

C4: Development of mobile services Personalization Evaluation Model

We have developed an approach and instrument to measure the effectiveness of personalization from various perspectives. Paper 6 mainly contributed to the development of mobile services of Personalization Evaluation Model (PEM). In this paper, we have proposed conceptual definitions of the research variables or constructs used. We also hypothesized the relationship among the research variables as shown above. We have developed an instrument to verify the hypotheses. Paper 7 aims at investigating the research model and to verify the validity of the PEM.

C5: Identification of the prospects of scrutable personalization of mobile services

Since scrutable personalization has not become an integral feature of personalized mobile services, a user with average experience might not have developed the prospects of how to control the user model and personalization effects. This contribution is related to know if users are interested in or willing to actively set up and maintain their user model on mobile devices. To understand this, we focused to externalize the user model of mobile services. In P5, we have described and verified the concept of scrutability along with a user study.

Research Questions	Contributions	Papers	Focus
RQ1	C1	P1, P2, P3	Concept
RQ2	C2	P2, P4	Design
RQ3	C3	P4, P5	Design
RQ4	C4	P4, P5	Design
RQ5	C5	P6, P7	Evaluation

Table 1.1: Overview of Research Contributions

1.5. Research Design

The research undertaken for this thesis has been based on analyzing a problem domain, designing and implementing a solution to it, and evaluating a problem solution by an experiment. As shown in Figure 1.1 the research has three main phases. A brief description of the phases is as follows:

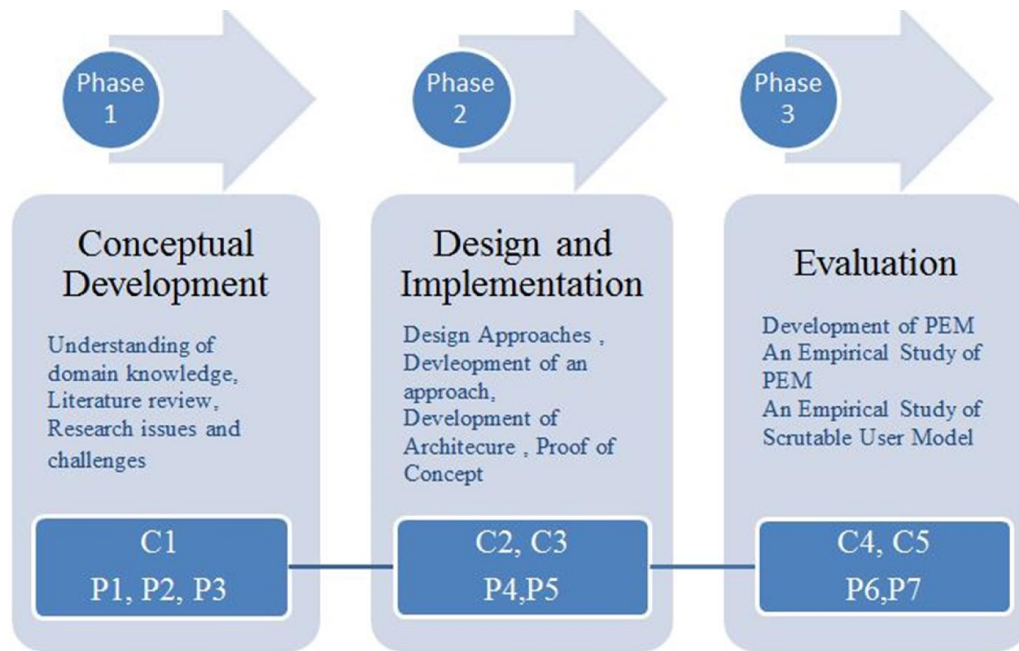


Figure 1.1 An Overview of Overall Research Approach

- 1. Conceptual Development:** The first phase of the research was devoted to the conceptual understanding of the domain knowledge. It included various tasks such as literature review, problem outline, identification of research issues and challenges related to the personalization of mobile services. This phase focused on RQ1 and partially RQ2. This phase resulted in paper P1 and P2. This phase produced a contribution C1 and provided basis for further research and development.
- 2. Design and Implementation:** This second phase based on the findings of the first phase. Its aim was to find out a suitable design approach for providing scrutable personalization of mobile services while keeping the user in control of privacy and personal data. This phase resulted in two contribution (C2, C3) and three papers P3, P4 and P5. This phase contributed to address three research questions RQ2, RQ3 and RQ4.
- 3. Evaluation:** The last phase of the research was concerned with using the results of previous phases to develop an evaluation model to measure the effectiveness of personalization of mobile services. In this phase, few empirical studies were performed to evaluate the findings of the previous phases. This phase resulted in two contributions C4 and C5. Paper 6 and 7 addressed RQ5. In paper 6, we have developed an evaluation model while in paper 6; an empirical study was performed to validate the model with a working prototype.

1.6. Papers

This section gives an overview of the papers published based on the research done for the thesis. We have included seven papers in this thesis published in peer reviewed international conferences and journals. The papers are included in Part II of the thesis. The research work has also resulted in three other publications that are considered secondary papers and are listed in Appendix A.

P1 Asif, Muhammad and Krogstie, John: “Taxonomy of Personalization in Mobile Services”. Proceedings of the IADIS International Conference e-Society 2012. IADIS Press 2012 ISBN 978-972-8939-67-0

Relevance to this thesis: This paper presents our initial findings towards the personalization of mobile services and details how and what kinds of personalization approaches exist. In a way, it gives a state of the art research and contributed towards the initial understanding of the problem domain. It describes taxonomies of personalization in mobile services and how the personalization is delivered so far in mobile services. This paper answers RQ1 and contributes towards the contribution C1 and partially to C2. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

P2 Asif, Muhammad; Krogstie, John: “Research Issues in Personalization of Mobile Services”. International Journal of Information Engineering and Electronic Business 2012; Volume 4.(4) s. 1-8

Relevance to this thesis: This paper presents the research issues and challenges found in personalization of mobile services. This article contributed to establish the foundation of this thesis. It helped to understand the current research issues and their potential solutions. This paper gives insights to the research of personalization of mobile services and assisted to define the problem domain in terms of research questions and possible research gaps. This paper answers RQ1, RQ2 and contributes towards the contribution C1 and partially to C2. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

P3 Asif, Muhammad; Krogstie, John: “Role of Personalization in Mobile Services Adoption”. Proceedings of the International Conference on Multimedia and Human Computer Interaction. International ASET Inc. 2013 ISBN 978-0-9867183-8-0. s. 1-10.

Relevance to this thesis: The adoption and acceptance of mobile services is a well-known research area that aims for finding different adoption factors. This paper contributed to find that how personalization is treated in adoption and acceptance studies so far. This paper assisted in understanding the personalization in mobile services adoption and contributed towards RQ1. It

contributes towards the contribution C1. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

- P4** **Asif, Muhammad** and Krogstie, John: “**Mobile Client-side Personalization**”. International Conference on Privacy and Security in Mobile Systems, Global Wireless Summit, 2013, ISBN: 978-87-92982-51-3

Relevance to this thesis: This article presented a design approach to deliver privacy-aware personalization. It also presented architecture to protect user’s privacy by shifting the control to the user. This paper addresses RQ2 and RQ3. The approach presented in this paper also provides opportunity to the users to scrutinize the user model and get personalized experience while keeping the control of their own data. This paper also addresses RQ4 partially and provides C2 and C3 contributions. The study contributes towards the Phase 2 Design and Development of the thesis.

- P5** **Asif, Muhammad** and Krogstie, John: “**Externalization of User Model in Mobile Services**”. International Journal of Interactive Mobile Technologies. Volume, 8. Issue 1, 2014.

Relevance to this thesis: The scrutability of a user model requires externalizing the user model. This empirical study was conducted to see if users are willing to scrutinize and control their user model. This paper addresses the RQ4 and partially RQ3. It also contributed towards the contribution C3. The study was the part of the Phase 2 Design and Development of the thesis.

- P6** **Asif, Muhammad** and Krogstie, John: “**Mobile Services Personalization Evaluation Model**”. International Journal of u- and e- Service, Science and Technology 2013; Volume 6.(2) s. 1-12

Relevance to this thesis: It is important to measure the effectiveness of personalization of mobile services to see how users’ perceive the personalized experience. This article presented an evaluation framework to measure the success of personalization. It also provides an instrument and guidelines to evaluate the success of personalized mobile services. This paper addresses the RQ5 and produce contribution C5.

- P7** **Asif, Muhammad**, Salimi, Neberd and Krogstie, John: “**An Empirical Study of a Mobile Services Personalization Evaluation Model**” Submitted to a Journal

Relevance to this thesis: This paper provides empirical study of mobile services personalization evaluation model by utilizing a personalized mobile news service. This study aims to validate the model presented in P6. This study tightly

linked to P6 and addresses RQ5. It contributes mainly to C5. This study contributes to the Phase 3 Evaluation of the thesis.

1.7. Thesis Outline

This thesis consists of two parts: Part I consist of thesis introduction and overview of the research work done already in the research field, and Part II contains a selection of research papers that together describe the overall research. The remainder of this thesis is organized as follows:

Chapter 2: State of the Art

This chapter gives an overview of the background and provides state of the art research and concludes research challenges.

Chapter 3: Context and Research Design

This chapter describes the research methodology and overall research process.

Chapter 4: Results

This chapter describes the research results achieved.

Chapter 5: Evaluation and Discussion of Results

This chapter evaluates whole research work and discusses results in terms of research questions and contributions.

Chapter 6: Conclusions and Future Work

This chapter makes some concluding remarks and describes future work in brief.

Part II: Selected Papers:

This part contains research papers (P1-P7) as they have published in journals and conferences.

Appendix A: Secondary Papers

This appendix lists the secondary papers that contributed towards as a part of research work but which is not included as a part of the thesis.

2. State of the Art

We have migrated from the PC-Internet era to the era of interconnected devices and connected ecosystem of mobile devices. Due to this, user experience is also shifting from desktop to mobiles. Besides this, users are also facing a number of challenges due to the inherited limitations of mobile devices such as small screen, limited battery, and limited bandwidth of mobile devices. Users of mobile technologies are getting exposed to information and services without being able to control the services. The information presented to the users may be of lower quality and less relevant. It seems natural to apply personalization to select items of interest and relevance. In almost all kinds of mobile services, personalization is expected as an obvious part of user experience and finding more useful purposes. Personalization has become an active research area wherever the user experience is involved. This chapter provides state of the art research in personalization of mobile services and related research areas.

2.1. Overview of Mobile Services

Mobile services are different from traditional services due to the capability and constraints of mobile devices. The term mobile service denotes all services that can be used independently of temporal and spatial restraints, and that are accessed through mobile devices [2]. There is a variety of mobile services ranging from basic communication service (voice and short messaging service) to more sophisticated mobile services such as context-aware mobile shopping, news services and location based services. Mobile services can further be classified into five categories: communication services, entertainment services, information services, transactional services and Web 2.0 services [3]. Different mobile services are providing various types of values to users such as enjoyment and entertainment in mobile games and music. However, mobile value can be created in five different settings: time- critical arrangements, spontaneous decisions and needs, entertainment needs, efficiency ambitions, and context-aware mobile services [4]. Following is a brief overview of the categories of mobile services:

Mobile Communication Services: are the most used mobile applications. These services include SMS, MMS, mobile video call and mobile email.

Mobile Entertainment Services: offer consumers services such as, ringtones, games, gambling, music, mobile TV, and so on. The combination of entertainment and mobility appears intuitively appealing for many consumers due to the possibility of killing time and having fun at the same time when wired entertainment applications are unreachable [3].

Mobile Information Services: offer consumers with prompt instant information services, such as Weather/News information, search services, Internet surfing, and street maps. Additionally, the positioning system can locate the user exactly (location-based service). *Mobile Transactional Services:* offer consumers business and banking services; these services include mobile shopping, mobile banking, online ticketing and mobile stock information [5]. These services require complex technology due to privacy concerns. *Mobile Web 2.0 Services:* offer the next generation of mobile Internet services that use the social web [6]. Social networking sites such as, Facebook and Twitter are examples of social web that provides collaboration or sharing information between mobile service users.

Earlier research has raised four aspects of mobile services [2] as shown in following Figure 2.1:

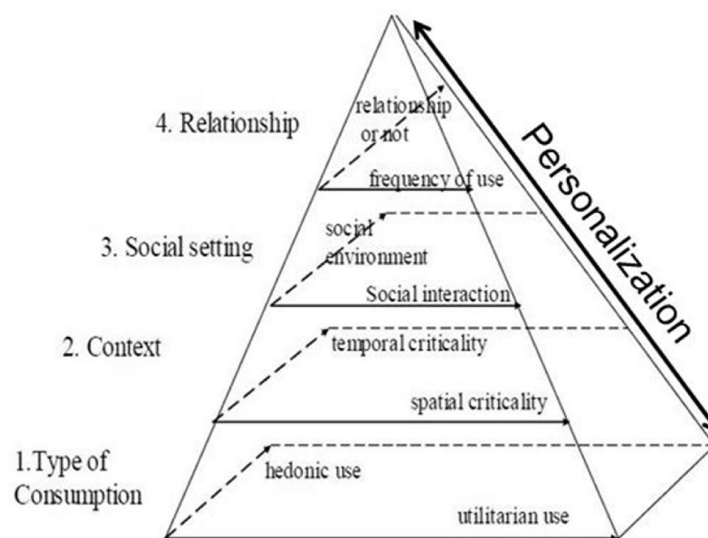


Figure 2.1: Classification of Mobile Services [2]

- a) Type of consumption: This is considered as the core aspect of mobile services. The use of mobile services can be hedonic (entertainment or amusement) or utilitarian (efficiency needs or usefulness). Mobile information services such as news, weather, and location services are of utilitarian use while mobile chats, games and music services are examples of hedonic use [2, 7].
- b) Context: The temporal and spatial context of service use is also considered as value to users. It also differentiates the mobile services from traditional services. Time critical services depends upon how urgent user needs information such as traffic or weather reports while spatial criticality is about location or situation such as point of sale advertisement, nearest restaurant or gas station etc.
- c) Social settings: The social setting is another major aspect of mobile services. It can enhance or inhibit the use of mobile services in a certain situation. This type of

mobile services addresses the needs of individuals or groups in a social environment. This may include presence services, friend finders or multiplayer games etc [2].

- d) Relationship: The relationship between the user and the service provider is can be used to describe the characteristics of the mobile services. Personalization is a key in this area and can help to develop the trust. Mobile services are considered more personal and service providers can take this opportunity in provisioning of personalized mobile services. Personalization is a key in building a valuable relationship.

The benefits of mobile services are often summarized in four factors: ubiquity, convenience, localization and personalization that differentiate mobile services from other online services [8]. However, there is a need to address the above mentioned four aspects of mobile services (Figure 2.1) at personalized level. The following section describes more about personalization and related research areas.

2.2. Overview of Personalization

The increasing variety of mobile services raises the need for users to find out how particular services are beneficial to them. Personalization can play a significant role to select and adjust their favorite services from the rapidly increasing diversity of mobile services. Personalization has been involved in many research areas having varied focus and implications which makes it a multidimensional concept [9]. So far the focus of personalization has been on the systems or applications intended for Web or stationary computers [10]. The focus of personalization is changing and introducing new opportunities for mobile services personalization.

In general, personalization is about choice, flexibility and control and it is about people knowing what their needs are and the people that have control over how those needs are being met. According to [11] delivering relevant information has two main facets. First, personalization allows users to obtain information that is adapted to their needs, goals, knowledge, interests or other characteristics. User models deliver the main parameters for selecting and adapting information presentation to the individual user. Secondly, contextualization complements personalization so that environmental states or the context of the use can also be taken into account.

2.2.1. Definitions of Personalization

There are various definitions of personalization in the literature with varied focus. According to [12] “Personalization of a service means that mechanisms exist to allow a user U to adapt, or produce, a service A to fit user U’s particular needs, and that after such personalization, all subsequent service rendering by service A towards user U is changed accordingly”. Personalization is defined by [13] as “a process of changing a

system behavior to increase its personal relevance”. Blom [14] has defined personalization as “a process that changes the functionality, interface, information content, or distinctiveness of a system to increase its personal relevance to an individual”. Krogstie et al [15] defined “Personalization means information systems that both automatically adapt themselves to the preferences of the user and that can be explicitly tailored by users through a specific user interface”. In a study [9] we defined personalization as “*Personalization is a controlled process of adaptation of a service/system to achieve a particular goal by utilizing the user model and the context of use*”. There are two main streams of research in personalization, one is about technical aspects of personalization and other is about user’s behavior [16]. Modern personalization seems to have different kinds of meanings, from location diagnosis, fitting the visual layout of the message to data terminal equipment, tailoring the content of the message, and tailoring the product.

There are different technical approaches to achieve personalization such as machine-learning algorithms, agent technology and ubiquitous and context-aware computing [17]. Each approach has a different focus on personalization. Context-aware approaches seem to be most suitable for personalization of mobile services. Context-awareness is one of the key enabling factors for providing personalized services [18]. Presentation of personal information can play a vital role and hence user modeling is an important feature for personalization [19]. The user model can be used as a building block of personalized service provisioning. Personalization is a practice that is shaped by the designer’s motives for personalization and viewpoint on “what personalization really is” [20]. Two types of personalization called ‘preference personalization’ and ‘location personalization’ was studied by [16]. Different mobile services may require different level of personalization. We have defined three different levels of personalization required in different mobile services [9]. There are various design approaches with different emphasis of personalization.

Simple personalization - Basic level: At this level, personalization remains static after the preferences are selected and set. This includes manual settings of look and feel, display properties and sound preferences. The main focus of this kind of personalization is presentation which requires no knowledge of the user except a few representational preferences. The user chooses and the application will behave according to the user’s choices. For example if the user wants to save battery life, s/he can customize the power profile to fulfill his requirements. This becomes more interesting with new modalities of interfaces such as speech recognition, synthesis etc. [15].

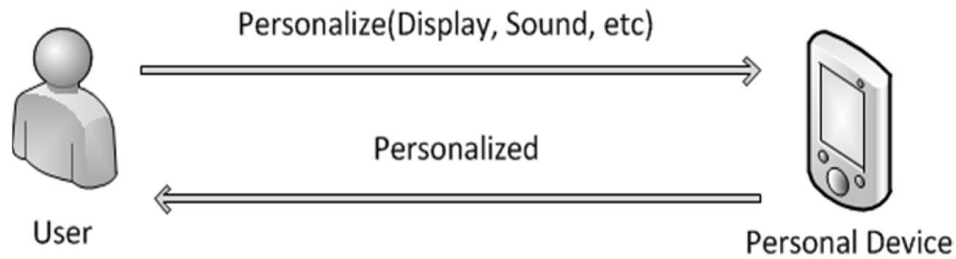


Figure 2.2: Basic Level

Profile-based personalization - Second level: By knowing something about the user, it will be much easier to improve the quality of services delivered to a user. Information about a user can be used to target services directly to a specific user. To provide personalized mobile services, different types of information are useful. Here our focus is on user's personal profile. The profile contains all the information related to a person as an actor, his goals etc., and follows the user everywhere independently of the context. The information that is to be captured in the personal profile can be divided in three main parts: personal information, stable interests and temporary interest [21]. This level provides adaption capability by utilizing user profile either created explicitly or implicitly. User profile describes user related information such as preferences, history, interest and roles or tasks. A user's profile may include user ID, background information, interest and preferences. A list of different types of profiles with varied emphasis is described by [22] which include personal profile, preference profile, relationship profile and others. Personalized news services [23, 24] such as personalize Google news, Yahoo, Lycos and Excite require simple user profiles which represents user's long or short term interests to receive personalized news. Direct marketing through SMS messages based on collected information about user behavior through profile subscription has been seen as a powerful personalization feature [12]. Personalized mobile service for food shopping [21], personalized product details and in-store customer advice [25] and personalized services in mobile learning [26] are similar kind of services.

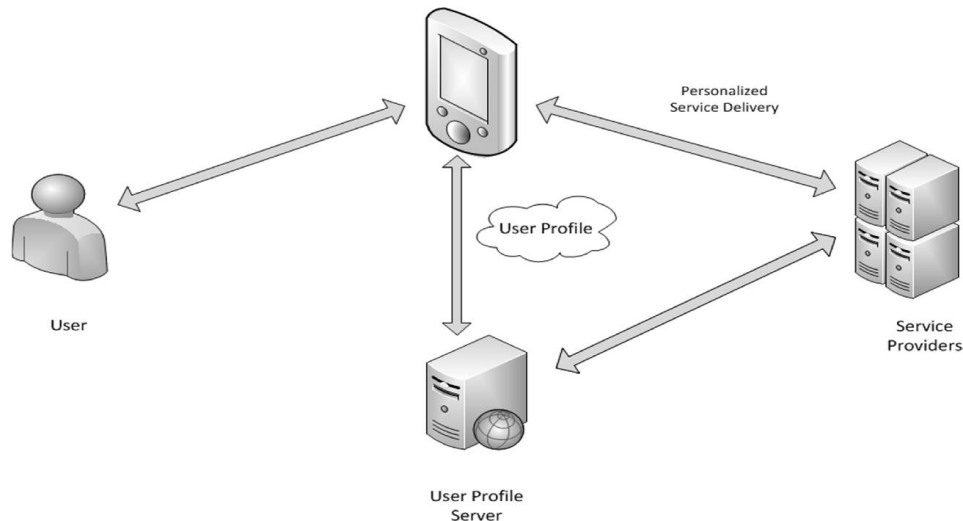


Figure 2.3: Second Level of Personalization

Contextual personalization -Third level: Personalized services at this level demands both user modeling and context-aware techniques. It is very important to take advantage of the relationship between user profile and user context. At this level, services can be adopted at different levels with the agreement of the user or in compliance with user's context and user model available. The focus of this level is to integrate user's profile and contextual information for personalized services. The services designed at this level are able to adapt to the user situation. Personalization at this level is extended by context-awareness which can enhance user experience [18]. It requires modeling both the user and the context. By combing the context information and user profile one can enhance the user-experience with the service. As stated by [11] the combination of user model and context model can provide valid models for personalized and contextualized services. Recently, personalized mobile advertising services are utilizing the user's profile and context to enhance the experiences of user. One may expect mobile advertising to be even more appealing to consumers who use *location-sensitive* and *time-critical* m-commerce applications [27, 28]. The utilization of time- and location-awareness as personalization variables can be highly beneficial. Personalized geonotes [29] are particularly appealing as a means of providing rich personalized information about cultural heritage sites. These kinds of applications offers a way to reduce, perhaps avoid, the anticipated information overload by utilizing user model and the context of use. The three main application areas of contextual personalization are 'Where am I' services, 'point of need information delivery', and 'industrial or corporate' services [16]. All these three areas somehow utilize user's profiles and few context elements such as location or time to deliver mobile services. The study [30] has introduced mobile value framework which shows how context value can enhance the user experience with personalized mobile services.

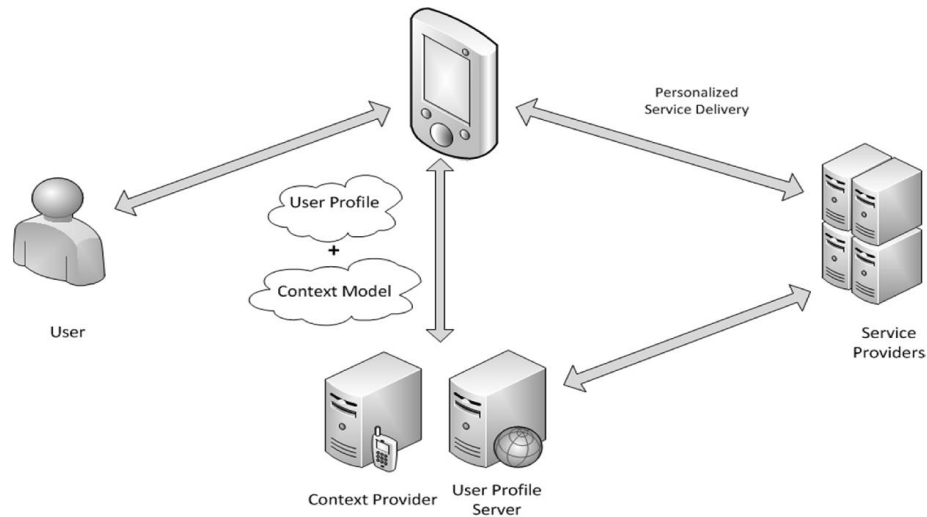


Figure 2.4: Third Level of Personalization

2.2.2. Perspectives of Personalization

Personalization has many facets and viewpoints depending on the focus of its application. For example, a study [31] has viewed three types of personalization *user-driven*, *transaction driven*, and *context-driven* personalization. In *user-driven personalization* a user specifies in advance the desired layout and contents that matches her/his interests and preferences. User-driven personalization provides the user with tools and options to specify information requirements and presentation format. *Transaction-driven personalization* represents the “normal” personalization whereby the online merchant generates personalized layout and content. Context-driven personalization is an adaptive mechanism to be employed to personalize content and layout for each individual user depending on the user’s context.

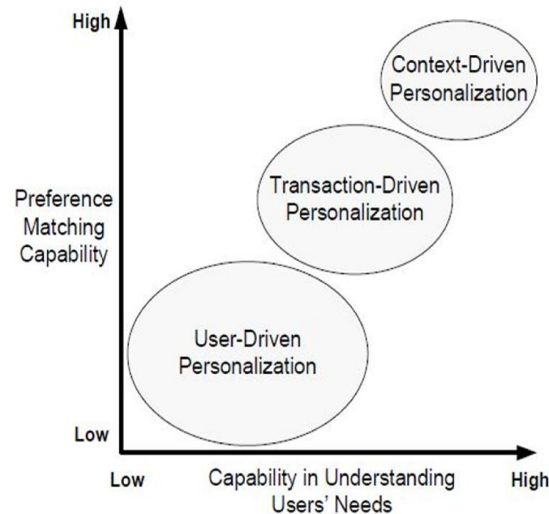


Figure 2.5: Types of personalization technologies [31]

Fan and Poole [20] provide a framework of personalization that builds on the earlier definitions. According to them [20], personalization can be seen as three-dimensional implementation choice: what to personalize, to whom to personalize, and who does the personalization.

1. The first dimension concerns the aspect of the information system (IS) that is manipulated to provide personalization (what is personalized). There are four aspects in IS that can be personalized: the information itself (content), how the information is presented (user interface), the media through which information is delivered (channel/information access), and what users can do with the system (functionality).
2. The second dimension is the target of personalization, which can either be a group of individuals or a specific individual. For groups, the personalization is directed to people who fit into certain categories such as women, single child families, or members of a club.
3. The third dimension applies to the degree to which personalization is automated. Personalization where the user can control the system is called explicit personalization, while personalization that is done automatically by the system is called implicit personalization.

Fan and Poole also defines four ideal types of personalization (See Table 2.1.1) architectural, relational, instrumental, and commercial. Each type represents a different philosophy concerning the motivation behind for personalization and what personalization tries to accomplish (its goal). These four ideal types are also distinct in two other dimensions. First, they can be differentiated in terms of utilitarian or affective orientation. The instrumental and commercial types are utilitarian, as they emphasize

task accomplishment, while the architectural and relational perspectives are affective due to their emphasis on user's feelings. Second, they can also be differentiated in terms of premise of use. While architectural and instrumental personalization are individual, and are concerned with the individual interaction with the system, commercial and relational personalization are considered interactional since they focus on the relations among multiple entities.

Ideal Types of Personalization

Architectural	<p><i>Motive:</i> To fulfill a human being's needs for expressing himself/herself through the design of the built environment.</p> <p><i>Goals:</i> To create a functional and delightful Web environment that is compatible with a sense of personal style.</p> <p><i>Strategy:</i> Individualization</p> <p><i>Means:</i> Building a delightful Web environment and immersive Web experience</p> <p><i>User model:</i> Cognitive, affective, and social cultural aspects of the user</p>
Instrumental	<p><i>Motive:</i> To fulfill a human being's needs for efficiency and productivity.</p> <p><i>Goals:</i> To increase efficiency and productivity of using the system.</p> <p><i>Strategy:</i> Utilization</p> <p><i>Means:</i> Designing, enabling, and utilizing useful, usable, user-friendly tools</p> <p><i>User model:</i> Situated needs of the user</p>
Relational	<p><i>Motive:</i> To fulfill a human being's needs for socialization and a sense of belonging.</p> <p><i>Goals:</i> To create a common, convenient platform for social interaction that is compatible with the individual's desired level of privacy.</p> <p><i>Strategy:</i> Mediation</p> <p><i>Means:</i> Building social interactions and interpersonal relationships</p> <p><i>User model:</i> Social context and relational aspects of the user</p>
Commercial	<p><i>Motive:</i> To fulfill a human's beings needs for material and psychic welfare.</p> <p><i>Goals:</i> To increase sales and to enhance customer loyalty.</p> <p><i>Strategy:</i> Segmentation</p> <p><i>Means:</i> Differentiating product, service, and information</p> <p><i>User models:</i> User preference or demographic profiling; user online behavior and user purchasing history</p>

Table 2.1: Ideal Types of Personalization

Another personalization framework [10] is suggested based on the existing literature of personalization. The focus of personalization in this framework is on one-to-one personalization and micro personalization as shown in Table 2.2: Personalization Framework. [10]. They further argued the one-to-one personalization may require more computation while micro personalization based on group behavior is easy and cheaper to implement.

<i>Personalization</i>			
	<i>Intangibles (Web, Context, Services)</i>		<i>Tangibles (Products)</i>
	<i>Individual</i>	<i>Group</i>	<i>Individual/Group</i>
<i>Customer initiated</i>	Web customization	?	Mass Customization, Customization
<i>System or Company initiated</i>	One-to-one personalization	Micro personalization	

Table 2.2: Personalization Framework. [10]

2.2.3. Personalization Process

The purpose of personalization is to enhance the experience of user by tailoring the system or service to the levels of individual. The only thing is to understand the goals of personalization in detail in a particular context. It is not enough to describe one general goal of personalization. We have to understand the full purpose of personalization in terms of goals, sub-goals, tasks and the whole process to achieve these goals. So, there must be a high-level personalization process to achieve the defined goals. In a way, goal oriented personalization process is required which can be applied in general as well as to a particular domain. User participation and system participation at different stages of personalization process is a key. A user can override the system at any stage and system should give preference to the user interaction with the whole personalization process. For example, the system may recognize that some aspects of the user's interaction with the software could be optimized but the change does not take place until the user has authorized it.

According to [32], personalization is an iterative process that can be defined by the stages shown in Figure 2.6.

- a) Understand users/consumers by collecting comprehensive information about them and building user model or profiles that can be utilized as an actionable knowledge.
- b) The second high-level step is to deliver the relevant offerings depending on the knowledge stored in the form of users' profile. The personalization engine must be able to find the most relevant offerings and deliver them to the users.

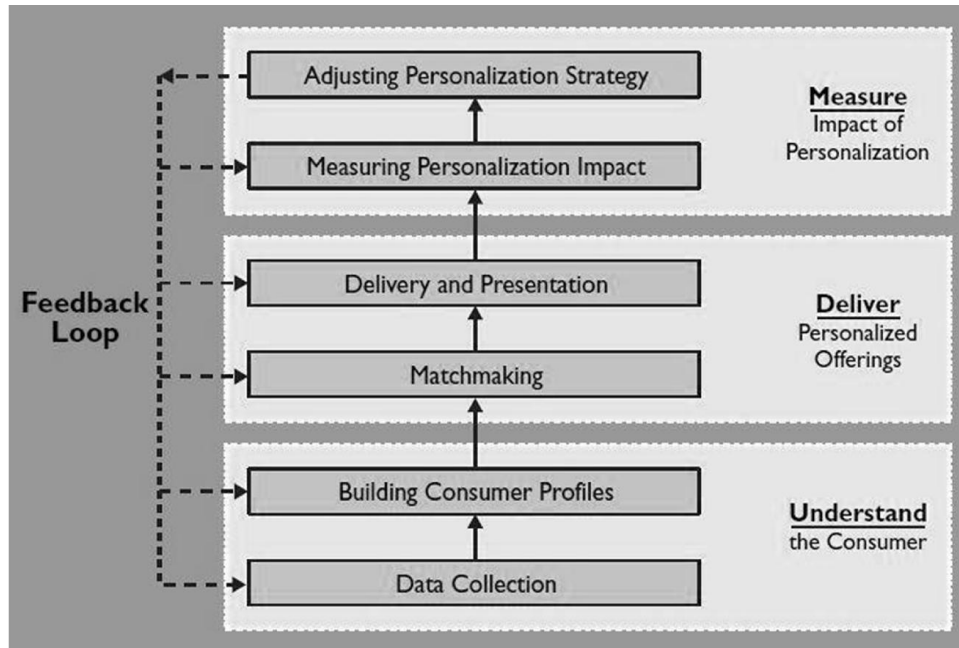


Figure 2.6: Personalization process [32]

- c) This stage consists of two steps. First is to measure the personalization impact by determining how much the user is satisfied or dissatisfied of personalized delivery. This measure can provide information that can enhance our understanding about users and deficiencies of the personalized delivery. This understanding and user's feedback (explicit/implicit) can serve as a source for possible improvements to each of other components in the process. The personalization will be better after the first iteration of the understand-deliver-measure cycle.

The feedback integration loop is a challenging recursive task. It determines how to adjust different stages of the personalization process based on feedback from the performance measures. However, feedback integration in the personalization process has not been studied extensively in the personalization literature; more research is needed to understand how to transform the measure to the different stages of personalization process [32].

There are seven stages to achieve an effective personalization effort [33] as shown in Figure 7. According to [33], there are three initial steps involved in planning the personalization: personalization goal, evaluating personalization approaches, and for planning data collection and management. According to the authors personalization initiatives should started with an understanding of the context of personalization. Personalization initiatives should be tied to discrete business goals. After deciding the tentative goals, the second step is to evaluate which personalization approach or a combination is better to achieve the goals. The next step is to decide how to collect users' data and how to store it so that it can be utilized to deliver personalized

experience. The building phase requires to build a personalization infrastructure [33] which describe the complete approach of achieving personalization. The next phases are about delivering personalized experience and measuring the effects and optimizing the approach as shown in Figure 2.7.



Figure 2.7: Personalization initiatives and workflow [33]

2.2.4. Personalization Techniques and Approaches

There is a variety of approaches depending on how the user model is built and exploited to provide mobile services personalization. This section describes an overview of the approaches. The approaches are discussed in detail in [33-35]. The increasing capability of mobile devices is making it possible to create system architecture that can share personal context to other mobile devices. It is also evident that mobile devices are equipped with various sensors such as GPS, accelerometer, Bluetooth, microphone, camera, calendar, contact list that can capture personal context [36]. Use of mobile device in context sharing with other mobile devices or service providers is gaining importance in the research community of context-aware computing. The most common architecture for personal context sharing using mobile devices is the centralized server architecture [36].

The most important issue in personalization is to create an accurate and comprehensive user model. The process of personalization starts from collecting information about a user, creating user model and adapting the services according to the available context and user model. The process of collecting user information can be implicit or explicit. In implicit method, systems can observe and record user behavior; afterwards system can analyzes it to create a user model. This method involved different machine learning techniques to build a personal model. This method requires trust of users on service providers by giving enhanced privacy protection. In explicit method, user is given questionnaires to give personal opinions. However, personalization is not a static process rather it is dynamic and iterative process [32].

Research on personalization has focused primarily on automated discovery of user profile and preference data [37]. In this way, users can easily lose control on how and to what extent the information is shared with service providers. A clear separation of concerns between the client and the server can help to understand the better opportunities in personalization. mPersona [38] is a system which provides personalized services using a portal technique. In such approaches, users may lose control over how much of their data is shared and with whom. In another study [39], the authors proposed ad delivery framework where personalization is done by both server and mobile device. In this framework, authors suggested that it is vital to use context information extracted from user's interactions and mobile device's sensors to deliver more targeted and personalized ads. Figure 2.8 and Figure 2.9 give an overview of the concerns and activities in both client and server-side personalization.

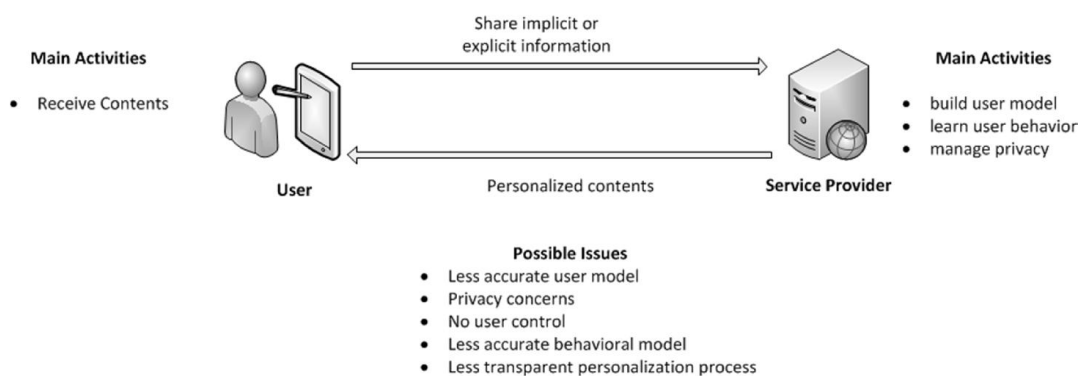


Figure 2.8: Server-side personalization

In client-side personalization approach, mobile devices are considered as a user modeling platform. User control is valuable in a client-side personalization approach. Scrutability provides the basis for user control over personalization [40]. In a study of privacy enhanced profiling [41], the authors described how to put the user in control of their personal information. They described the user control as: a) Make user profile data sharable and available to other applications, b) access to the profile information should be governed by the user's controlled privacy policy, and c) the data model of the profile should be extendable and open. Personalized ad services is another area where privacy is a major concern and a study [39] has described an approach to deliver privacy-aware personalized ads on mobile devices. A study [42] has presented various technical solutions employed so far to address the privacy concerns in various systems.

User data can be stored and managed locally. Since the data is collected and processed at the user's device rather than the server side, user may perceive more control over their data and perceive less privacy risks [43]. The required data for personalization can be selectively provided to different service providers through a scrutable process.

PersonisJ [44] has significant contribution in client-side user modeling. This way of storing and managing the user data at the source also avoids consistency problems of the user model [45]. An interesting case study [46] advocates client-side personalization which delivers personalized insurance rates. In some other studies [47, 48], authors argued that client-side personalization can reduce privacy problems and user may be inclined to disclose more information if personalization is done locally.

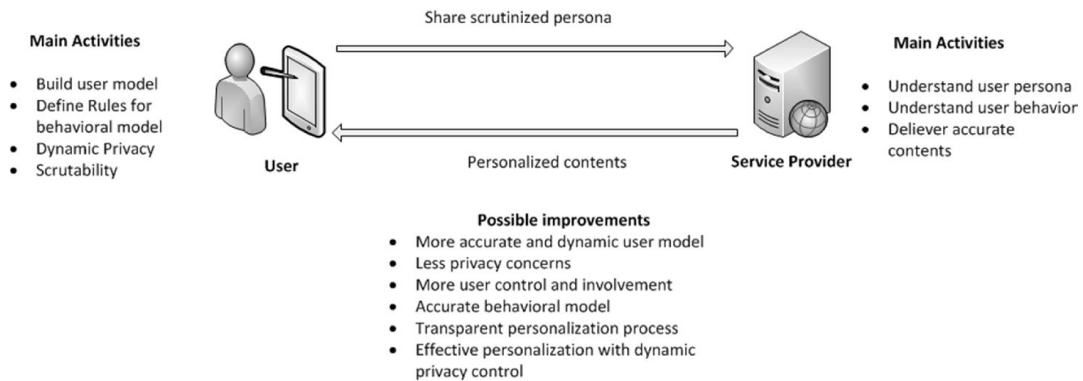


Figure 2.9: Client-side Personalization [49]

The user is willing to share personal information in order to get a better user experience, but s/he wants to remain in control of what information is used, by whom and for what purpose [37]. It is obvious that a user may not want to share all his/her personal information to a service provider at a certain time. On the other side, authors [50] are also suggesting that users should be able to tailor their contents and can have the sense of control. However, the authors are considering personalization as a system driven and customization as a user driven approach. According to [43, 47] this approach has some challenges: First, existing personalization algorithm needs to redesign to fit the client-side model; second, there is a need to protect confidential business rules or methods. Therefore, trusted computing platform have to develop to achieve the purpose. This research work fits in this context as well.

In our approach, we are proposing an architecture [49] that can accommodate both adaptive and adaptable approach to achieve effective client-side personalization. We are giving users control over their personal data by providing scrutability and dynamic privacy control which is an adaptable part of the architecture. However, users will receive personalized contents and recommendations depending on the user model they shared and that reflect the adaptive behavior of the system.

The following Table 2.3 gives a comparison of two approaches.

Issues	Server-side Personalization	Client-side Personalization
<i>Scalability of Storage and Processing power</i>	Can deal with storage and computational power issues in a scalable way. Supports service based approach.	Less likely to cope with storage and processing issues. This approach can partially support service based approach due to advancements in processing power and storage capacity.
<i>Battery Consumption</i>	Has no such issue	This approach has an issue of battery consumption.
<i>Network</i>	Requires continuous connectivity and secure communication to connect to distributed elements.	No need to deliver processing roles to remote servers.
<i>Context Management</i>	It can be easily done on dedicated context servers.	It is hard to manage a variety of context information on mobile devices.
<i>Lifelong User Model and Scrutability</i>	This approach may not be feasible for lifelong scrutable user model	This approach seems appropriate for lifelong scrutable user model. This will put the user in control of the personalization process.
<i>Dynamic Privacy Control and Security</i>	To deliver personal information on remote servers (or third party servers) can raise privacy and security issues. It is hard to achieve dynamic privacy control.	Users can take control of personal information on mobile devices anytime on the go.
<i>Ubiquitous User Modeling</i>	Different parties may not agree to share user models (due to commercial competition), can cause replications of the user model.	Users can take control over their profiles. They can control how to share their profile with service providers. Users can share a part of their user model to a service provider.
<i>Group Personalization</i>	This approach can support group personalization in a scalable way. User or group characteristics can be explicitly or implicitly captured.	It is difficult for this approach to handle group personalization.
<i>Personalized Recommendations</i>	Server-side approach can deliver recommendations based on the transactional history, and other collaborative techniques. Machine learning techniques and data mining techniques are usually applied to build user models.	Since the user model will primarily reside on user's device, the user may not be willing to share profiles for recommender systems to deliver personalized recommendations.

Table 2.3: Client-side vs Server-side Personalization

2.3. Personalization through User Modeling

Historically, user models have been used for providing adaptive and personalized services/systems. User modeling is a process of creating, maintaining and consuming the user model. The internal representations of the users are required for a system to say the *right thing* at the *right time* in the *right way* [51]. User modeling is a part of human computer interaction and has a central role in the research of adaptive and adaptable systems, intelligent and expert systems, business systems, social networks and recommender systems. User modeling is involved wherever the better user experience is required for example in Intelligent Tutoring System [52].

The following Figure 2.10 gives an overview how and where user modeling fits into personalization process.

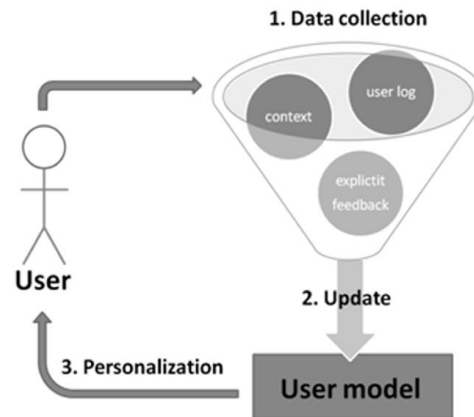


Figure 2.10: User modeling and Personalization

2.3.1. Types of User Models

A user model represents a collection of information about a user which is utilized by a system to change the behavior accordingly. User model can be quite general or can be very specific to a particular application. According to [53] a user model is the knowledge and inference mechanism which differentiate the interaction across individuals. It can include personal information such as users' names and ages, their interests, their context, their skills and knowledge, their goals and plans, their preferences and their dislikes or data about their behavior and their interactions with the system. A user model can also be encoded with great deal of situational, task or environmental information [53]. Rich [54] has presented some dimensions of user model. However, the user model can have different dimensions or design patterns as shown in Figure 2.11

1. *Simple to Complex*: A simple user model may consist of demographical information of a user such as name, age, gender, interests or preferences. And, a user model can be more complex such as purchase history, search behavior and ratings etc.
2. *Short to Long Term*: User models can have different life span depending on the nature of users' needs or application. Some user models can have short life span for example only for a session or short term need of search. Sometimes, the user model can be lifelong or depending on the life of the application.

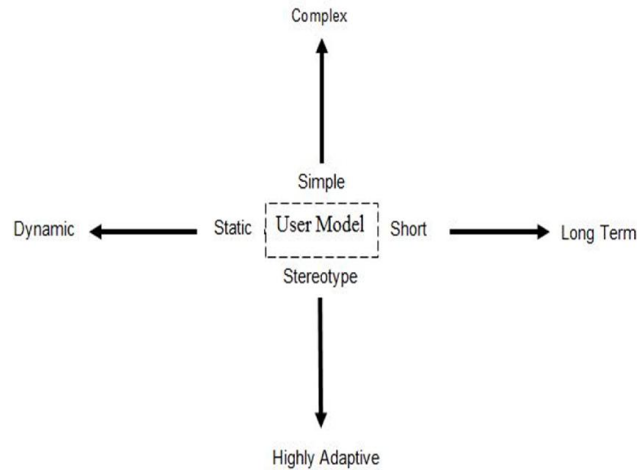


Figure 2.11: Types of User Model

3. *Stereotype to Highly Adaptive*: A stereotype represents a collection of traits [54]. A stereotype model is based on the gathered information of various users and then the system adapts to this stereotype [55]. It is a common approach in user modeling to create group models and for creating initial individual user models [56]. Highly adaptive user models are used to represent one particular user and therefore allow a very high adaptivity of the system. In contrast to stereotype based user models they do not rely on demographic statistics but aim to find a specific solution for each user. Although users can take great benefit from this high adaptivity, to utilize this kind of model one needs to gather a lot of information first [57].
4. *Static to Dynamic*: The data about users are not always static or dynamic. Some data elements remain stable and some are changing frequently. Static user models are of basic types and usually include demographics such name, id, birthdate etc. Once the main data is gathered they are normally not changed again. Dynamic user models usually represent most up to date representation of the user model. This type of user model used to represent dynamic elements such as interests, preferences and context etc. This model can be updated and take the current needs and goals of the user into account.

A user model can be a combination of any of these types of user models depending on the type of the application. However, a user model can represent an individual or a group of users. The aim of user modeling is to capture user information such as preferences, beliefs, goals, and intentions to construct a user model [58]. User model is as an essential input for every personalization technique. The user model can either be collected by the service provider i.e.; through accumulating the information on user's preferences and interests, or imported into the system from user's personal devices.

2.3.2. Data Gathering for User Model

Information about a user can be gathered in several ways to create a user model. The basic three types of information gathering techniques are as follows:

1. *Explicit method*: In this method users are asked about information explicitly either through feedback, questionnaires or registration process. While registering users are asked for specific facts, their likes and dislikes and their needs. This method is a good way to collect data rapidly about the users and give full control to the users. The main disadvantage in this that user model may not be dynamic and updated.
2. *Implicit method*: In this case users are not asked directly for their personal data and preferences, but this information is derived from their behavior while interacting with the system. The systems learn about the user through interactions of the users and build a behavioral model. Different methods such as search history, user log or machine learning algorithms are used to gather user information. It takes a certain learning time before a user can benefit from adaptive changes. This is currently the most widely used method to learn about users in recommender systems. In this method users are not aware or the process of collecting data is not transparent and gives users almost no control.
3. *Hybrid method*: This approach is a mix of the above mentioned approaches. This approach tries to combine the advantages of the both (implicit and explicit) methods. It is up to the designers how are they going to collect the data and it also depends on the system's purpose.

It is no longer just desktop and/or web applications that require the use of UM components, but also becoming an essential part of this new breed of mobile application/services. It is becoming inevitable that future mobile services will have significant interaction with feature rich UM ecosystems and with one another based on such ecosystems [59]. 3GPP Generic User Profile [60] gives an abstract representation of a user profile which contains no data. More specific user profiles can be derived from this abstract representation of a user profile. It consists of five main components User Personal Data, User Devices, Personal User Devices, Subscribed Services and Subscribed Networks. It is further classified into User Level and Universe Level [61] as shown in Figure 2.12: Generic User Profile. [60]. The User Level represents the user and the context. The Universal Level specifies formal description or schemas of all existing devices, access networks, services, and personal user devices.

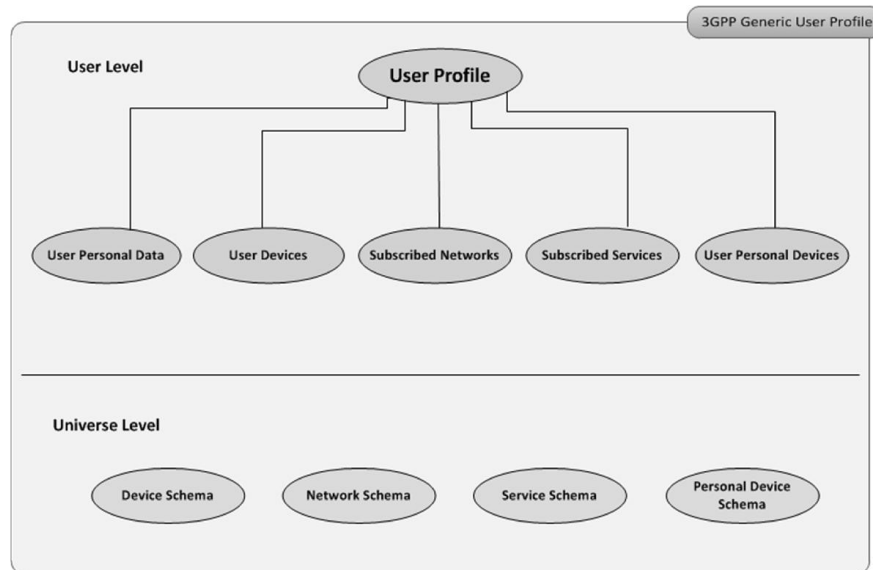


Figure 2.12: Generic User Profile. [60]

A number of research challenges are being discussed in UM community about modeling and sharing of user models [62] in various domains: (i) the one is related to the architecture of the user model-*centralized* (aiming to collect, store and share all user data at one central place), or *decentralized* (aiming to share user data across application/services directly with each other on demand) (ii) user model semantic interoperability, and (iii) user privacy and user control of their user model.

Service providers may neither cooperate, nor share the data stored in their repositories due to commercial competition [63]. Even if they agreed, there can be an issue to mediate users' models. It requires mediating mechanism that facilitates user modeling data sharing by translation and integration of the user model. Another issue that should be tackled by the mediator is integrating partial models from different domains. In [64], authors have discussed different profile management and discovery issues and challenges such as profile sparseness, user profile persona, using out-of-bound data and difficulties to reuse the profile data. The user preference is personal and subjective and it needs to be handled carefully. Personal or group user models can also make it possible to represent and use information about preferences, knowledge, abilities, emotional states, and many other characteristics of a user to adapt the user experience and support [11].

Personalization has some challenges include profile ownership, managing complexity, user acceptance and agreed standards, to name a few. There is a lack of an agreed standard for user profile capture and sharing [21]. More importantly the user profile created from one service could not be reused with another service. This might bode well with the service provider, but, from the user perspective, it is undesirable to create a user profile every time a new service requires it [65].

2.3.3. Scrutability and partial user model

The existence of a user model is a key to personalization. The compilation of a user model and using that model effectively is crucial for personalization. A user model may consist of a fixed part, containing a set of domain-independent user's attributes, and a configurable part, containing the user's preferences for domain-dependent product properties. Dynamic user profiling is an essential part of personalization due to the heterogeneous needs. Therefore, there is a need to consider the user profile in terms of the user's primary goal and needs. The data that can be used for constructing user profile can be distinguished as *data model*, classified as demographic and transactional data and *profile model*, classified as factual data and behavioral data [66].

A complete user model may not be required to personalize a mobile service at a certain time. Further, it is suggested that elements defined within a user profile that suits to a specific situation, but related to many different services should only need to be defined once [67]. However, a part of a user model can serve the purpose. Similarly, some services may not need all contextual elements to personalize a mobile service. Thus, we require a partial user model and the related context to personalize a mobile service which we call *persona per service*. User's interests, needs and context are dynamic. Therefore, it may require constructing a persona dynamically or reusing an existing persona with slight modifications whenever required. In this research, we consider persona as a dynamic entity which contains required elements of a user model and the user's context to personalize a mobile service. Similarly, a study [68] also suggests that same persona should not be used in distinct services. It also states that personas are useful to convey information about users' context, goals, background and expected behavior.

Reusability of user models across different services is also of high importance. According to [69], if users model are to be reusable, they are no longer the property of one service or program. The only thing is to find out which elements of the user model are required or relevant to a service in the current user's goal and context. Different users may have different goals at a time or; the same user may have different goals at different times. It can be useful to consider the user's goal as a part of a persona at the time of sharing with the service provider. Figure 2.13 gives an overview of the persona-information.

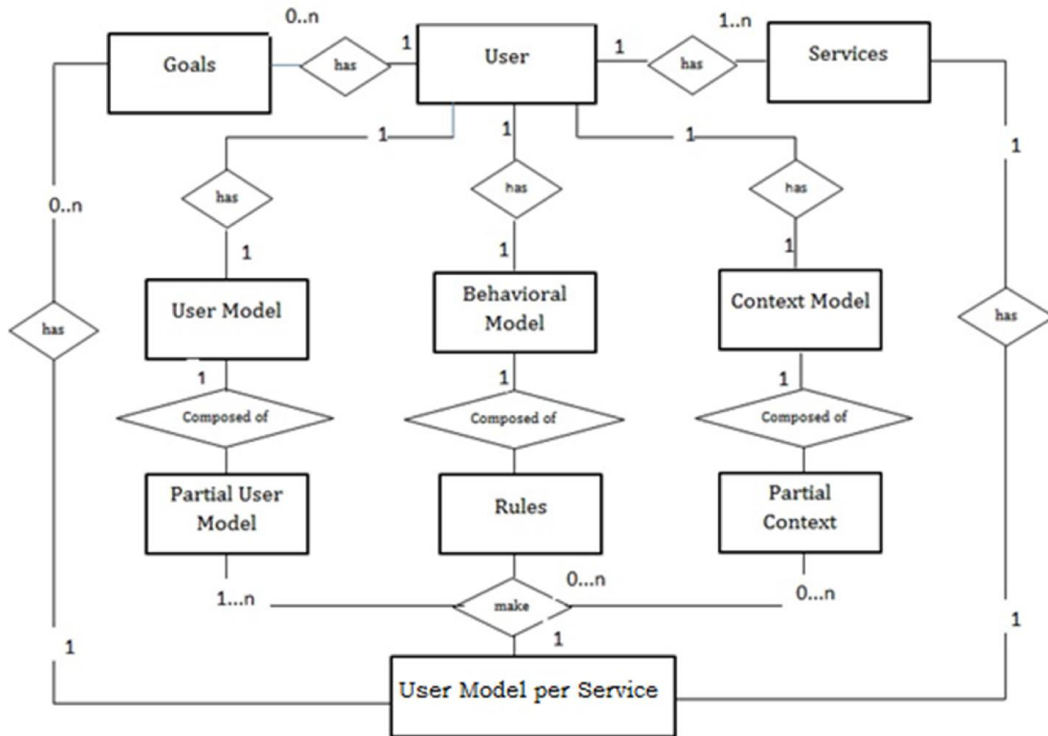


Figure 2.13: Overview of a User Model

A user can have subscribed services and have some goals. The goals can be a long term or can be changed anytime. The context part represents contextual elements required by a service and a user is willing to reveal. It is very important to understand which contextual attributes are required for a particular service. Sometimes, different services may require different type of contextual elements. For example, looking for nearby shopping center, location is the crucial context but when a user is in the shopping center it is not further required for that shopping session. Creating and maintaining user profile is critical for personalization. Full profile may not require in personalizing a particular service, a part of user profile may be sufficient. In a way, it is not required to utilize full context and profile to personalize a mobile service. It may require investigating further which contextual elements and which part of the profile is required to personalize a mobile service. However, the focus of personalization should be to improve the user experience while protecting privacy. The partial user model represents only those elements which are relevant to the service. In addition, the rules can represent the behavior and privacy preferences of a user for service personalization. User Model in Figure 2.13 is a combination of personal user model and user context to personalize a mobile service. It can contain the user's information (user model), the context and behavioral model (history, recommendations) required by a particular service. Every service may require different user information and context to personalize. Therefore, the persona per service can be an ideal choice for designing personalized

mobile services. There can be one persona per service or one persona against multiple services. User can have full control over his/her persona which is stored on their personal device. One can make any element of their persona private or public. For example, a user may want to utilize a service, but do not want to reveal his location but still want to receive personalized experience of the service.

2.3.4. Stereotyping and User Model

Using a stereotype approach is quite common in user modeling to create group models as well as for creating initial individual user models [56]. According to [55], stereotypes are simply collections of personal characteristics of system users and this approach is a common technique in user modeling. The use of stereotypes when combined with the ability to record explicit statements by the user about him/herself and to make direct inferences about a user from his/her behavior, may provide a powerful mechanism for creating systems that can react differently to different users [55]. Stereotypes can provide a better initial user model [40, 56, 70]. However, using stereotype has an issue of accuracy as well [56].

In this work, we have proposed that a service should come with a stereotype as an initial persona to start an immediate personalization process. As the process of personalization starts, user can adapt the stereotype to his/her requirements for the service. Further, a user can add more knowledge to extend the stereotype based persona. Default profiles can also play a significant role in personalized mobile services. According to [71], if a user can be assumed to be of a certain type, i.e. fitting into a certain profile pattern, only a minimal list of attribute overrides have to be transmitted for service execution.

The user model template should be part of the service. The template can describe what features this service is providing to personalize and which information is required about the user and his context. While subscribing to a service, service should present this persona either as wizard configuration or manual configuration. The persona should be stored on the user's personal device and the interface of the service should be presented based on the preferences given by the user. The interface should provide easy controllable features to control the access of user's information to keep the user in control with ease. This can be achieved by keeping the structure of user's persona to a level similar to the structure of user interface model. The persona should have a place for recommendation made the service which the user can accept or reject in real-time or can go through later to improve his/her persona. After accepting recommendations, these recommendations will become the part of the user's persona and should be reflected in interface as well. However, a study [72] also argued that user can control the learning process because 1) users can decide whether to accept or reject the systems suggestions, and 2) users can directly access and modify their preference (either privacy or others) anytime. The study applied the evaluation in location sharing applications and yields promising results.

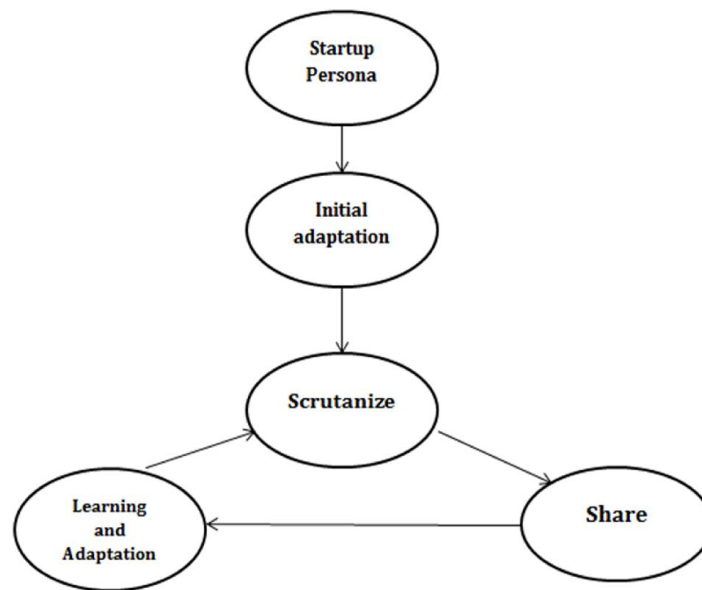


Figure 2.14: Adaptation process

In our approach, the service deliver a stereotyped user model with some default attributes as an initial user model. After that, the user can adapt stereotyped persona through an easy to use interface to receive personalized contents or recommendations. The stereotyped profile can be adapted by the user through learning and filtering techniques. Once the profile is initiated, the user may continuously make updates to the persona to make it more precise and reflect new preferences or change of preferences.

2.4. Mobile Services and Context-awareness

Context-awareness is one of the drivers of today's mobile services and utilized in a variety of ways to deliver context-aware mobile services. Context awareness is neither a service, nor a technological solution, but a service enabling class of features which gives a new service dimension [73]. Mobile devices are equipped with a variety of physical and logical sensors [74] making an ideal case for context enabled personalization. Context-awareness is particularly interesting in mobile services where the context is highly dynamic and allows exploiting it in many ways. Context dependency is a major issue in recent research work in the area of context-aware mobile services. The following Figure 2.15 outlines its evolution change in different domains of research.

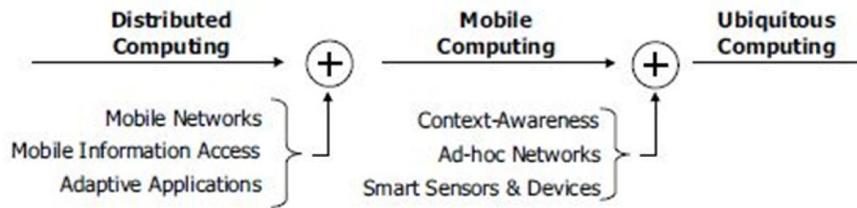


Figure 2.15: Evolution change [75]

Context-awareness is to provide mobile services anytime, anywhere with the right thing at the right time and in the right way. Context has significant impact on the personalization and adoption of mobile services. In the literature several definitions of the context can be found [74, 76, 77]. When dealing with context three entities can be distinguished [76]: *places* (room, building, house, office, shopping store), *people* (individuals or group), and *things* (physical objects). However, user's *situation* related to the place, people and things is also characterized as an important dimension.

Context-awareness and user modeling are considered as two key research areas which are contributing for adaptation and personalization of services. Both research areas have a strong role in providing personalized services and information delivery to the users. Analysis of similarities and difference between these two approaches can be useful to understand personalization better. Both research fields are contributing to personalization research particularly in personalized mobile services. A study [78] has made similar analysis describing the relationship between these two approaches to design a context-aware Personal Digital Secretary. This study utilizes both a context model and a user model to design the application. According to the requirements of the application, they have compared both context and user model as shown in Table 2.4:

Issues	Context Models	User Models
Data Acquisition	Mostly collected from all types of sensors	Mostly built from user interactions
Coupling to Applications	Can be insulated from applications	To be a part of an application could be more efficient
Representation	A data model represents various context elements	A data model represents a user's facts, or a behavior model or a combination of both
Time period required for data acquisition	There is no time gap to capture a user's context but may require sometimes to process	Sufficient time and interactions (Cold start problem [32]) required for behavior model to learn a user's behavior

Table 2.4: Comparison of Context and User Model [78]

The imprecise utilization of context is extending the problem space for the personalization of mobile services. However, it is required to understand which context information is necessary and how to represent it using a context model to design any context-aware application. According to [76] "*a system is context-aware if it uses*

context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Context modeling is a hard problem due to its complexity and the multitude of different applications. It is required that only relevant context information should be considered for different application scenarios. Associating the context to user's preferences can play a significant role for personalized services [58].

A high-level categorization of context is provided in [79]:

- a) The *spatio-temporal context* describes aspects related to time and space. It contains attributes like time, location, direction, speed and track.
- b) The *environmental context* captures the entities that surround the user, for example, physical objects, services, temperature, light, humidity and noise.
- c) The *personal context* describes the user state. It consists of the physiological and the mental contexts. The physiological context may contain information like pulse, blood pressure, and weight. The mental context may include elements such as like mood, expertise, anger and stress.
- d) The *task context* describes what the user is doing. The task context may be described with explicit goals or the task breakdown structure.
- e) The *social context* describes the social aspects of the user context, e.g., Information about friends, neighbors, co-workers, and relatives. The role that the user plays (e.g. Status and tasks to be performed) is an important aspect of social context.
- f) The *information context* is the information space that is available at a given time.

Quality of the available context information is a fundamental issue. It is exceedingly hard to collect complete and accurate context information. According to [80], it is evident that sensed context information is often inaccurate or unavailable as a result of noise or sensor failure. Moreover, user supplied information is subject to problems such as human error and staleness. Different types of context imperfections discussed by [12] are *unknown* (when no information is available), *ambiguous* (several different values exists), *imprecise* (information is correct, but inexact), and *erroneous* (mismatch between actual and determined value) as shown in Table 2.5. Mobile applications have the opportunity to take context into account.

Type	Source	Persistence	Quality Issues	Source of Inaccuracy
Sensed	Physical and logical sensors	Low	May be inaccurate, unknown or stale	Sensor errors or failure, network disconnection, delays in processing
Static	User/administrator	High	Usually none	Human error
Profiled	Implicit or explicit	Moderate	Prone to staleness, may be unknown	Omissions to update
Derived	Other context elements	Variable	Errors due to derivation process	Imperfect input, depends on machine learning process

Table 2.5: Properties of Context Information [80]

2.5. Mobile Services Acceptance and Personalization

A number of industrial and academic research have been conducted around the field of mobile services adoption and acceptance to see if these services are worth being used by the wide part of the population or not. The focus of this research area is to find out the factors that can/are influencing users' intention to use a particular mobile service.

The adoption of new mobile services has been slower so far than expected, and the basic challenge is to understand how and why people adopt or do not adopt mobile services [81]. However, many mobile services failed to generate revenue due to the lagging adoption of the services [3]. The possible reasons of slow adoptions are lack of user friendly interfaces, security and privacy issues, complexity of services, relatively high cost, lack of content quality, inappropriate business models, or users' needs, and requirements have not been taken in account [3, 82]. The present research in determining adoption and use of mobile services is significant but not appropriate enough. In many adoption and acceptance studies, technology and service characteristics are treated as a black box, and the service designers should pay more attention to the users' preferences [3]. It is remarkable to know that how and why people adopt mobile services. The understanding of why users accept mobile services can be helpful to understand the adoption factors. Understanding the motivation of personalization can help to design those features that can promote acceptance and motivation of information and communication technology (ICT) [83]. Both research areas (adoption and personalization) have a significant contribution toward mobile services. Due to the importance of both research areas, there is a need to combine the efforts to excel in devising mobile services that are suitable and acceptable for users. Literature showed that personalization is taken as only a small factor in adoption of mobile services [84].

Authors [85] suggested that to overcome the limitations of diffusion research, there is a need to understand the users' needs and requirements. On the other side, [86] suggested that technology and service adoption requires and instantiate continuous behavioral changes. Mobile services are mainly designed for individual users and can be perceived in a different way by different users. Moreover, users can have different expectation and needs. Personalized mobile services that can improve user satisfaction can be valuable for the success of m-commerce [87]. Authors further argued that although there is no study on the relationship of personalization and perceived value; but it can be envisioned that personalization is associated with usefulness and can encourage users' perceived value.

The development of mobile services is driven by user's behaviors. The success of mobile services lies in understanding users, their life styles, and attitudes and needs [88]. The characteristics of mobile services such as personalization, context, and ubiquity make mobile services adoption different from other ICT services [89]. These characteristics require exploring different adoption factors in addition to the traditional

ones. Many of the studies in mobile services adoption have ignored the users' needs. It is required to target the individuals' needs for successful adoption of mobile services in any domain such as m-commerce, m-learning, information service etc. Many researchers who are exploring the m-commerce have ignored the users' needs [90]. However, mobility can also be a key adoption factor in mobile services [3]. Moreover, the study showed that mobile services adoption depends largely on service functionality, service quality, usability, and accessibility. We believe that personalization can enhance all these adoption factors.

Both personalization and adoption are significant areas of research on mobile services. The application of both research areas becomes more relevant to mobile services due to the inherited constraints of mobile devices. It can be productive to look how these two research areas are contributing towards mobile services and how personalization can bring improvements in adoption of mobile services.

So far, the focus of mobile services acceptance research is to find out the factors that can affect the adoption of mobile services. On the other hand, the emphasis of personalization of mobile services is to target the individual needs. In addition, personalization is improving the user's experience with mobile services and enhancing overall productivity. However, the literature of mobile services adoption research has revealed that personalization is not utilized properly. Due to the success of personalization and relevancy in mobile services, we envision that personalization should be an integrated part of mobile services adoption. Personalization features can align the psychological resources with the users' actions and can enhance users' experience which can lead to increase the adoption [83]. To address this, we have analyzed that how and where personalization can play a significant role in mobile services adoption. We have analyzed the role of personalization on different adoption factors suggested in Technology Acceptance Model [91] as an example.

There is a rich literature on technology adoption, but Technology Acceptance Model [91] is widely accepted and applied model which much of later work in this area builds upon. The basic concepts used in TAM are:

- External Variables (EV) are defined as variables that affect perceived usefulness (PU), perceived ease of use (PEU), and Attitude toward Using.
- Perceived Usefulness (PU) means that a person believes that using the particular system/technology will improve his or her action.
- Perceived Ease of Use (PEU) means that a person believes that using the particular system/technology will be simple and not complicated.
- Attitude towards use (A) is defined as the users' desirability to use the particular system/technology.
- Behavioural Intention (BI) is anticipated by attitude towards use (A) combined with perceived usefulness (PU).

The TAM model has been extended, modified and applied in various studies. Perceived ease of use and Perceived usefulness are the most prominent concepts in most

of the studies. TAM is applied in a variety of technologies, and mobile services adoption is one of the popular areas of its application. Authors [92] suggested that even though TAM is popular, its application is limited due to the nature of constantly changing the IT environment. However, there is a need to look into more adoption factors due to the application of TAM in a variety of domains such as mobile services. Theory of Reasoned Actions (TRA) [93] is extensively used in different adoption studies. It states that a person's belief decides his behavior, and other factors influence behavior through attitude, subjective norms or relative weights. It can be argued that the attitude and subjective norms of the people could be different from one another and in different situations. Therefore, the attitude and subjective norms of individuals should be reflected at personalized level in adoption studies to understand one's behavior towards adoption. We can argue that personalization studies can play a significant role here which seems overlooked so far in mobile service adoption studies. Similarly, Theory of Planned Behavior (TPB) [94] focuses on the relationship among attitude, intention and behavior under the situation that an individual's behavior is in completely controlled by himself. The perceived behavioral control depends on perceived control and perceived convenience, which refers to an individual's perceived ease or difficulty of performing a particular behavior. Therefore, one can argue to address the behaviors at personalized levels. In a way, we can say that personalized services can have a positive effect on the behaviors of individuals.

A study [92] has investigated factors affecting perceived usefulness such as cost, time, enjoyment, mobility, and content. Moreover service quality, speed and simplicity factors are affecting the ease of use. The technology and habits are identified as factors affecting the user's attitude and should be addressed at personalized level. Prior research shows that the effect of personalization of mobile services is significant, and it can be evident that the personalization has become an essential feature of mobile services. Therefore, there is a need to analyze the aspects of personalization for broad understanding of adoption factors that may have influence when looking for adoption factors as shown in Figure 2.16.

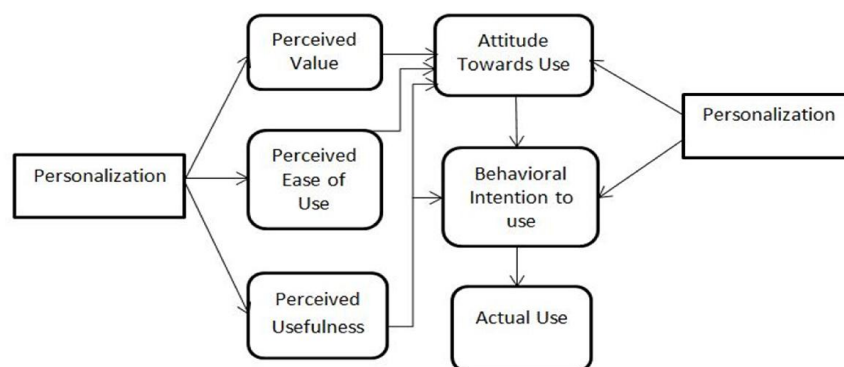


Figure 2.16: Role of Personalization

Mobile services are highly sensitive to the user's environment and the requirements. Personalization has a user centric nature and can address the sensitivity of the environment and user's needs. While studying adoption of mobile services, it is not wise to ignore the personalization aspects. Moreover, adoption is not a one step process rather it is a continuous process, and personalization can improve the process of adoption. With the proper application of personalization, the adoption of mobile services can be increased if fits according to the needs of the individual users. Despite the benefits of personalization, if it is not addressed properly it can increase the complexity and can annoy the users as well [95]. Since the objective of personalization is to enhance users' experience therefore its role in adoption of mobile services cannot be overlooked.

2.6. Personalization and User Modeling Challenges

The personalization is a complex concept with many aspects and viewpoints that need to be analyzed and resolved particularly for mobile services. Personalization has become an umbrella term and one needs a clear understanding in a particular application domain such as mobile services. In modern personalized systems that integrate user-modelling components one need to satisfy not just a number of functional requirements but also end-user requirements such as the accessibility, location, ownership, scrutability, user control, and reuse of user model content [59, 96]. Primarily, the personalization problem revolves around the issues related to what content to present to the user, how to show the content to the user, how to ensure user's privacy, and how to create a global personalization scheme [38]. There is a variety of issues related to the user model such as incorrectness, inconsistency and incompleteness that can make personalized mobile services unacceptable for the users. In addition to this, user has serious concerns of privacy and no control over the user model. However, the externalization of a user model can help alleviate the issues of invisibility and inconsistency.

2.6.1. Privacy-aware Personalization

Privacy is a key issue in adoption of mobile services. Personalization offer many opportunities for enhancing the user experience in a wide variety of mobile services. The user model that drives personalization is normally based upon user's personal information and raises considerable privacy concerns [44]. If privacy concerns will not be addressed it can lead to lack of trust and could result in avoidance of system use. A mobile user regularly moves from system to system and from one network to another. Therefore privacy-aware personalization is required to discover and use different mobile services in a dynamic environment.

The shift of research focus from technology oriented towards the user-centered approach raises the issue of individual privacy and data protection [97]. The information

required to personalize the services has raised the concerns for “right to privacy”. Mobile users are facing a dilemma: while they demand more customized services, they are increasingly concerned about privacy infringements and how their information is being used by mobile service providers. Therefore, mobile users are more suspicious of new personalized services [16]. Acquisition, processing, and storage of personal data ubiquitously may require an intensified consideration of user demands to security, privacy, and anonymity [98]. According to [19], there is a need to find out what services, what personal information the users are willing to share with the surrounding services in order to encompass the service provisioning based on personal information. A tradeoff may require exploiting how much personal information a user is willing to share in order to continue using a service. However, it is difficult to achieve balance and guarantee of this tradeoff. One possible solution is to shift the control to the users over their personal information and make explicit the tradeoff between benefits and risks according to level of involvement. In this case, client-side personalization seems a better option for the personalization of mobile services.

Privacy enhanced personalization has remained a challenging task. Various technical solutions have been proposed to protect the user’s privacy while keeping the pleasant experience of personalization [42]. In the literature of privacy studies [42], there are three main themes of privacy concerns: the protection of user’s identities, user’s right to seclusion, and users’ right to control their own data.

2.6.2. Lifelong personalization

The usage of mobile services may have short life or some may remain in use for a longer period of time. Long lived and long usage services are likely to have an important role and each is likely to need its own user model. However, to fulfill the long term goal of lifelong personalization there is a need of lifelong user model. For personalized systems, it should be possible to query the user model for aspects such as users’ long term goals, knowledge, preferences, interests and attributes [99]. Lifelong personalization/user modeling must enable the user to control [52]:

- a) What is allowed into their model?
- b) Which parts of the model are stored on which devices?
- c) Which parts of the model should be shared with particular application and people?

A number of other challenges are also described [52, 99] which are out of the scope of the current subject. Mobile device is truly a personal device and remains with user most of the time. This makes it an ideal platform for client-side personalization. The current capability of mobile device has the potential to provide unique opportunities of real-time adaptation of services in a dynamic user environment. The key change that a lifelong user model can bring is that the user can carry their user model, for example, on

their mobile device. This perhaps can reduce the need for acquisition of the user model. Therefore, the user model can then be reused in other contexts. To model the user's context, especially their location and relevant aspects of their activity and attention, there can be significant technological challenges, both in collecting relevant information from sensors and then interpreting it. This may run on the user's carried device and/or an infrastructure of sensors [100]. Client-side personalization can provide a valuable foundation for lifelong user modeling, in which a user can create, edit, reuse, and extend their user model throughout their digital life experiences [44]. It seems that having an integrated, standard, personal "lifelong" user model can provide a starting point for personalization in several forms. The user model can be stored physically or logically on the user's mobile device, perhaps with parts made available to different domains. However, it is essential to be able to use user modeling data across domains [100].

2.6.3. Scrutable personalization and user control

The term scrutability in user modeling signifies that every user's model can be inspected and altered by its owner in order to determine what should be modeled about him/her and how that modeling and following personalization process will be conducted [101]. In scrutable personalization users are provided with a complete control over the management and use of their personal data. To enable a user to control what goes into their model, what leaves it, and other privacy concerns, there are challenges at both the systems level and in creating effective user control interfaces [52]. The support of lifelong user model is a key factor for lifelong personalization. Lifelong user models should be scrutable, meaning that the user can, when they want, scrutinize the user model to determine what information it holds about them. This is a foundation for enabling the user to control their model and its use, and in this way to control the personalization processes. Scrutability is as a foundation for user control over personalization. There is a need for solutions that aim for a balance between privacy and personalization. There is a variety of ways named pseudonymous personalization, scrutable personalization and dynamic personalization, they all address a handful of the main privacy concerns and achieve at least reasonably acceptable personalization [42].

Most of the personalized systems are generating user model from implicit feedback from the users' search and browsing history, and explicitly from the classical interfaces that allowed people to express their preferences by browsing along the set of well-defined categories of contents. In UM community, there is a debate on the tradeoff between the user control and the use of intelligent agents that learn about the user [102]. A user should be aware of her/his user model used by a system or a service. In addition, user should have control over her/his user model to personalize a mobile service.

2.6.4. Externalization and Scrutability of User model

User has the right to know which information is being shared with service providers. Invisible user models could raise usability issues which can affect the acceptance of the personalized services. The externalization of user models can assist the users to know what information system is utilizing to provide personalization. This can give an opportunity to complete/correct the user models. Moreover, it can facilitate users to have a sense of control over the adaptation of systems by controlling the user model and, the way that the model is interpreted and the way that it used to perform the personalization. It can help people to become more self-aware and avoid self-deception. It can also motivate people to share user model data because they feel confident about its meaning and use. Understanding, accepting and trusting a personalized system can improve the user-system interaction [103].

In many personalized systems, the user model is considered as purely internal system information, and it is partially or completely hidden from the user [101, 104, 105]. Currently, in most personalized systems, user has no way to discover the details of their user model and the associated personalization [106]. The user models should be visible and accessible so that people may have insight of it. However, user must be able to view and alter the user model to increase the acceptance of personalized systems [104]. Hiding user models may occlude the system status and hinders control on the adaptation, which might lead to errors, e.g. issuing irrelevant recommendations [104].

Externalization of user model can increase the user's understanding of how their user model and feedback can contribute to scrutable personalization. This can help the user to feel in control of personalization and thereby can increase their experience with mobile services. Making user models accessible to the users is a key requirement to the acceptance and success of adaptive systems. To ensure acceptance by users, these models need to be scrutable, i.e., users must be able to view and alter them to understand and if necessary correct the assumptions the system makes about the user [104]. Externalization is a first step towards the scrutability of user models. Jameson [107] argued that allowing inspection and parameterization of user models are essential measures to achieve predictability, transparency, and controllability of an adaptive system. According to Cook and Kay [108], the user needs to be able to understand the provenance of information in her user model, e.g., the user needs to understand why the system believes she is interested in a certain topic.

Usually, so far the focus of externalization of user model was on larger systems. Introspective views were used to represent user knowledge or interest [104]. According to the authors introspective views can help the user to gain an overview of the entire user model and zoom into a certain part of the model to get a better view on it. Moreover, it can enable the users to filter out unwanted items in order to focus on the relevant ones. A similar study [105] has proposed an approach to control adaptive behavior of the recommender system by allowing users to view and adjust the profile. It

also allows users' to see the effects of personalization and modify the interests or preferences accordingly. The um-view interface [108] allows traversing through a user model by expanding the tree of leaves and viewing detailed information about the items in the model. VIUM [109, 110] and its successor SIV [110] are capable of visualizing large user models and enable users to get an overview of the whole model, view a subset of related beliefs, filter items by relevance, and obtain detailed information about the displayed items.

Understanding the goal of externalization of user model in mobile services and the means how to achieve that goal is vital. Here, the goal is to provide reflection and improve the accuracy of the user model. Moreover, the purpose is to provide control to users of their models and improve privacy. SMILI (Open Learner Modeling Framework) [111] has described various issues to consider for externalization of user models. A brief description of the few relevant issues is as following:

- *Extent of model accessibility*. Up to what extent the model will be accessible completely or partially.
- *Presentation*: How the model will be presented graphical or textual. In addition, how the model will provide the information (summary, overview, targeted detail or all details).
- *Access Initiative*: How the model will be accessed either initiated by the system or by the user.
- *Control over accessibility*: Who will control (System, User or Others) and how (complete, partial, or none)
- *Awareness of effect of model on personalization*: How much the user (complete, partial or none) will be aware of the effect the model on personalization?
- *Flexibility of access*: How much (complete, partial or none) of the user model can be chosen to be accessed.

Externalization of user model provides an opportunity to view and access the user models. Moreover, it can help users to understand the behavior of personalization depending on their models. Therefore, one objective to externalize the user's model is to alleviate the invisibility of user model and personalization process. If the model is simple or easy to understand then the complete access to the user model can improve accuracy and in case of large and complex models, partial access can be more effective [111]. An incorrect user model is a major issue in personalization [106] and needs to be addressed carefully. Externalization of user model in mobile services is a challenging task due to the inherited constraints of mobile devices. In addition, it is critical to know which elements of the user model should be externalized and what should be the main objective of the externalization.

2.6.5. Evaluation of Personalization

Today, a lot of information and services are available delivering more than a user needs. One size fits all approach is no more valid. Instead, this approach may cause dissatisfaction or can annoy mobile users. Personalization is providing a means of fulfilling users' needs more effectively and efficiently and, consequently increasing users' satisfaction. By providing successful personalization, a high degree of user satisfaction and a pleasant user experience can be achieved. Some features of personalization can cause problems and may outweigh the benefits of personalization. Since personalization is becoming a key feature of mobile services, therefore there is a need to measure the effectiveness of personalization delivered to the users. Personalization is an iterative process and requires continuous monitoring and reassessment of the user's satisfaction.

Although it is intuitive that personalization could add value to content providers, existing literature has not provided adequate theoretical and empirical evidence to show whether the user likes personalized services [112]. It is also necessary to examine the effect of personalized services on user satisfaction and the factors that affect the satisfaction with these services. Although, the effectiveness of web personalization is evaluated, but there is little effort to evaluate the effectiveness of personalization of mobile services [113]. According to [32], personalization is iterative processes that can be defined by three stages understand, deliver and measure cycle. It also suggests that personalization process should start by specifying the measures that can be used to measure the impact of personalization. The purposed evaluation model focuses the "measure" phase of this process.

Personalization is a multidimensional construct and measuring such a multidimensional construct is always a challenge [20]. Few studies have investigated whether personalized services can improve user satisfaction, or why user satisfaction is increased. In order to take full advantage of personalization technology, we need to have a better understanding of how users respond to this service and its theoretical foundation [112]. During an evaluation, the perception of personalization should not be asked directly as "Do you like personalization" or what is your perception about personalization [114, 115]. It will not be easy for a user to perceive personalization as a whole. Instead, it should be posed in terms of variables it is supposed to serve.

Personalization is not a single variable rather it is a combination of several complex variables. Measuring personalization as a single variable will not give a full picture as [32] described "you cannot manage what you cannot measure". Instead, it is required to study all the variables involved in personalization of a service to verify that if personalization is successful or not. Moreover, studying different personalization variables will help to identify which variable requires modification to satisfy a user. In the literature studied, most of the services or systems have treated personalization as a single variable. For example, in a study [116], personalization is treated as composite

variable called “relationship drivers”. This term is used to express personalization in terms of time, location and adaptation to user profile. This kind of treatment with personalization will lead to different challenges of measuring personalization. In a study [16], authors argued that the impact of mobile personalization is still inconclusive. According to [117], there is no science if personalization methods, techniques and algorithms cannot be effectively evaluated. User’s evaluation feedback can play a key role in measuring and enhancing personalization. The use of feedback can be used to adjust preferences and can improve the user satisfaction [35].

Background Theories Theory of information load [118] and theory of uses and gratification [119] are relevant to measure the personalization of mobile services. The information overload theory implies that user satisfaction increases when the recommended content fits user interests. This theory focuses on the principles of least effort and information load. Zipf’s principle of least effort [120] states that each individual will adopt a course of action that will involve the least average work from the person. The principle of least effort predicts that information seekers will minimize the effort required to obtain information.

An alternative to the least effort theory is information overload, which means users are given more information than they can handle within a given time frame. That is the user would prefer to remove some information in order to reduce the necessary effort for finding the target. We can say that personalized services can increase user satisfaction by reducing information overload, if such services can provide accurate service delivery. Theory of uses and gratification indicates that motivations for information access affect user satisfaction. According to the theory, users’ access information with a certain purpose and play an active role in selecting the source and information they like. User’s gratification with a personalized service is vital for effective personalization. Different users may have different goals to personalize a service. It is quite natural that user’s satisfaction increases with the achievement of the goal.

In a literature survey [121], different studies used 44 different variables related to user-centered evaluation of personalized systems. Though, different names were used by the different authors, but the concept was identical. The main terms used were usability, perceived usefulness, and appropriateness of adaptation (detailed list can be found in [121]). A prototype evaluated in a study [122] used only two metrics to measure the personalization; effective rate as a quantitative metric and overall success factor as a qualitative metric. The effective rate represents the percentage of the times the system was successful in providing what the user wanted. The overall success factor denoted the average of “actual success factor” for all provided results. The ratio between overall success factor and desired success factor provides an indication if a personalization system meets the given quality restrictions.

Mobile advertising is a popular research area where personalization is playing a prominent role. General attitude towards mobile advertising was measured by five main

attributes [123], personalization, entertainment, informativeness, irritation and credibility. In this study, authors measure attitude of users in general; and made an assumption that perceived personalization of mobile advertisement affects the attitude towards mobile advertising. Again, asking users about personalization as a whole will not give the true evaluation of personalization.

The metrics like accuracy, consumer lifetime value, loyalty value and purchasing experience were suggested [32] to evaluate the effectiveness of personalization. According to the authors [32], much more work is needed to develop more ways to measure personalization impact. In a case study [124], author found that perceived relevancy and perceived expectancy as evaluation factors to understand the attitude and behavior of users towards personalization. The author found that the relationship from perceived relevance to attitude, intention and actual use was significant. In a study [20], authors described four different kinds of user motives for using personalized systems under different theoretical perspectives of personalization. These include aesthetic value for architectural personalization, social welfare/psychological well-being for relational personalization, productivity/efficiency for instrumental personalization, and material and psychic wellbeing for commercial personalization. Authors also argued that it is not reasonable to measure everything of personalization using a single yardstick. Other measurement constructs should be developed to suit different contexts of personalization.

A study has investigated the effects of location-based mobile personalization on user's trust and distrust of mobile services and looked at two aspects: preference personalization and location personalization [16]. Personalization aim is to increase the usefulness and acceptance of information and services [88]. According to [33] personalization is about correct guessing about what the users perceive as having added value for her/his and there is a need to evaluate the personalized offerings in terms of user satisfaction. An empirical study [125] found that perceived enjoyment and perceived ease of use are the most important factors in adoption of personalized mobile services. According to [126], the negative consequences of personalization have rarely been investigated. Therefore, there is a need to evaluate to get a comprehensive view of the success of personalization. [112] has also evaluated personalized services and measure user satisfaction with four dimensions- information content, personalized service, user interface, and system value.

3. Context and Research Design

This chapter describes research goal and the research methodology adopted in this thesis.

3.1. Research Goal

A key challenge service providers are facing while aiming at personalized service delivery is getting information about their users. Such systems usually need to build a user model, representing their users, their characteristics, including, knowledge, needs, preferences and other aspects needed to provide them with the best possible service. Users usually refrain from investing a lot of time in building user model from question-answer or item evaluation technique, especially for ad-hoc services. A vast amount of heterogeneous (and redundant) user modeling data is scattered among various systems. However, practical personalization systems (and, especially commercial ones) neither allow other external systems to access them, nor share their proprietary user modeling data. However, mediation and use of stereotypes are two types of solutions, but also these are raising privacy issues as well. One way to reduce this risk is giving the user full control over the information and its disclosure.

The followings are some goals

- To understand and improve the personalization process.
- To develop an architecture for scrutable mobile client-side personalization.
- To develop an evaluation framework to measure the effectiveness of mobile services personalization.

3.2. Research Method

The research process follows the design science research methodology. The design science research methodology suggests three objectives: it is consistent with previous literature, it provides a nominal process model for doing design science research and it provides a mental model for presenting and evaluating design science research in IS [127]. Design science research involves a rigorous process to design artifacts to solve problems, to make research contribution, to evaluate the designs, and to communicate the results to the appropriate audience. Such artifacts may include *constructs*, *models*, *methods*, and *instantiations* [128].

The focus of this research is to create artifacts to address the proposed research questions in Chapter 1. Therefore, we have framed this research as a design science research. The design science research process can be sequential or can be started with

different activity depending on the type of problem and approach. In practice, researchers may start at almost any step and move outward. Peffers et al [127], also suggested that researchers may follow the nominal sequence, starting with activity one in a *problem-centered approach*. This can be adopted if the idea for the research resulted from observation of the problem or suggested from a future research from a paper. While, in *objective-centered approach* researchers can start with activity two. This can be triggered by an industry or research need that can be addressed by developing an artifact. A *design and development-centered approach* can start with activity three. It would result from the existence of an artifact that is not realized as a solution yet for the explicit problem domain in which it will be used or it can be from another problem domain and have appeared as analogical idea. There can be another approach called *client/context initiated solution* that can base on observing a practical solution that worked and it can start with activity four.

In our approach, we have selected a problem-centered approach and follow the nominal sequence of the activities. To maintain the quality of our research, we would like to achieve the desired type of research result by following the suggested guidelines in [127, 128].

Activity 1: Problem Identification and Motivation: This activity involves identifying and defining the specific research problem. Another important aspect of this activity is to justify the value of the solution. In this activity, we have defined our problem statement in section 1.1. The problem definition forms basis to develop an artifact that can effectively provide a solution. In this regard, we have formulated research questions (See section 1.3) that split up the problem conceptually to provide a clear understanding of the solution. In section 1.1, we have described motivations in defining the problem domain and the objectives of the solution. This activity is aligned with the phase 1 of the research process described in Section 1.5.

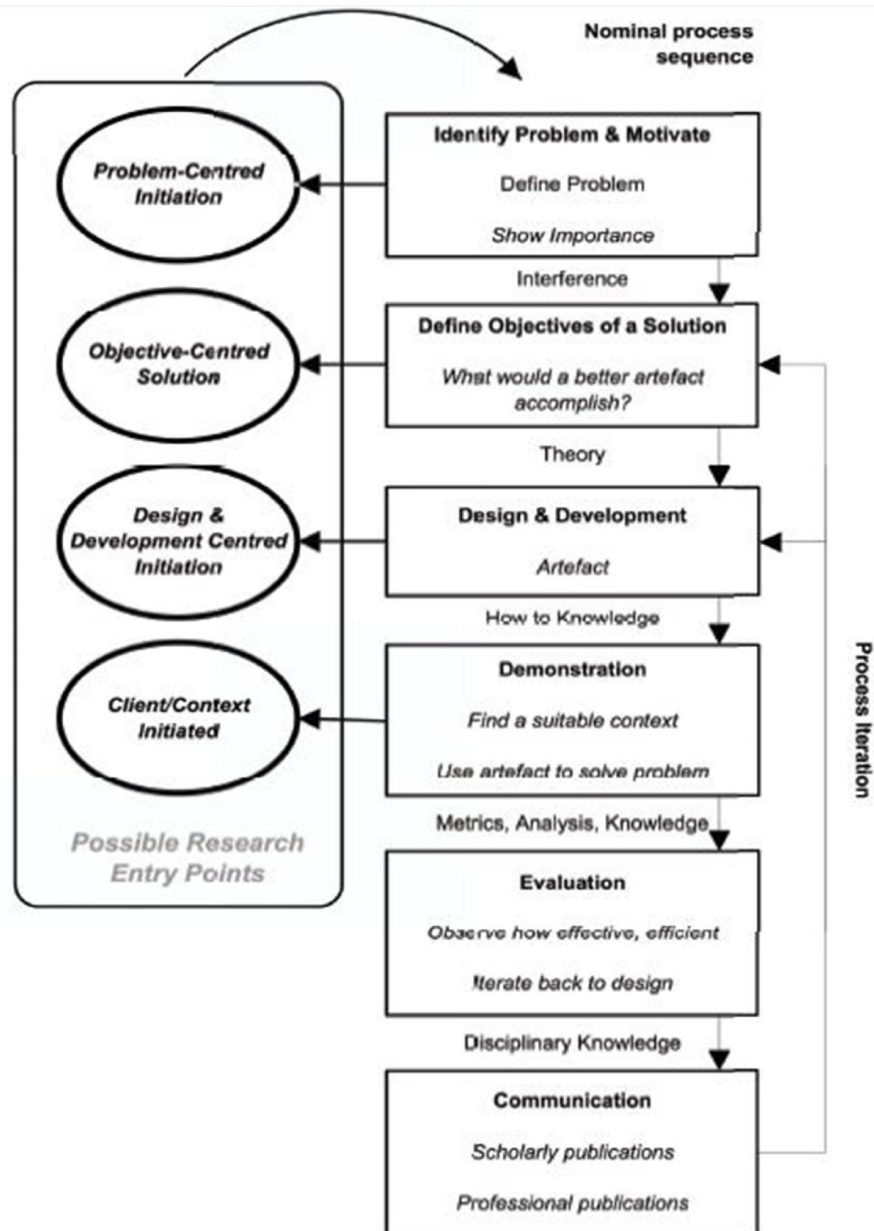


Figure 3.1 Design Science Research Methodology [127]

Activity 2: Objectives for Solution: This activity requires inferring the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives should be inferred rationally from the problem specification. The objectives can be quantitative, e.g., how a desirable solution will be better than the current one. And, objectives can be qualitative, e.g., it can describe how an artifact is expected to support solution to the identified problem. To describe the objectives of the solution in this research, we have defined our research goal (Section 3.1) based on the

activity 1. Moreover, we have also described contributions (Section 1.4) to meet our research goal. This activity is aligned with the phase 1 of the research process described in Section 1.5.

Activity 3: Design and Development: This activity involves producing a viable artefact in the form of a construct, a model, a method or an instantiation. A design research artifact can be any designed object in which a research question is embedded in the design. This activity includes determining the artifact's desired functionality, its architecture and then the actual artifact. In the context of this activity, our artifact is an evaluation model for measuring the effectiveness of mobile services personalization and client-side personalization architecture to deliver personalized mobile services while keeping the user in control of their personal data. This activity is aligned with phase 2 of the research process described in Section 1.5.

Activity 4: Demonstration: This activity involves demonstrating the use of artefact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof or other appropriate activity. We have utilized the mobile services personalization evaluation model to measure the effectiveness of mobile services (See Chapter 5 for detail). In addition, a prototype was developed based on the mobile client-side architecture and empirically tested with PEM.

Activity 5: Evaluation: This activity involves observing and measuring how well the artifact supports a solution to the problem. This often involves comparing the objectives of a solution to actual observed results from the use of artifact in the demonstration. This may include any appropriate empirical evidence or logical proof. This process can be iterative to improve the artifact and depends on the nature of the artifact.

We have evaluated the feasibility of scrutable mobile client-side personalization with the proposed mobile services personalization evaluation model. We also have done an empirically study to validate the mobile services personalization evaluation model. This activity is related to the Phase 3 of the research process described in Chapter 1.

Activity 6: Communication: Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences, such as practicing professionals, when appropriate. Regarding this activity, we have published 7 articles in different peer reviewed international journals and conferences. A list of papers is presented in Chapter 1 and full text of these papers is presented in Appendix.

4. Results

This chapter will give an overview of the results of the research conducted in this thesis. It is structured in to three research phases (See the below Sections). We give a high level introduction to the results of each phase followed by a more detailed description of the results obtained for each paper in each phase.

4.1. Phase 1: Conceptual Development

The main focus of this phase was to develop the conceptual basis of the problem domain. This phase provided the foundation of all the research activities reported in this thesis. The key focus of this phase was to address research questions RQ1 and RQ2. The main result of this phase was the identification of research issues and challenges so far in personalization of mobile services. We have developed a definition of personalization in paper P1 depending on the current needs and technological developments in the area of mobile services.

Definition 1: *Personalization*:

“Personalization is a controlled process of adaptation of a service to achieve a particular goal by utilizing the user model and the context of use”. (From Paper P1)

We have identified various design approaches and challenges in paper P2 which laid the foundation of the further research. We also identified how personalization is overlooked in the research of adoption and acceptance studies of mobile services. This phase results in papers P1, P2 and P3.

4.1.1. Paper 1

Publication Detail: Asif, Muhammad and Krogstie, John: **“Taxonomy of Personalization in Mobile Services”**. Proceedings of the IADIS International Conference e-Society 2012. IADIS Press, 2012 ISBN 978-972-8939-67-0.

Abstract: *Personalization of mobile services is a growing trend. The increasing capability of smartphones and enabling technologies has opened many possibilities of personalizing mobile services. There are different levels of personalization ranging from personalized wallpaper or ringtones to complex mobile services. The goal of personalization is to support the user by providing the right service at the right moment. Based on recent trends in mobile personalization, a definition of personalization is given. The factors such as user needs and goals, choice and flexibility, control and privacy which are of highly importance for the true realization of personalized mobile*

services are discussed. The combination of context-awareness and user-modeling is becoming a key approach in delivering personalized services. Based on this trend, three generic levels of personalization: Basic personalization, profile based personalization and contextual personalization are presented to give insight to design perspectives of personalization in mobile service.

Relevance to the thesis: This paper presents our initial findings towards the personalization of mobile services and described how and what kinds of personalization approaches exists. In a way, it gives a state of the art research and contributed towards the initial understanding of the problem domain. It describes taxonomies of personalization in mobile services and how the personalization is delivered so far in mobile services. This paper answers RQ1 and contributes towards the contribution C1 and partially to C2. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

My Contribution: I was the first author of the paper and did literature review to provide taxonomy of personalization of mobile services. John Krogstie gave feedback on writing and improving the structure of the paper. This paper highlighted various areas of personalization of mobile services and helped to improve the understanding of the research topic.

Approach: In this paper, we have explored the theory and practices in personalization of mobile services. Various definitions and perspectives of personalization have been explored. The early focus of personalization was on content adaptations in different information systems. The meaning and approach of personalization is needed for mobile services. Mobile users can have different needs and focus differently than traditional approaches of personalization due to the inherent constraints of mobile devices such as limited input-output, wireless connectivity, and computational power and battery issues. All these constraints require specific approaches for personalization and demanded to explore more about personalization of mobile services. In this paper, we have done a literature review and proposed a taxonomy of personalization of mobile services.

Evaluation and Results: This paper sets the basis of the research and gives insights of personalization of mobile services. This paper discussed various dimensions and levels of personalization of mobile services and contributed towards the understanding of the problem domain. In this paper, we have presented the user's perspective of personalization such as *user needs and goals, choice and flexibility, control and privacy* which are of highly importance for the realization of personalized mobile services. We have provided a definition of personalization depending on the state of the art of research in personalization of mobile services.

4.1.2. Paper 2

Publication Detail: Asif, Muhammad and Krogstie, John: “**Research Issues in Personalization of Mobile Services**”. International Journal of Information Engineering and Electronic Business 2012; Volume 4 (4) s. 1-8

Abstract: *Personalization is gaining more importance with the increase of mobile and community services. Provision of personalized mobile services can help to meet the individual needs at a time and place when and where a user needs it. Mobile services should be designed to be usable and useful to realize the benefits of personalization. It is not an easy task to satisfy the individual’s goals or needs. Currently, mobile services are designed either using a client side or server- side approach. At the same time, it is raising different research issues ranging from technological to security or privacy concerns. In this work, we described the current research and development in the area of personalization of mobile services. The objective of this paper is to analyze which design approach is suitable for the personalization of mobile services. Finally, we have discussed issues and challenges related to client-side personalization vs server-side personalization and the recent trends in personalization of mobile services.*

Relevance to the thesis: This paper presents the research issues and challenges found in personalization of mobile services. This article contributed to establish the foundation of this thesis. It helped to understand the current research issues and their potential solutions. This paper gives insights to the research of personalization of mobile services and assisted to define the problem domain in terms of research questions and possible research gaps. This paper answers RQ1, RQ2 and contributes towards the contribution C1 and partially to C2. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

My Contribution: I was the first author of this paper and explored the research issues and challenges. John Krogstie gave feedback on writing and structuring the paper.

Approach: A thorough study was conducted to identify the research issues and challenges so far in various facets of the personalization of mobile services. We explored existing theories, design approaches and practical studies to find out the research challenges in this area of study. It was a kind of literature review but with a focus to understand and analyze the current research issues in the area of personalization of mobile services. We also compare design approaches to know the advantages and disadvantages of different ways of delivering personalized mobile services.

Evaluation and Results: This paper evaluates and explores the existing knowledge base in the field of personalization of mobile services. It has identified various research issues that need to be addressed. This study highlighted various gaps in the knowledge

that provide the basis of this and future research. This paper has contributed in terms of highlighting different design and practical issues that are hindering the rapid development of personalized mobile services.

4.1.3. Paper 3

Publication Detail: Asif, Muhammad and Krogstie, John: “**Role of Personalization in Mobile Services Adoption**”. Proceedings of the International Conference on Multimedia and Human Computer Interaction. International ASET Inc. 2013 ISBN 978-0-9867183-8-0. s. 1-10.

Abstract: *The role of personalization is overlooked in adoption of mobile services research so far. This study aims to explore how personalization can play a key role in mobile services adoption. To answer this, literature of mobile services adoption and mobile services personalization is reviewed to understand the commonality of the concepts, theories and models. The intention is to find common grounds from both research areas to provide better approach for mobile services adoption. The basic challenge is to understand how and why people use mobile services. However, there are still many gaps regarding the adoption of mobile services in the existing literature. This study gives state of the art on mobile services adoption and describes how personalization can play a significant role to increase the adoption of mobile services. The main goal of this study is to identify the gap between adoption and personalization studies so far. Moreover, the study offers insights for researchers to look into the important aspects of mobile services personalization that can escalate the adoption of mobile services.*

Relevance to the thesis: The adoption and acceptance of mobile services is a popular research area that aims to identify different adoption factors. This paper contributed to illustrate how personalization is treated in mobile services adoption and acceptance studies so far. This paper assisted in understanding the personalization in mobile services adoption and contributed towards RQ1. It contributes towards the contribution C1. The study contributes towards the Phase 1 the Conceptual Development of the thesis.

My Contribution: I was the first author of this paper and explored the literature of personalization and adoption of mobile services. John Krogstie gave feedback on writing and structuring the paper.

Approach: This paper has explored the application of personalization in the adoption of mobile services. In this study, we have discovered the role of personalization in acceptance of mobile services by exploring the existing literature and studies that deliver personalized mobile services. We have analyzed studies of personalized mobile services of various domains such as m-commerce, m-learning and mobile news services

etc. Moreover, the role of personalization was analyzed by utilizing the Technology Acceptance Model [91] that is widely used and extended in various studies.

Evaluation and Results: The purpose of the research was to investigate whether the conventional acceptance studies and theories have considered personalization sufficiently to study users' adoption intentions and behaviors. To discuss this, we have analyzed literature regarding mobile services adoptions. It was revealed that using the conventional acceptance theories as the sole research approach does not provide sufficient insights to understand user behavior and intentions to adopt the mobile services. The present paper contributes to the discussions in mobile services adoption on how personalization is overlooked so far and how it can play a substantial role in diffusion of future mobile services.

4.2. Phase 2: Design and Implementation

The focus of this phase to design, develop and implement the artifacts to solve selected research challenges or issues. The main focus was to develop an approach that can leave the user in control of the personalization process ensuring the user's privacy. This phase resulted in two contribution (C2, C3) and three papers P3, P4 and P7. This phase contributed to address three research questions RQ2, RQ3 and RQ4.

4.2.1. Paper 4

Publication Detail: Asif, Muhammad and Krogstie, John: “**Mobile Client-side Personalization**”. International Conference on Privacy and Security in Mobile Systems, Global Wireless Summit, 2013, ISBN: 978-87-92982-51-3

Abstract: *The recent development of powerful mobile devices is encouraging people to take them as a computing platform. Users are expecting to personalize services to meet their individual needs and will no longer accept “one size fits all” approach. On the other hand, there is contention between personalization and privacy. This leads to the question of how to maximize the user's experience of personalized mobile services while keeping their privacy. One possible solution is to provide user's control of their personal data by keeping their user model on their personal mobile devices. In this way, a user can scrutinize the data while sharing with service providers depending on her/his requirements. The client-side personalization approach can shift the control of privacy to the users and can involve them in personalization process. In this paper, we have proposed a solution with the objective of scrutable client-side personalization while keeping the user in control of both privacy and personalization. Moreover, the objective is to provide a conceptual layer of privacy enhanced personalization for future mobile services.*

Relevance to the thesis: This article presented a design approach to deliver privacy-aware personalization. It also presented an architecture supporting the protection of the

user's privacy by shifting the control to the user. This paper addresses RQ2 and RQ3. The approach presented in this paper also provides an opportunity to the users to scrutinize the user model and get personalized experience while keeping the control of their own data. This paper also addresses RQ4 partially and provides C2 and C3 contributions. The study contributes towards the Phase 2 Design and Implementation of the thesis.

My Contribution: I was the first author of this paper writing, designing and development part. John Krogstie gave feedback on writing and structuring the paper.

Approach: Privacy-aware personalization and user control are the main research issues in personalization of mobile services. An approach was articulated to address these issues. To implement the approach, we proposed mobile client-side architecture to deliver privacy-aware personalization while keeping the user in control of their personal data. Moreover, the architecture put the user in control of his/her personal information and provided an opportunity of scrutability. The purpose here is to provide an architecture that can meet the above mentioned objectives in a flexible and scalable way. Moreover, the architecture can support the end users to

- Check, what information is in the user model.
- Modify the information in the user model.
- Scrutinize, when other services access or attempt to modify their user model.
- Understand how their preferences affect the service personalization and their experience.

Evaluation and Results: To evaluate the design approach, a mobile client-side personalization architecture was proposed. An application was built called mobile personalized news services to get a proof of the concept. The approach can have two significant benefits. First, the model will be more accurate and up-to-date which is a key to the personalization. Second, the model can be scrutinized by the user and can be updated as his/her interest or requirements changes. It is annoying and inconvenient to repeat the personalization process for the mobile users and repetition can be reduced from the reusability of the user model. This approach combines both adaptive and adaptable design depending on the user's requirements and expertise.

4.2.2. Paper 5

Publication Detail: Asif, Muhammad and Krogstie, John: “**Externalization of User Model in Mobile Services**”. International Journal of Interactive Mobile Technologies, Volume 8, Issue 1, 2014.

Abstract: *In most personalized mobile services, the user model remains invisible, and users do not have control over it. Externalization of user models can allow users to get*

an overview the user model that is used for personalization, and adjust the profile and personalization effects to their needs and preferences. We have evaluated the interactive user model with 42 users, which were exposed to a prototype of interactive user model of personalized news service, for determining whether the proposed externalization, scrutability and privacy privileges were acceptable to the users. The purpose of the study was to find out if it is appropriate to present a user model on the mobile device and to control the sharing of the user model with the service provider. The conclusions show that the users expressed their general approval of the proposed privileges while making useful suggestions regarding improvements to the presentation and interface to the system.

Relevance to the thesis: The scrutability of a user model requires externalizing the user model. This empirical study was conducted to see if users are willing to scrutinize and control their user model. This paper addresses the RQ4 and partially RQ3. It also contributed towards the contribution C3. The study was the part of the Phase 2 Design and Implementation of the thesis.

My Contribution: I was the first author of this paper writing, designing and development of the different parts. John Krogstie gave feedback on writing and structuring the paper.

Approach: In this study, we have developed a prototype to do an experimental study to analyze how users' will respond to provide a user model on their mobile devices. We have evaluated the approach to externalize the user model of mobile services. In order to do this, we have utilized a working prototype of an interactive user model of a personalized news service and collected 42 responses from a variety of users. Before commencing the test, the participants were given a brief introduction to the prototype of the interactive user model and the services it may provide. The whole experiment was divided into three main tasks of *viewing the user model, managing the user model and control of user's privacy elements.*

Evaluation and Results: The main focus of the study was to find the subjects opinion about the possibility to inspect, modify and taking control of their user model. The first research question was to know *if users really feel that it is useful to inspect, modify and control their user models.* Users showed great interest in inspecting the preferences and privacy elements shared with a mobile service. The second research question was to know *if it is appropriate to present a user model in a comprehensive and user friendly way on mobile devices.* We have presented a user model with very few elements and used common GUI elements to present it. The results showed that it was not difficult for users even with limited experience in the use of mobile services to handle such kind of user model on the mobile device. Although, the presentation of the user model was not intuitive, users liked the idea to have the user model under their control.

4.3. Phase 3: Evaluation

This phase mainly related to the measurement of the effectiveness or success of personalization on mobile services. Moreover, the focus was to evaluate the development done in the Phase 2. The main contribution of this phase is to develop and validate the Mobile Service Personalization Evaluation Model (PEM). In this phase, empirical studies were performed to evaluate the findings of the previous phases. This phase resulted in two contributions C4 and C5. Paper 5 and 6 addressed RQ5. In paper 5, we have developed an evaluation model while in paper 6; an empirical study was performed to validate the model with a working prototype.

4.3.1. Paper 6

Publication Detail: Asif, Muhammad and Krogstie, John: “**Mobile Services Personalization Evaluation Model**”. International Journal of u- and e- Service, Science and Technology 2013; Volume 6.(2) s. 1-12

Abstract: *The proliferation of personalized mobile services is emphasizing the need to determine the users’ perception of how successful personalization is, and how it can be improved and in which facet. For some users, personalization can be useful; others may find it confusing and prefer to turn it off. The motivation of the article is to explore and understand the success criteria of delivering personalized mobile services. The goal of this research work is to develop a theoretical model called Personalization Evaluation Model (PEM) to measure the effectiveness of personalization of mobile services. The main purpose of Personalization Evaluation Model (PEM) is to improve the understanding of the effectiveness of personalization of mobile services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM should provide the theoretical basis for practical testing of the effectiveness of personalized mobile services. The constructs developed for PEM are primarily adapted from the previous research of personalized mobile services.*

Relevance to the thesis: It is important to measure the effectiveness of personalization of mobile services to see how users’ perceive the personalized experience. This article presented an evaluation framework to measure the success of personalization. It also provides an instrument and guidelines to evaluate the success of personalized mobile services. This paper addresses the RQ5 and produce contribution C5.

My Contribution: I was the first author of this paper writing and development of the Mobile Services Personalization Evaluation Model. John Krogstie gave feedback on writing and structuring the paper.

Approach: Different mobile services focused on different aspects of personalization ranging from user interface to highly complex services. The constructs used in PEM are adapted from previous studies and practical examples of personalized services. To do this, a literature review and analysis was done to find out relevant theories that could contribute to measure the personalization. A number of studies were also evaluated to find out the success criteria of the effectiveness of the personalization of mobile services. The main objective of personalization is to increase the user satisfaction with the mobile services; therefore, the primary construct to measure the personalization is user satisfaction. User satisfaction is a general term used to represent overall satisfaction of a user with a service. The construct is very often used to assess the success of various services or systems in different domains such as e/m-commerce, e-Government, and e/m-learning. Personalization has the direct impact on user satisfaction, and it was utilized to measure the construct to evaluate the personalization of mobile services.

Evaluation and Results: The main purpose of PEM was to improve the understanding of the effectiveness of personalized mobile services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM provides the theoretical basis for practical testing of the user satisfaction of personalized mobile services. The main objective of this work is to explore and identify the success criteria of personalization of mobile services. In this study, we have proposed an evaluation model to measure the impact of personalization. Different constructs are adopted from partially evaluated personalized systems or services performed by different studies. User satisfaction is a central construct in this research model due to its high relevance to personalization. Different hypothesis are described to measure the impact of different variables of personalization. We have developed an instrument that can be utilized to measure the effectiveness of personalized mobile services.

4.3.2. Paper 7

Publication Detail: Asif, Muhammad, Salimi, Neberd and Krogstie, John: “**An Empirical Study of a Mobile Services Personalization Evaluation Model**” Submitted for journal publication.

Abstract: *The proliferation of personalized mobile services is emphasizing the need to determine the user’s perception of how successful personalization is, and how it can be improved. The study aims at investigating a research model, called Personalization Evaluation Model (PEM) along with 8 hypotheses to measure the effectiveness of personalization of mobile services. The proposed research model and hypotheses were empirically tested using data collected from a survey of 47 users of a personalized mobile news service. The findings indicated that the fitness of the research model is good and strong support was found for the research hypotheses. The main purpose of PEM is to improve the understanding of the effectiveness of personalized mobile*

services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM provides the theoretical basis for practical testing of the user satisfaction of personalized mobile news services.

Relevance to the thesis: This paper provides empirical study of mobile services personalization evaluation model by utilizing a personalized mobile news service. This study aims to validate the model presented in P5. This study is tightly linked to P5 and addresses RQ5. It contributes mainly to C5. This study contributes to the Phase 3 Evaluation of the thesis.

My Contribution: I was the first author of this paper writing and development of the Mobile Services Personalization Evaluation Model. John Krogstie gave feedback on writing and structuring the paper while Neberd developed the prototype application used to validate the PEM.

Approach: The study aims at investigating a research model, called Personalization Evaluation Model (PEM) along with 8 hypotheses to measure the effectiveness of personalization of mobile services. The proposed research model and hypotheses were empirically tested using data collected from a survey of 47 users of a personalized mobile news service. A personalized mobile news service was developed to deliver personalized news depending on user's context, preferences, interests and device profile.

Evaluation and Results: The findings indicated that the fitness of the research model is good and strong support was found for the research hypotheses. The findings of this empirical study provide some insights to both researchers and practitioners of personalized mobile services. This study contributes to the literature on mobile services personalization and adoption. The findings demonstrated the appropriateness of the research model and hypotheses for measuring the effectiveness of personalization. However, this study has some limitations. Firstly, we have only tested the research model and hypotheses on a single mobile information service (news service). Therefore, the generalizability of the results to other personalized mobile services remains to be determined. In addition, the findings of this study may be limited due to the relatively small sample size. Last but not least, the subjects in the study were asked to download the application on their mobile devices and this study didn't collect the type of devices used for the testing.

5. Evaluation and Discussion of Results

In this chapter we will revisit the research questions described in Chapter 1 and evaluate how we have answered them in our research. This will be followed by the discussion of contribution we have made and relation to the papers published. Finally, we discuss concerns about the validity of our research.

5.1. Research Questions Revisited

In this section, we revisit the research questions stated in Section 1.3 and show how we have answered these. The following Table 5.1 shows which papers answered which research questions.

Research Questions	P1	P2	P3	P4	P5	P6	P7
RQ1	X	X	X				
RQ2		X		X			
RQ3				X	X		
RQ4				X	X		
RQ5						X	X

Table 5.1: The relation between the research questions and the papers

RQ1. What are the research issues in personalization of mobile services?

The first research question was the main focus of the first phase of the overall research (Section 1.5). This research question aims at finding the research issues and challenges related to personalization of mobile services. This research question formed the basis of research reported in this thesis. The identified challenges and research issues in different phases of personalization process helped to formulate the problem domain of the thesis.

In papers P1, P2, P3 we focused on different aspects of the personalization process. We have analyzed various approaches and solutions to different perspectives of personalization. A large number of partly incompatible definitions of personalization exists, thus we have developed our own definition of personalization to reflect the current needs and trends of personalization of mobile services. In this we have identified several conceptual and practical challenges that guided our further research. The main issue is that the personalization is a multidimensional concept and required clear understanding and focus when used in the context of mobile services. Paper 1 helped to understand and define the concept of personalization of mobile services. Paper 2 has

identified several research issues and challenges. And, Paper 3 has described how the personalization is treated so far in the research of mobile services adoption and analyzes how personalization can be significant in acceptance of mobile services.

RQ2. How to achieve privacy enhanced personalization of mobile services?

Privacy is a major concern in personalization of mobile services. This research question helped to explore the different approaches utilized so far to understand how the privacy was maintained in delivering personalized experience. This research questions motivated to identify various challenges and solutions to deliver privacy-enhanced personalization.

Paper 2 revisited the approaches that treated privacy and personalization together. We have highlighted issues in different design approaches and that lead us to develop our own approach to address the challenges. The focus of the Paper 4 was to deliver privacy-aware personalization of mobile service. We have analyzed the requirements of privacy and personalization together in the context of mobile services. Previous approaches of personalization are quite general and have not considered the new requirements and constraints of mobility. First we have designed an approach and then developed an architecture to implement the approach. Later, we have developed an application based on the architecture and evaluated our approach.

RQ3. How to put a user in control of her/his data and overall personalization process?

This research question aims at finding how to put the user in control of his/her personal data and personalization process. This research question helped to explore the possibility of delivering control to the users to achieve a desired level of privacy. This research question is tightly linked to RQ2.

Paper 4 and 5 addresses the research question. To address the research question, we have proposed an approach called mobile client-side personalization. Mobile client-side personalization approach allows a single system to develop and maintain a life-long user model that can be applied to a variety of mobile services. The objective of this paper is to introduce a client-side personalization architecture that incorporates privacy and scrutability of a user model as an integrated part of the personalization process. The proposed architecture and application developed based on the architecture that can accommodate both adaptive and adaptable approach to achieve effective client-side personalization. We are giving users control over their personal data by providing scrutability and dynamic privacy control which is an adaptable part of architecture. However, users will receive personalized contents and recommendations depending on the part of the user model they shared and that reflect the adaptive behavior of the system. The approach showed promising results and turnout to be interesting approach

in designing personalized mobile services that provide more user control over their personal data.

RQ4. How to achieve scrutable user modeling for personalization process?

This research questions aims at finding how to achieve lifelong personalization of mobile services. In addition, it was interesting to find out how the user control and scrutability of user model can help to achieve scrutable lifelong experience of personalization of mobile services. RQ4 and RQ5 are tightly linked to each other.

Paper 4 and 5 addresses the research question. Invisible user models could raise usability issues which can affect the acceptance of the personalized services. The externalization of user models can assist the users to know what information a system is utilizing to provide personalization. This can give an opportunity to complete/correct the user models. Moreover, it can facilitate users to have a sense of control over the adaptation of systems by controlling the user model and, the way that the model is interpreted and the way that it used to perform the personalization. It can help people to become more self-aware and avoid self-deception. Externalization can increase user's understanding of how their user model and feedback contributes to personalization and thereby enhancing their experience of the system. It can also motivate people to share user model data because they feel confident about its meaning and use. The main focus of the study was to find the subjects opinion about the possibility to inspect, modify and take control of their user model. From the results, it is revealed that users agreed to view, manage and control the privacy of their user model. Moreover, it is evident that users strongly agreed on taking control of their privacy elements and willing to manage their user models.

RQ5. How to evaluate and measure the effectiveness of personalization of mobile services?

This research question was the part of Phase 3 of the thesis. This research question targets to understand and measure the personalized experience delivered to the users. It was interesting to find out how to measure the success of personalization of mobile services particularly due to the inherited challenges of mobile devices. Moreover, this research question helped to understand various challenges related to measuring the effectiveness of personalization of mobile services.

Phase 3 of the research study was dedicated to the evaluation of the artifacts/approaches developed in the Phase 2. The main focus of the phase was to address this research question. The study contributes to the literature on mobile services personalization and adoption. Mobile services Personalization Evaluation Model was developed in this phase. In this model, different constructs were adopted from partially evaluated personalized systems or services performed by different studies. User satisfaction is a

central construct in this research model due to its high relevance to the personalization. Different hypothesis are described to measure the impact of different variables of personalization. An empirical study was done to validate the research model. From a survey of 47 users of a personalized mobile news services, we found that perceived relevancy and accuracy, perceived information load, perceived effort, perceived goal fulfillment and device adaptability has direct effect on the user satisfaction while user control and perceived privacy and security has direct effect on trust. The results indicated that the fitness of the research model is good and all eight research hypotheses were supported. In addition, the statistical results of the research model provide insights to better design personalization features for mobile services. The personalized mobile news service used in this study makes an ideal case to validate the personalization evaluation model. The application used was developed by using mobile client-side personalization approach (Phase 2) to deliver new services.

5.2. Evaluation of the Contributions

This section gives an overview of the contributions of our research work related to the papers published as a part of the thesis.

Contributions	P1	P2	P3	P4	P5	P6	P7
C1	X	X	X				
C2		X		X	X		
C3				X	X		
C4						X	X
C5					X		

Table 5.2: The relation between the contributions of this thesis and the papers.

The main focus of this research is to improve the different phases of personalization process of mobile services. To accomplish this, different design approaches are analyzed, and the research challenges related to the personalization of mobile services are identified. The main challenge in personalization process is to evaluate the effectiveness of personalization of mobile services. There is a need to develop an evaluation model which can be used to measure the overall effectiveness of personalization. The next step is to develop privacy enhanced personalization architecture to provide of highly personalized mobile services. Further, an application is built based on this architecture and evaluated by the personalization evaluation model.

C1: Identification of the research issues and challenges in personalization of mobile services.

This contribution is the result of phase 1 of the overall research and consists of three papers P1, P2 and P3. The concept of personalization is multidimensional. So, it was important to understand personalization in the context of mobile services and the needs

of the mobile users. To understand this, we have developed taxonomy of personalization of mobile services which describes various dimensions and levels of personalization needed from a user's perspective. The presented taxonomy in P1 provided the basis for further investigations of the issues and challenges to the personalization of mobile services. It highlighted the requirement of new design approaches to address the concerns and challenges of personalization of mobile services. Depending on the current needs of mobile services, we have defined personalization as:

“Personalization is a controlled process of adaptation of a service to achieve a particular goal by utilizing the user model and the context of use”.

This definition highlighted the need to utilize the user model and the context of use to fulfill the user's goal in a controlled process of personalization which we later called it *scrutable personalization*.

In P2, we have further investigated the challenges faced by various approaches and highlighted the issues that needed to be addressed. In this paper, we have analyzed two main design approaches and have done a comparison to find a suitable approach to deliver personalized mobile services. The aim of the study was to find out how the existing studies are addressing the issues and challenges of the personalization. This forms the basis to explore a better approach to address the challenges identified so far and meet the needs of the mobile users.

We have also looked at the role of personalization in mobile services adoption in P2. Various reasons of the slow adoption of mobile services have been described in the existing literature. The literature of mobile services adoption research has revealed that personalization is not utilized properly. Due to the success of personalization and relevancy in mobile services, we envision that personalization should be an integrated part of mobile services development and adoption. To address this, we have analyzed how and where personalization can play a significant role in mobile services adoption. We have analyzed the role of personalization on different adoption factors suggested in the Technology Acceptance Model [91] as shown in Figure 5.1 Role of Personalization and TAM.

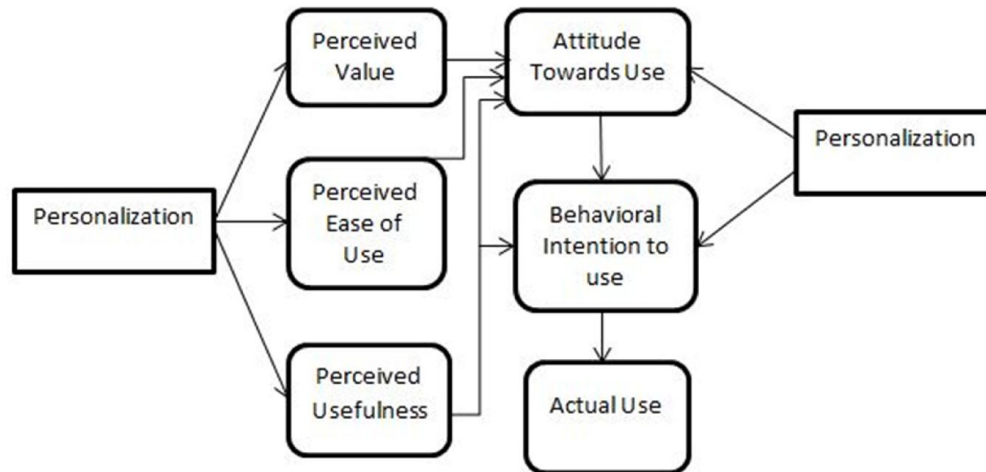


Figure 5.1 Role of Personalization and TAM

In this study, we have found that personalization was not treated as a separate approach, but instead treated as a single adoption factor. We argued that personalization is not treated earnestly in the research of adoption studies of mobile services. We have argued to reduce the gap between the two research areas personalization and adoption of mobile services. It was revealed that using the conventional acceptance theories as the sole research approach does not provide sufficient insights to understand user behavior and intentions towards adoption of mobile services. To make an understanding, we have discussed TAM as described above and highlighted the need to address the factors needed to be addressed at personalized level.

C2: An approach for delivering personalized mobile services.

We have analyzed various design approaches in P2 and discussed challenges / issues of personalized mobile services. It was revealed that privacy is a challenge for personalization of mobile services. Users may have different priorities for privacy. Some people may not want to share much information as they do not have trust in the service provider they are more curious about their personal information. Others may want to share more personal information to gain more personalized experience. However, there are two key issues regarding the personalization of mobile services; the business competition and the privacy. This can be a cause for the service providers to not to share the user information with other service providers.

Client-side personalization provides an important foundation for life-long user modeling, in which the user is able to create, edit, reuse, and extend their user model throughout their digital life experiences. This can also make it possible to keep the user model on the client side and in such way have control over it. A main challenge in user modeling currently is to find a balance between the principles of construction and acquisition of distributed user models. The user model created from one service could

not be reused with another service. This might bode well with the service provider, but, from the user perspective, it is undesirable to create a user profile every time a new service requires it. Client-side personalization can make use of a mobile device as a lifelong user model server can make personalization of services ubiquitous. Users can carry their user models on mobile devices and, this approach can reduce the need for acquisition of the model. In this way, the model can be reused in different services and from other contexts. The user model can be stored physically or logically on the mobile, perhaps with parts made available to different domains.

In this approach, we advocated scrutable mobile client-side personalization. Since privacy is a big challenge in personalization, the main idea was to develop an approach which provides privacy-aware personalization while leaving the user in control of their data. We also advocate that the problem of privacy can be alleviated if the users are given control of their data sharing with different mobile services. Since a user is an owner of their user model. The user should have access to their user model and the processes that created it. There is a variety of methods to collect information about users (implicit or explicit). Another important issue in personalization is to create accurate and comprehensive user model. The process of personalization starts from collecting information about a user, creating user model and adapting the services according to the available context and the user model. The collected information is used to create user models for personalization. The approach in this research is bit different in that a user should build his/her model and share according to the requirements. We think that a user should build his/her model instead of giving raw information to the systems to build a model for the user. A user can share his/her model with different services and his/her requirements of personalization. The users will remain in complete control of his/her model by applying constraints of his/her choices. The approach can have two significant benefits. First, the model will be more accurate and current that is a key to the personalization. Second, the model can be scrutinized by the user and can be updated as his/her interest or requirements changes. It is annoying and inconvenient to repeat the personalization process for the mobile users and repetition can be reduced from the reusability of the user model. User data can be stored and managed locally. Since the data is collected and processed at the user's device rather than the server side, user may perceive more control over their data and perceive less privacy risks. This way of storing and managing the user data at the source also avoids consistency problems of the user model. In the client-side personalization approach, mobile devices are considered as a user modeling platform and user control can be valuable in reducing the privacy challenge. In P5, we have done an empirical study to verify the feasibility of doing scrutability of user model on mobile devices and it revealed promising results.

C3: *Development of mobile client-side personalization architecture.*

A mobile client-side personalization approach allows a single system to develop and maintain a life-long user model that can be applied to a variety of mobile services. The objective of the P4 was to introduce a mobile client-side personalization architecture that incorporates privacy and scrutability of a user model as an integrated part of the personalization process. It has been attempted to combine both adaptive and adaptability within one architecture. However, mobile devices have issues of limited bandwidth, processing power and storage capacity which can be a challenge for this approach. The cross platform availability of the user model will remain an open question for this approach.

In general, there is a tradeoff between privacy and personalization. It is essential to put the user in control to achieve the personalization of a required level. The more information a user reveals a more personalized experience can be achieved. It is a difficult task to achieve the desired level of personalization and privacy at the same time. To address this challenge, we have developed an architecture that can address privacy and personalization together. Moreover, the architecture is designed to put the users in control of their personal information. The purpose was to provide an architecture that can meet the above mentioned objectives in a flexible and scalable way. Moreover, the architecture support the end users to (a) check, what information is in the user model, (b) modify the information in the user model, (c) scrutinize, when other services access or attempt to modify their user model and, (d) understand how their shared user model affects the service personalization and their experience. The following Figure 5.2 Mobile Client-side Personalization Architecture shows the basic architecture of a mobile client-side personalization to convey the essence of privacy, scrutability and personalization together. We also advocated that scrutable personalization layer should be added at OS level of mobile devices to meet the challenges of privacy and personalization together.

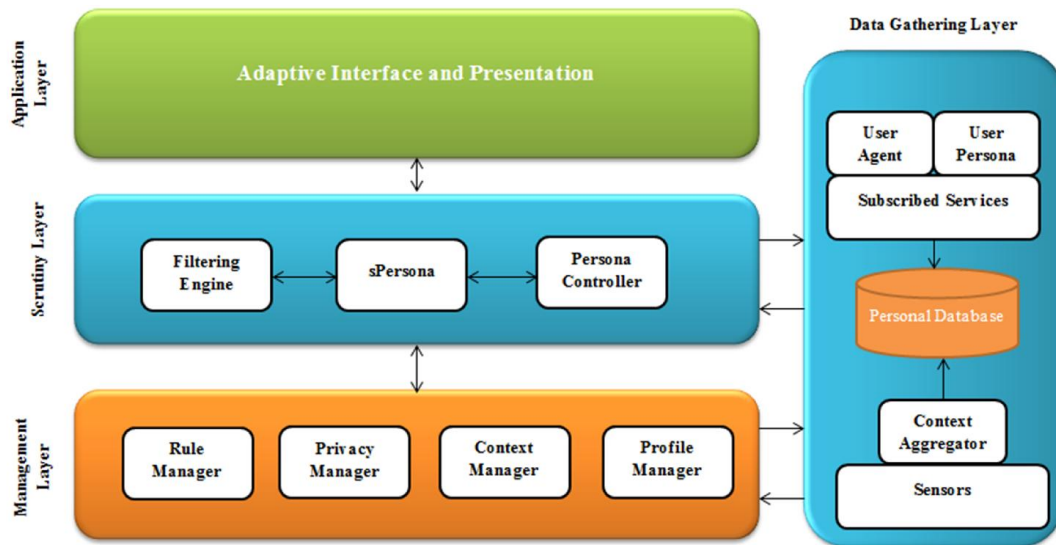


Figure 5.2 Mobile Client-side Personalization Architecture

C4: Development of Mobile Services Personalization Evaluation Model.

Personalization has become an essential feature of mobile services. A number of mobile service acceptance and adoption studies has identified and measure various adoption factors. It was found that personalization is treated as single adoption factor to measure. It is not an appropriate approach to ask users whether they like personalization or not as a single adoption factor. Instead, it requires measuring various elements to understand the effectiveness of personalization of mobile services. It is evident that existing literature has not provided adequate theoretical and empirical evidence to show whether the user likes personalized services. It showed a huge gap in the context of measuring the effectiveness of personalization of mobile services.

We have developed an approach and instrument to measure the effectiveness of personalization from various perspectives. We have broken down the concept of personalization into various constructs which were used in different mobile services acceptance studies. We have also looked at different theoretical foundations for measuring the personalization and developed relationships among the constructs as shown in Figure 5.3 Mobile Service Personalization Evaluation Model

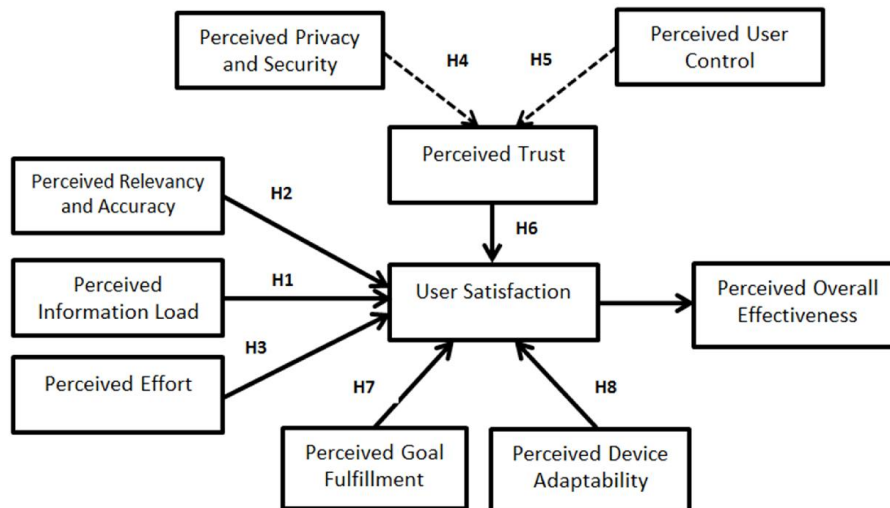


Figure 5.3 Mobile Service Personalization Evaluation Model

Paper 6 mainly contributed to the development of mobile services of Personalization Evaluation Model (PEM). In this paper, we have proposed conceptual definitions of the research variables or constructs used. We also hypothesized the relationship among the research variables as shown above. We have developed an instrument to verify the hypotheses. Paper 7 aims at investigating a research model, called Personalization Evaluation Model (PEM) along with 8 hypotheses to measure the effectiveness of personalization of mobile services. The purposed research model and hypotheses were empirically tested using data collected from a survey of 47 users of a personalized mobile news service. The findings indicated that the fitness of the research model is good and strong support was found for the research hypotheses. The main purpose of PEM is to improve the understanding of the effectiveness of personalized mobile services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM provides the theoretical basis for practical testing of the user satisfaction of personalized mobile news services.

C5: Identification of the prospects of scrutable personalization of mobile services.

In most of the personalized systems, the user model and the personalization process remains invisible. Users do not have direct access to the information the system collects about them and do not have control over the personalization behavior. This can raise a number of critical usability and privacy issues that can hinder the acceptance of personalized mobile services. Since scrutable personalization has not become an integral feature of personalized mobile services, a user with average experience might not have developed the prospects of how to control the user model and personalization effects.

This contribution is related to know if users are interested in or willing to actively set up and maintain their user model on mobile devices. To understand this, we focused to externalize the user model of mobile services. The externalization of user models can assist the users to know what information system is utilizing to provide personalization. This can give an opportunity to complete/correct the user models. Moreover, it can facilitate users to have a sense of control over the adaptation of systems by controlling the user model and, the way that the model is interpreted and the way that it used to perform the personalization. It can help people to become more self-aware and avoid self-deception. Externalization can increase user's understanding of how their user model and feedback contributes to personalization and thereby enhancing their experience of the system. We have utilized a working prototype of an interactive user model of a personalized mobile news service and collected 47 responses from a variety of users. In this process, we have externalized the model from three perspectives, *viewing the user model*, *managing the user model* and *scrutability of privacy preferences*. It was revealed that users showed great interest in inspecting the preferences and privacy elements shared with a mobile service. We also received a considerable positive response on that users are willing to manage or correct their preferences. The results showed that it was not difficult for users even with limited experience in using mobile services to handle such kind of user model on the mobile device.

5.3.Threats to Validity

This section discusses some threats to the validity of our research. We have described following threats depending on the potential types of threats described in [129].

5.3.1. Internal Validity

Internal validity is concerned with the relationship between the cause and effects of an observation. It can affect the outcome of an experiment without the researcher's knowledge. For example, a participant of an experiment is not putting his/her best effort into the experiment.

In our empirical studies, the subjects were students at our department or from other departments. Factors that can influence the subjects' performance are, e.g., competitiveness (similar research area), existing relations with the researchers, teacher/student relationships. There was no direct teacher/student relationship between the authors of the papers and the study participants. There lies a potential threat to the outcome of our studies in using subjects in the vicinity of the researchers. For example students and friends may feel obliged to perform the evaluation in a certain way. In the study of Paper 5 and Paper 7 the evaluation time was 45 mins to 1hrs. Hence we consider the amount of work as a small risk. The mobile applications used in both

experiments may not be of interest to the users. There is a risk that users get bored or tired with the task resulting in a loss of focus.

5.3.2. External Validity

External validity is concerned with whether the findings can be generalized to other settings. Typical threats of this kind include the representativeness of the subjects with respect to the target population, and whether the problems studied are representative.

The first potential risk to external validity we have identified is the relation between the evaluation subjects and the population we want to generalize to. All test subjects were students of different departments. This means that we have dealt with a homogeneous population which cannot be generalized. In paper 5, the application tested was not fully functional and users' were not able to analyze the outcome of the idea. Moreover, this kind of applications requires long term evaluation and it can be difficult to understand the scrutability. In paper 7, the users were given an application to test but it was difficult to verify all the elements of the personalization. It requires more time for the users to understand all the aspects of the personalized mobile service.

The second potential risk to the external validity is posed by the collection of data. In paper 7, we have given an online questionnaire with the application link to be installed and tested. It was not clear that which kind of mobile devices have been used by the users and in which way.

5.3.3. Construct Validity

Construct validity is concerned with the relationship between the concepts and theories that are the basis for the experiment and the observations made, or in other words, what is measured. Examples of such threats are concepts that are not clearly defined, and subjects who are not sufficiently trained.

In the empirical studies (P5,P7), all users received a written description of the task and definitions of the most important concepts related to the task. Some participants were of average knowledge and skills. This might have affected results since this group of people had a different starting point than other potential users, which in turn may have affected the measurements made.

5.3.4. Conclusion Validity

Conclusion validity is concerned with the reliability of the observed effects of the experiments. A typical example of such a threat would be if the measurements made are not trustworthy, i.e., the reliability of the experimental measurements is not high enough.

The first threat to conclusion validity we have identified is the number of evaluation subjects. If the number of evaluators is too low, the reliability of the results could also

be low. The number of participants in both studies (P5, P7) was range from 42-47 and this can affect the validity of the results. In both the studies, users were required to explore various aspects of the system and there is a chance that user does not perceives an exploratory task as exploratory. However, the conclusion may be influenced falsely since the user did not evaluate the system according to the researcher's intention. On the negative side, the result may be interpreted as the user's finding the system useless, "giving up" after a single query. The conclusion will also in this case be influenced falsely.

6. Conclusion and Future work

This chapter gives the conclusions of the thesis and describes our most important insights. We will also suggest future areas of work.

6.1. Conclusions

Personalization of mobile services is becoming an urgent need in this era of information overload. Both users and service providers of mobile services are facing different conceptual and technical challenges of achieving personalization. The research area is equally popular among both industrial and academic researchers. This thesis has focused on how to achieve scrutable mobile client-side personalization while keeping the user's privacy. The issue of privacy in personalization of mobile services can be reduced by shifting the control of their personal information towards the users. To guide the research process, we have posed five research questions (Section 1.3) which were answered in Chapter 4. The research led to five contributions (Section 1.4) to the research field which were published in seven scientific research papers.

We have described our research goal earlier (Chapter 1 and 3) mainly consists of following elements:

- To understand and improve the personalization process.
- To develop an architecture for scrutable mobile client-side personalization.
- To develop an evaluation framework to measure the effectiveness of mobile services personalization.

We have approached the problem by identifying various issues and challenges in personalization of mobile services. The main focus of this research was to improve the different phases of personalization process of mobile services. To accomplish this, different design approaches are analyzed, and the research challenges related to the personalization of mobile services are identified. Depending on the results achieved, we have defined the personalization and developed a taxonomy of personalization to highlight the trends and needs of the mobile services personalization. We have also looked at the role of personalization in mobile services adoption. Various reasons to the slow adoption of mobile services have been described in the existing literature. Due to the success of personalization and relevancy in certain mobile services, we envision that personalization should be an integrated part of mobile services development and adoption. We advocated scrutable mobile client-side personalization. Since privacy is a big challenge in personalization, the aim was to develop an approach which provides privacy-aware personalization while leaving the user in control of their data. We also advocate that the problem of privacy can be alleviated if the users are given control of

their data sharing with different mobile services. We have developed a mobile client-side architecture which provides scrutable personalization while keeping the users' privacy.

Another challenge in personalization process is to evaluate the effectiveness of personalization of mobile services. There is a need to develop an evaluation model which can be used to measure the overall effectiveness of personalization. We have developed mobile services personalization evaluation model and instrument to measure the effectiveness of personalization from various perspectives. We have broken down the concept of personalization into various constructs which were used in different mobile services acceptance studies. We have also looked at different theoretical foundations for measuring the personalization and developed relationships among the constructs.

6.2. Future Work

Finally, we would like to make a few suggestions for future work.

- Since our mobile client-side architecture was utilized only to develop personalized mobile news service. It requires to be applied on different domains of mobile services such as mobile shopping, personalized food, mobile learning etc.
- The limitation of our study is that we have investigated the concept of scrutability only with personalized news services. The concept of scrutable mobile client-side personalization requires more empirical investigation in different domains of mobile services.
- We have suggested that scrutable personalization should be addressed at OS level to gain lifelong privacy-aware personalized experience.
- We have developed and empirically tested mobile services personalization evaluation model (PEM) to measure the effectiveness of mobile services personalization. It requires more empirical investigations in different domains of mobile services.

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Appendices

Selected Papers

Paper 1

Asif, Muhammad and Krogstie, John: “**Taxonomy of Personalization in Mobile Services**”.
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TAXONOMY OF PERSONALIZATION IN MOBILE SERVICES

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ABSTRACT

Personalization of mobile services is a growing trend. The increasing capability of smartphones and enabling technologies has opened many possibilities of personalizing mobile services. There are different levels of personalization ranging from personalized wallpaper or ringtones to complex mobile services. The goal of personalization is to support the user by providing the right service at the right moment. Based on recent trends in mobile personalization, a definition of personalization is given. The factors such as *user needs and goals*, *choice and flexibility*, *control and privacy* which are of highly importance for the true realization of personalized mobile services are discussed. The combination of context-awareness and user-modeling is becoming a key approach in delivering personalized services. Based on this trend, three generic levels of personalization: *Basic personalization*, *profile based personalization* and *contextual personalization* are presented to give insight to design perspectives of personalization in mobile service.

KEYWORDS

Personalization, Mobile services, User profile, Privacy, User modeling and Context-awareness.

1. INTRODUCTION

The increasing variety of mobile services raises the need for users to find out how particular services are beneficial to them. Personalization can play a significant role to select and adjust their favorite services from the rapidly increasing diversity of mobile services. Personalization has been involved in many research areas having varied focus and implications which makes it a multidimensional concept. So far the focus of personalization has been on the systems or applications intended for Web or stationary computers (Sunikka & Brage, 2008). There is a growing need to deliver only the information that is of direct relevance to an individual for a specific purpose at any point in time (Kim, 2002).

In general, personalization is about choice, flexibility and control and it is about people knowing what their needs are and the people that have control over how those needs are being met. For example, personalized news service can deliver news during the day about user's working interests and entertainment news in the evening. In another case, a user usually does shopping during the weekend and wants to receive advertisement only at the weekend; a personalized advertisement service can send advertisements on the days preferred by the user. For the user, it is important to be in charge of the flow of information and services. Personalization aims at supporting users in selecting their favorite services from the rapidly increasing diversity of mobile services and adjusting selected services to their individual needs. According to (Zimmermann et al, 2005) delivering relevant information has two main facets. First, personalization allows users to obtain information that is adapted to their needs, goals, knowledge, interests or other characteristics. User models deliver the main parameters for selecting and adapting information presentation to the individual user. Secondly, contextualization complements personalization so that environmental states or the context of the use can also be taken into account.

In recent years the focus of personalization has changed from simple system personalization to complex service oriented personalization. Users and service providers of mobile services are facing different conceptual and technical challenges of achieving personalization. It is very important to understand what information different types of services require and what information users are willing to reveal for those services. According to (Heikinen et al, 2004) there is a need to find out that for what services, what personal

information the users are willing to share with the surrounding services in order to encompass the service provisioning based on personal information.

However, the meaning of personalization is context sensitive hence it is important to define and understand it clearly from the perspective of mobile services. As described by (Haiyan & Marshall, 2006) that “*the current practice of focusing on ‘how to do personalization’ rather than ‘how can personalization be done well’ suggests that the field is still in its infancy*”. In a way, personalization is a practice that is shaped by the designer’s motives for personalization and viewpoint on “what personalization really is.”

2. MOTIVATION FOR PERSONALIZATION OF MOBILE SERVICES

Personalization has the potential to offer many benefits particularly in reducing information load and finding relevant information (Simon et al, 2010). Users of mobile technologies are getting exposed to information and services, without being able to control the flow of services. Various mobile devices (smartphones, tablets etc.) can be used to access information and services. Due to variety of mobile services, there is an urgent need to filter information, adapt it, and customize it, not only to the individual user but also to the current context of use (Oppermann & Specht, 2000). They further recommended that the future applications must consider the user profile, history and current context of use. Personalization is not only limited to ringtones or logos but now it can be realized at various levels of complexity. Mobile devices can enable context-awareness and personalized data services (Lankhorst et al, 2002) which makes it an ideal tool for personalization. This can offer unique opportunities of providing personalized mobile services to the dynamic.

On the other hand, service providers are delivering multiple types of mobile services. Service providers are facing difficulties in targeting the right user groups, thus missing valuable customers. Hence, personalization is a desirable property of both existing and future services. The main goal of personalization should be to improve the overall experience of user with mobile services. As described by (Ho & Bull, 2010) that the immediate objectives of personalization are to understand users’ preferences and contexts to deliver highly focused, relevant contents matched to their needs. The benefits to mobile users include more relevant contents and fewer problems with information overloading. Providing personalized information to mobile users will create better user satisfaction and will in turn increase the demand for mobile services (Xu et al, 2008).

Early focus of personalization was on content adaptations in different information systems. The meaning and approach of personalization are still needed for mobile services as it is a compelling feature of mobile communication systems for both end users and service providers. However, mobile users can have different needs and focus other than traditional approaches of personalization. Furthermore, mobile devices have some inherent constraints such as limited input-output, wireless connectivity, and computational power and battery issues. All these constraints require specific approaches for personalization. There is a demand to explore more about personalized mobile services and more work is needed to identify new and useful mobile applications and services, including those dealing with personalization of mobile content and location-awareness.

3. DEFINING PERSONALIZATION

There are various definitions of personalization in the literature with different focus. Our objective here is to define and understand personalization from the perspective of mobile services. We have to identify important design factors for practical personalization in mobile services. We have chosen some definitions which are relevant to our focus. Personalization is defined by (Jørstad. et al, 2004) as “*Personalization of a service means that mechanisms exist to allow a user U to adapt, or produce, a service A to fit user U’s particular needs, and that after such personalization, all subsequent service rendering by service A towards user U is changed accordingly.*”

Personalization is defined by (Mussi, 2007) as “*a process of changing a system behavior to increase its personal relevance*”. Another study by (Staffort & Gillenson, 2003) has described that personalization of services is to adapt services to fit the needs and preferences of a user or a group of users. In another study

(Blom, 2000) has defined personalization as “*a process that changes the functionality, interface, information content, or distinctiveness of a system to increase its personal relevance to an individual*”. According to (Riecken, 2000) personalization is about mapping and satisfying user’s goal with respect to service’s goal. (Krogstie et al, 2004) has stated it as “*Personalization means information systems that both automatically adapt themselves to the preferences of the user and that can be explicitly tailored by users through a specific user interface*”. Due to the relevancy of user modeling and context-aware approach, we define personalization as “*Personalization is a controlled process of adaptation of a service to achieve a particular goal by utilizing the user model and the context of use*”.

Some key elements for personalization of mobile services are:

User needs and goal: Sending information about relevant events when it is impossible for the receiver to attend or react to the information (e.g. because the user is in a different city). Sending information about something that is not relevant for the user, (e.g. about a shop where the user never buys anything because it is not of his style), when the user has stated explicitly what he prefers will not be beneficial for the user. Sending irrelevant information at all when the user has signed up for information has a negative effect. The user needs should result in a goal that can be explicitly or implicitly stated, and result in the delivery of a reply to the user’s device, where the reply consists of a result that should satisfy the initial need of the user (Asif & Krogstie, 2011). A common characteristic of any personalization strategy is the necessity to understand and represent user needs, interests, and requirements. The quality of that representation is a major factor in the value associated with the personalization service itself (Perugini & Gonçalves, 2002).

Choice and flexibility: Choice and flexibility can be different at different levels of personalization. For practical use of personalization, it should be easy to use. To be easy to use, it is a presumption that it is quick to learn, and that result of the personalization appears without delay. Also, it is advantageous to avoid current explicit extensive manual configuration. The personalization possibilities should also be available when they are needed. In principle, personalization is concerned with matching and negotiation between user requirements and abilities on one hand and service offerings and resulting adaptation of network and application level services on the other hand (Lankhorst et al, 2002).

Control and privacy: In order for services to be personalized, the user not only interacts with the (primary) service itself, but also provides information on his or her personal preferences, and access rights to this personal information (Lankhorst et al, 2002). The user model that drives personalization is normally based upon user’s personal information and there many are concerned about privacy (Simon, G. et al, 2010). It is very important to understand what information different types of services required and what information users are willing to reveal for those services. In personalization, users should have control over personal information to keep their privacy (Korth & Plumbaum, 2007). User should be aware of the services s/he is using and the personal information required for that service. To control such kind of services and personal information can pose different challenges. One such challenge is to provide a user interface (Heikinen et al, 2004) to handle such services and privacy at the same time. Trust on mobile services is another major issue as described by (Ho & Bull, 2010). Trust has direct impact on the adoption of mobile services (Ho & Bull, 2010; Gao, S. et al, 2011). With increased personalized, the privacy and control of data should continue to be considered in every service.

4. DIMENSIONS OF PERSONALIZATION

Some major dimensions of personalization such as *implicit* or *explicit*, *static* or *dynamic* and *system* or *user oriented* is briefly described in this section.

4.1 Implicit or Explicit

Jørstad (Jørstad. et al, 2004) has split the personalization of services in two. Explicit personalization is where one of the parts sets the parameters of the service manually. Implicit personalization is related to mechanisms connected with the service more or less continuously to adapt the service according to specific user behavior and assumed requirements. Implicit personalization has challenges of recording, storing, processing and analyzing information about users to adapt the service. The study (Haiyan & Marshall, 2006) describes personalization in which the user participates by making choices or providing information to give the system

guidance as to how to adapt is termed explicit personalization. Personalization that is done automatically by the system is termed implicit personalization. According to (Barnes, 2002) a user model is an explicit representation of properties of a particular user, which allows the application to adapt diverse aspects of its performance to individual user's needs.

4.2 Static or Dynamic

Because of the variety of input and output channels, new forms of interaction and continuous updates of user and context models become more important. Basic information of a user remains the same and can contribute to the static part of personalization. Various parts of the user profile remains static for a long period. User can have short or long term preferences which can lead to static or dynamic aspects of personalization. User's context is dynamic and contributes to the dynamic part of personalization. In mobile service personalization, it is important to understand the static and dynamic parts of personalization. Some services may only require static information or some may require real-time information about the user. (Hella & Krogstie, 2010) has divided this information into three categories, 1: Personal information consists of categories of information that is common for all users. It changes seldom and typical examples are name, birth date and address. 2: Stable interests. It is called stable because the type of information does not change frequently, due to importance and relevance of the information to long-term interests of the user. 3: Temporary interests. For a limited time period a user could be interested in for example buying a new digital compact camera. As soon as the goal is fulfilled information in this domain is no longer required.

4.3 System or User-Oriented

Both the system and user can participate in the personalization process (Blom, 2000). A user can subscribe to some services or system can recognize some aspects of user's interactions. But user must have control to accept or reject the choices the system makes. Managing the degree of initiations can play a vital role in achieving a reasonable level of personalization. According to (Jørstad, et al, 2004) explicit personalization either user or service provider has to adjust some parameters for service.

5. LEVELS OF PERSONALIZATION FROM A DESIGN PERSPECTIVE

There are various design approaches with different emphasis of personalization. Modern personalization seems to have different kinds of meanings, from location diagnosis, fitting the visual layout of the message to data terminal equipment, tailoring the content of the message, and tailoring the product. It is easy to get confused with different focus of personalization. If there is no common framework of personalization, there are problems because parties involved do not understand each other (Vesanen, 2007).

There are different technical approaches to achieve personalization such as machine-learning algorithms, agent technology and ubiquitous and context-aware computing (Haiyan & Marshall, 2006). Each approach has a different focus on personalization. Context-aware approaches seem to be most suitable for personalization of mobile services. Context-awareness is one of the key enabling factors for providing personalized services (Liao et al, 2004), (Asif & Krogstie, 2011). Presentation of personal information can play a vital role and hence user modeling is an important feature for personalization (Heikinen et al, 2004). The user model can be used as a building block of personalized service provisioning. Personalization is a practice that is shaped by the designer's motives for personalization and viewpoint on "*what personalization really is*" (Haiyan & Marshall, 2006). Two types of personalization called '*preference personalization*' and '*location personalization*' was studied by (Ho & Bull, 2010).

Different mobile services may require different level of personalization. As described by (Krogstie et al, 2004) personalization becomes increasingly important, both at the individual level where user-interface details such as commands and screen layout are tailored to personal preferences and hardware, and the work level where functions are tailored to fit the user's preferred work processes. So it is important to identify and understand these levels which can be achieved for particular mobile services. These can help to understand the requirement of personalization needed for a particular service and the design concerns. These levels of

personalization based upon user-modeling and context-aware approaches are identified are described in the following sections.

5.1 Simple Personalization - Basic Level

At this level, personalization remains static after the preferences are selected and set. This includes manual settings of look and feel, display properties and sound preferences. The main focus of this kind of personalization is presentation which requires no knowledge of the user except a few representational preferences. The user chooses and the application will behave according to the user's choices. For example if the user wants to save battery life, s/he can customize the power profile to fulfill his requirements. This becomes more interesting with new modalities of interfaces such as speech recognition, synthesis etc. (Krogstie et al, 2004)

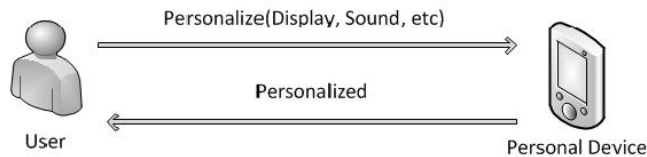


Figure 1. Basic personalization-Level 1

5.2 Profile-based Personalization - Second Level

By knowing something about the user, it will be much easier to improve the quality of services delivered to a user. Information about a user can be used to target services directly to a specific user. To provide personalized mobile services, different types of information are useful. Here our focus is on user's personal profile. The profile contains all the information related to a person as an actor, his goals etc., and follows the user everywhere independently of the context. The information that is to be captured in the personal profile can be divided in three main parts: personal information, stable interests and temporary interest (Hella & Krogstie, 2010). This level provides adaption capability by utilizing user profile either created explicitly or implicitly. User profile describes user related information such as preferences, history, interest and roles or tasks. According to (Zhang, 2003) the user's profile may include user ID, background information, interest and preferences. A list of different types of profiles with varied emphasis is described by (Korth & Plumbaum, 2007) which includes *personal profile*, *preference profile*, *relationship profile* and others. At the same time, personalization of this level can be of any dimension as described in section 4.

Personalized news services (Billsus & Pazzani, 2000; Liu et al, 2010) such as personalize Google news, Yahoo, Lycos and Excite require simple user profiles which represents user's long or short term interests to receive personalized news.

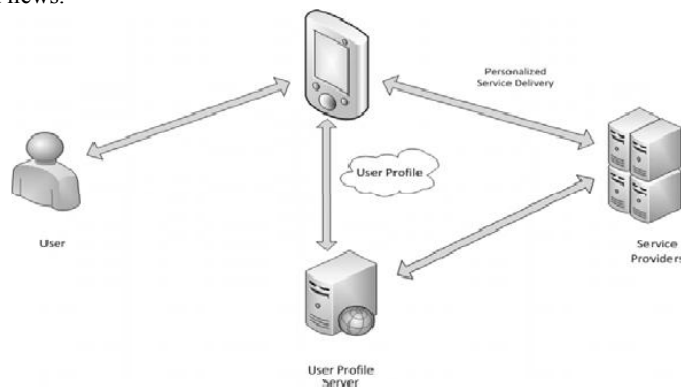


Figure 2. Profile based personalization -Level 2

Direct marketing through SMS messages based on collected information about user behavior through profile subscription has been seen as a powerful personalization feature (Jørstad. et al, 2004). Personalized

mobile service for food shopping (Hella & Krogstie, 2010), personalized product details and in-store customer advice (Jun et al, 2009) and personalized services in mobile learning (Zare, 2011) are similar kind of services.

5.3 Contextual Personalization -Third Level

Personalized services at this level demands both user modeling and context-aware techniques. It is very important to take advantage of the relationship between user profile and user context. At this level, services can be adopted at different levels with the agreement of the user or in compliance with user's context and user model available. The focus of this level is to integrate user's profile and contextual information for personalized services. The services designed at this level are able to adapt to the user situation. Depending on the requirements of personalization at this level one can adapt to any of the dimensions described in section 4. Personalization at this level is extended by context-awareness which can enhance user experience (Asif & Krogstie, 2011). It requires modeling both the user and the context. The context elements (Dey & Abowd, 2000; Krogstie et al, 2004; Sigg et al, 2010) that can play significant role in personalized services are many but here we described only primary level context:

- *Identity*: It is the primary element of user's context which can be used to derive secondary context. This identity information can be utilized in a variety of ways to provide personalized mobile services. Usually identity is static information about a user that very seldom changes.

- *Location*: Location is a crucial element of user's context. Simply knowing that a person is "at home," "in office," "in car" is often sufficient for applications to carry out predetermined actions in given situation, such as turning off a cell phone during a meeting. Other services might utilize the geographical position of the user (e.g. listing the nearest resources of a certain type such as the nearest restaurant).

- *Time*: To get the right information at the right time is beneficial. For personalized services, it will be inconvenient for user if we send information at the wrong time and wrong place.

- *Task or Activity*: It describes what the user is doing. The task context may be described with explicit goals or the tasks and task breakdown structures.

By combing the context information and user profile one can enhance the user-experience with the service. As stated by (Zimmermann et al, 2005) the combination of user model and context model can provide valid models for personalized and contextualized services. Recently, personalized mobile advertising services are utilizing the user's profile and context to enhance the experiences of user. One may expect mobile advertising to be even more appealing to consumers who use *location-sensitive* and *time-critical* m-commerce applications (Xu et al, 2008). The utilization of time- and location-awareness as personalization variables can be highly beneficial.

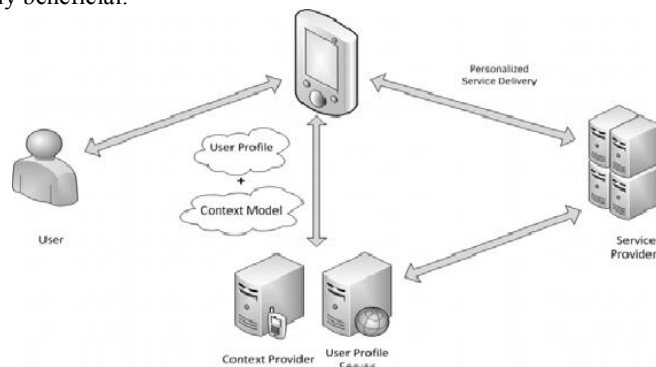


Figure 3. Contextual personalization- Level 3

Personalized geonotes (Brem et al, 2010) are particularly appealing as a means of providing rich personalized information about cultural heritage sites. These kinds of applications offers a way to reduce, perhaps avoid, the anticipated information overload by utilizing user model and the context of use. The three main application areas of contextual personalization are 'Where am I' services, 'point of need information delivery', and 'industrial or corporate' services (Ho & Bull, 2010). All these three areas somehow utilize user's profiles and few context elements such as location or time to deliver mobile services. The study

(Gummerus & Pihlström, 2011) has introduced mobile value framework which shows how context value can enhance the user experience with personalized mobile services.

There are two main streams of research in personalization, one is about technical aspects of personalization and other is about user's behavior (Ho & Bull, 2010). The design perspectives of personalization presented above can delineate the new approaches of designing personalized mobile services. These can help to describe general design choices and guidelines for personalized mobile services. This distinction of levels can help to understand the design requirements at each level of personalization. Personalization at different levels has different issues and concerns. Different levels of personalization are also posing some challenges on both user behavior and technical aspects. Personal Service Environment suggested by (Lankhorst et al, 2002) provides a mechanism to assist a user in finding, adapting and using services that fulfill his needs given his personal profile, his mobility and his context. However, with increasing level of personalization, users are becoming more suspicious about why and how mobile service providers use their personal data, resulting in high distrust (Ho & Bull, 2010). To provide a common frame of reference in understanding, designing and analyzing personalized services, these levels of personalization can help to describe the functional elements needed for service-oriented personalization.

6. CONCLUSIONS AND FUTURE WORK

Providing the same contents or information to everyone at the same time may end up not serving anyone. We have to understand real user needs before delivering the personalized service. User must have control over the service to personalize it; on the other hand service delivered should have the flexibility to fulfill the user's needs. Depending on the user's needs not every personalized service require real-time user context or user model. We have to find out which level of personalization is required for a particular service. One challenge is to find out how to provide personalized services that leave the user in control. The challenge of privacy can be treated as a part of personalization preference and hence should be the part of service delivery. Privacy can also be handled by shifting the control to the user's end which in turn will increase the level of trust. This taxonomy can be used as a basis for the further development of a personalization framework for mobile services.

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Paper 2

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Research Issues in Personalization of Mobile Services

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Abstract — Personalization is gaining more importance with the increase of mobile and community services. Provision of personalized mobile services can help to meet the individual needs at a time and place when and where a user needs it. Mobile services should be designed to be usable and useful to realize the benefits of personalization. It is not an easy task to satisfy the individual's goals or needs. Currently, mobile services are designed either using a client side or server-side approach. At the same time, it is raising different research issues ranging from technological to security or privacy concerns. In this work, we described the current research and development in the area of personalization of mobile services. The objective of this paper is to analyze which design approach is suitable for the personalization of mobile services. Finally, we have discussed issues and challenges related to client-side personalization vs server-side personalization and the recent trends in personalization of mobile services.

Index Terms — mobile services, personalization, user model, context model, mobile information systems

I. INTRODUCTION

The increasing range of mobile services raises the need for users to find out how services are beneficial. Personalization can play a significant role to select and adjust favorite services from the rapidly increasing range of mobile services. Sometimes users receive a lot of information that is irrelevant or sometimes miss urgent messages. In this setting, users demand filtered and related information according to their needs^{[1][2]}.

In general, personalization is about choice, flexibility and control, and it is about people knowing what their needs are and that people have control over how those needs are being met. For example, a personalized news service can deliver news during the day about user's working interests and entertainment news in the evening.

In another case, a user usually does shopping during the weekend and wants to receive promotions only in the weekend; a personalized advertisement service can send advertisements on the days preferred by the user. For the

user, it is important to be in charge of the flow of information and services. According to^[3], delivering relevant information has two main facets: first, personalization allows users to obtain information that is adapted to their needs, goals, knowledge, interests or other characteristics. User models deliver the main parameters to select and adapt the information to the individual user. Secondly, contextualization complements personalization so that the context of use can also be taken into account. We have earlier presented a taxonomy of personalization^[4], and defined as “*Personalization is a controlled process of adaptation of a service to achieve a particular goal by utilizing the user model and the context of use*”.

So far the focus of personalization has been on the systems or applications intended for Web or stationary computers^[5]. In recent years, the focus of personalization has changed from a basic system personalization to complex service oriented personalization. Users and service providers of mobile services are facing different conceptual and technical challenges of achieving personalization. It is extremely valuable to understand what information different types of services require and what information users are willing to reveal for those services. According to^[6] there is a need to find out that for what services, what personal information the users are willing to share with the service providers in order to encompass the service provisioning based on personal information.

However, the meaning of personalization is context sensitive, and it can be beneficial to define and understand it clearly from the perspective of mobile services. As described by^[7], “*the current practice of focusing on ‘how to do personalization’ rather than ‘how can personalization be done well’ suggests that the field is still in its infancy*”. In a way, personalization is a practice that is shaped by the designer's motives for personalization and viewpoint on “what personalization really is.”

The rest of the paper is structured as follows: Section 2 describes the driving factors for personalization. The main design approaches for personalization of mobile services are described in section 3. Section 4 discusses client-side personalization and server-side

personalization approaches and related issues. Section 5 concludes the paper.

II. DRIVING FACTORS FOR PERSONALIZATION AND RELATED WORK

A common characteristic of any personalization strategy is the necessity to understand and represent user needs, interests, and requirements^[8]. Context-awareness and user modeling are considered as two key research areas which are contributing for adaptation and personalization of services. Both research areas have a

strong role in providing personalized services and information delivery to the users. Analysis of similarities and difference between these two approaches can be useful to understand personalization better. Both research fields are contributing to personalization research particularly in personalized mobile services. A study^[9] has made similar analysis describing the relationship between these two approaches to design a context-aware Personal Digital Secretary. This study utilizes both a context model and a user model to design the application. According to the requirements of the application, they have compared both context and user model as follows:

Issues	Context Models	User Models
Data Acquisition	Mostly collected from all types of sensors	Mostly built from user interactions
Coupling to Applications	Can be insulated from applications	To be a part of an application could be more efficient
Representation	A data model represents various context elements	A data model represents a user's facts, or a behavior model or a combination of both
Time period required for data acquisition	There is no time gap to capture a user's context but may require sometimes to process	Sufficient time and interactions (Cold start problem ^[35]) required for behavior model to learn a user's behavior

Table 1. A Comparison of Context and User Model^[9]

2.1 Context and Context-awareness

The use of context-information can play a significant role to personalize the systems. According to Dey and Abowd^[10], "*Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves*". The utilization of context is extending the problem space for the personalization of mobile services. It is required to understand which context information is necessary and how to represent it using a context model to design any context-aware application. "*A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task*"^[10]. Context modeling is a hard problem due to its complexity and the multitude of different applications. It is required that only relevant context information should be considered for different application scenarios. Associating the context to user's preferences can play a significant role for personalized services^[11].

Quality of the available context information is a fundamental issue. It is exceedingly hard to collect complete and accurate context information. According to^[12], it is evident that sensed context information is often inaccurate or unavailable as a result of noise or sensor failure. Moreover, user supplied information is subject to problems such as human error and staleness. Different types of context imperfections discussed by^[12] are *unknown* (when no information is available), *ambiguous* (several different values exists), *imprecise* (information

is correct, but inexact), and *erroneous* (mismatch between actual and determined value). Mobile applications have the opportunity to take context into account. In^[13], a high-level categorization of context is provided as follows:

- (1) The spatio-temporal context describes aspects related to time and space. It contains attributes like time, location, direction, speed and track.
- (2) The environmental context captures the entities that surround the user, for example, physical objects, services, temperature, light, humidity and noise.
- (3) The personal context describes the user state. It consists of the physiological and the mental contexts. The physiological context may contain information like pulse, blood pressure, and weight. The mental context may include elements such as like mood, expertise, anger and stress.
- (4) The task context describes what the user is doing. The task context may be described with explicit goals or the task breakdown structure.
- (5) The social context describes the social aspects of the user context, e.g., Information about friends, neighbors, co-workers, and relatives. The role that the user plays (e.g. Status and tasks to be performed) is an important aspect of social context.
- (6) The information context is the information space that is available at a given time.

Table 2^[12] provides an overview of some typical properties of context information.

Type	Source	Persistence	Quality Issues	Source of Inaccuracy
Sensed	Physical and logical sensors	Low	May be inaccurate, unknown or stale	Sensor errors or failure, network disconnection, delays in processing
Static	User/administrator	High	Usually none	Human error
Profiled	Implicit or explicit	Moderate	Prone to staleness, may be unknown	Omissions to update
Derived	Other context elements	Variable	Errors due to derivation process	Imperfect input, depends on machine learning process

Table 2. Properties of Context Information ^[12]

2.2 User Modeling and Profiling

Historically, user models have been used for providing adaptive and personalized services. The aim of user modeling is to capture user information such as preferences, beliefs, goals, and intentions to construct a user model ^[11]. User model is as an essential input for every personalization technique. The user model can either be collected by the service provider i.e.; through accumulating the information on user's preferences and interests, or imported into the system from user's personal devices.

To populate the user model, the main approaches are ^[14] (1) Implicit, based on the user interaction with the personalized system (2) Explicit modeling based on a questionnaire. (3) Stereotypes, which may be selected by the user or the system.

Service providers may neither cooperate, nor share the data stored in their repositories due to commercial competition ^[15]. Even if they agreed, there can be an issue to mediate users' models. It requires mediating mechanism that facilitates user modeling data sharing by translation and integration of the user model. Another

issue that should be tackled by the mediator is integrating partial models from different domains.

User profile is a key element in personalization. Management of user profile is an essential aspect to enable personalization. Users, according to their age, concerns, and situation are likely to have different preferences and needs. The use of profiles is integral in the provision of personalized services. The need to have a well-defined user profile structure sits well with the idea that multiple applications could reuse the user profile and provide a personalized experience ^[16]. 3GPP Generic User Profile ^[17] gives an abstract representation of a user profile which contains no data. More specific user profiles can be derived from this abstract representation of a user profile. It consists of five main components User Personal Data, User Devices, Personal User Devices, Subscribed Services and Subscribed Networks. It is further classified into User Level and Universe Level ^[18] as shown in Figure 1. The User Level represents the user and the context. The Universal Level specifies formal description or schemas of all existing devices, access networks, services, and personal user devices.

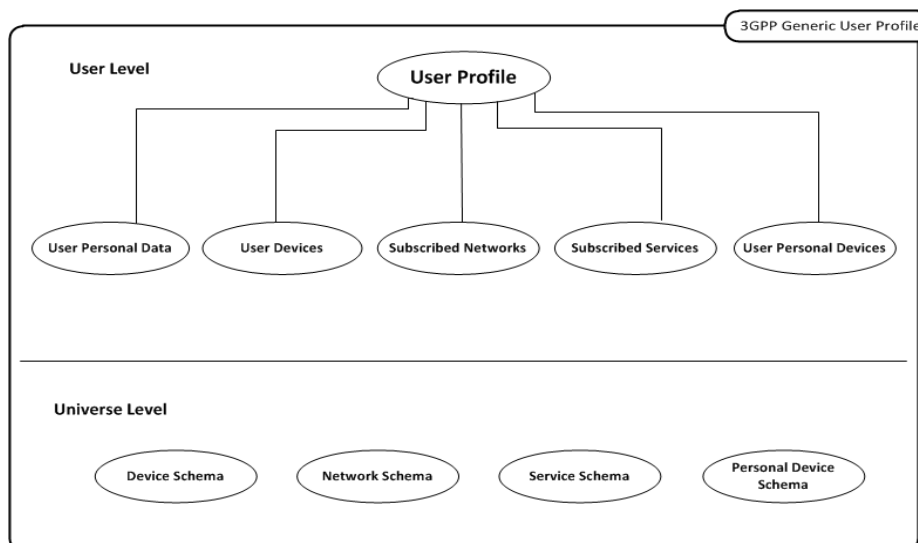


Figure 1. Generic User Profile adopted from ^[18]

In ^[19] the authors have discussed different profile management and discovery issues and challenges such as profile sparseness, user profile persona, using out-of-bound data and difficulties to reuse the profile data. The user preference is personal and subjective and it needs to be handled carefully. Personal or group user models can also make it possible to represent and use information about preferences, knowledge, abilities, emotional states, and many other characteristics of a user to adapt the user experience and support ^[3].

Personalization has some challenges include profile ownership, managing complexity, user acceptance and agreed standards, to name a few. There is a lack of an agreed standard for user profile capture and sharing ^[36]. More importantly the user profile created from one service could not be reused with another service. This might bode well with the service provider, but, from the user perspective, it is undesirable to create a user profile every time a new service requires it ^[16].

III. DESIGN APPROACHES

Server-side personalization and client-side personalization are two distinct types of design approaches. The following sections describe these two approaches and provide a comparison of these approaches based on key elements required for personalization.

3.1 Server-side Personalization

The most common approach for the personalization of mobile services is performed at the server-side. For example, the study ^[9] has described a system Personal Digital Secretary based on this approach. According to the authors, this approach can be useful to deal with issues like storage size and computational power in a more scalable way. It can give flexibility in adopting new contexts and modeling new behaviors.

Scalability is an important issue when capturing the available context and continuous modeling of user behavior. Machine learning approaches can also generate overhead for low computational power devices. According to ^[20], it is hard for a server-based architecture to have dynamic privacy control. User modeling servers and mediations demonstrate some technological solutions but at the same time they raised privacy issues ^[21]. Server-based personalization requires the service providers to store and manage user model. This approach leads to the issues of scalability and optimization. Service-providers may have an incomplete or inconsistent user model which can effect personalization. It should also be noted that if the personalization is performed on the server-side implicit analysis of a user's behavior may infringe user privacy. In this way, a server-side approach must require the user's permission before gathering information this way ^[22].

An *advisory system* ^[23] uses this approach to elicit user preferences to provide personalized e-services. It has a dedicated server which keeps personalized sessions of users and generates services according to the learned behavior of users. A distributed approach is utilized in ^[24] to manage the profile data of users. In the framework presented, each profile is associated with a profile manager. A user's profile can be made available to the service providers by allowing access to a respective user profile manager. This approach also applies policies and rules to handle conflicts in data. Another distributed approach ^[25] is used to provide personalized news delivery on mobile devices.

3.2 Client-side Personalization

The increased computation power of mobile devices has opened the possibility of client-side personalization. With their increased performance and various ways of sensing their environment; it is possible to utilize it as a platform for client-side personalization. It is a most recent trend to store the user model on the mobile device to support the client-side personalization. According to ^[26], it is now becoming feasible to support the client-side personalization due to the advancements in computational power of mobile devices. The authors believe that a user can have better privacy and control over data by storing the information on the mobile device. On the other hand, there can also be privacy issues through loss of devices, and applications using the personal information on the device without permission. These devices are capable of sensing aspects of the context, such as the user's location and activity. It is now possible to store a user model, communicate with the environment, and to perform client-side personalization ^[27]. PersonisJ ^[27] is a mobile client-side user modeling framework which supports client-side personalization. A user study ^[28] has shown that users prefer to store their personal information on their personal devices (smart phones) rather than store in third party servers.

Client-side solutions give a greater sense of user trust. It is easy for a user to understand that their personal information will stay under their control at all times. Trust has a positive effect on users' attitudes towards personalized mobile services. Attitude of a user towards personalized mobile services can have a positive effect on user's intention of using personalized mobile services. However, as the personalization level increases, users become more suspicious about why and how mobile service providers use their personal data, resulting in high distrust ^[29]. The approach usually offers the greater potential for user control over information and stronger protections ^[30].

Issues	Server-side Personalization	Client-side Personalization
Scalability of Storage and Processing power	Can deal with storage and computational power issues in a scalable way. Supports service based approach.	Less likely to cope with storage and processing issues. This approach can partially support service based approach due to advancements in processing power and storage capacity.
Battery Consumption	Has no such issue	This approach has an issue of battery consumption.
Network	Requires continuous connectivity and secure communication to connect to distributed elements.	No need to deliver processing roles to remote servers.
Context Management	It can be easily done on dedicated context servers.	It is hard to manage a variety of context information on mobile devices.
Lifelong User Model and Scrutability	This approach may not be feasible for lifelong scrutable user model	This approach seems appropriate for lifelong scrutable user model. This will put the user in control of the personalization process.
Dynamic Privacy Control and Security	To deliver personal information on remote servers (or third party servers) can raise privacy and security issues. It is hard to achieve dynamic privacy control.	Users can take control of personal information on mobile devices anytime on the go.
Ubiquitous User Modeling	Different parties may not agree to share user models (due to commercial competition), can cause replications of the user model.	Users can take control over their profiles. They can control how to share their profile with service providers. Users can share a part of their user model to a service provider.
Group Personalization	This approach can support group personalization in a scalable way. User or group characteristics can be explicitly or implicitly captured.	It is difficult for this approach to handle group personalization.
Personalized Recommendations	Server-side approach can deliver recommendations based on the transactional history, and other collaborative techniques. Machine learning techniques and data mining techniques are usually applied to build user models.	Since the user model will primarily reside on user's device, the user may not be willing to share profiles for recommender systems to deliver personalized recommendations.

Table 3. Client-side vs Server-side Personalization

Storing personal information on the server-side raises serious privacy concerns that client-side solutions do not. Client-side systems offer the primary benefit of distributed information. However, when all of the personal information is stored on the client-side, the user identity can remain anonymous to the service provider.

User model on a Key^[21] has suggested a general framework for client-side personalization by keeping the user "in control" of personal information. It has merged the user modeling server and mediation role to allow users to explicitly select the information to disclose to a particular service provider at a time. Similarly,^[25] has suggested distributed approach which stores permanent parts of user model on a server and short term user model on the user's personal device (i.e.; a mobile phone). Personalized Cultural Heritage GeoNotes^[31] is

a system which also utilizes the client-side personalization approach to store user and context model of visitors on mobile devices. Hence, to create a personalized mobile service for a particular situation, it may require determining which design approach is better. However, a detailed analysis is required to understand the design requirements of a particular mobile service.

In the next section, we discussed key elements to personalization such as *context management, lifelong user modeling and scrutability, ubiquity of user model, dynamic privacy control* listed in table 3 and related issues. We have also discussed how these key elements should be considered while choosing a design approach such as a client-side or server-side approach. The table 3 above gives a brief comparison of both approaches and detailed discussion is presented in section 4.

IV. DISCUSSIONS

Personalization has become an umbrella term and expects a clear understanding in a particular application domain such as mobile services. To achieve adequate personalization, there is a need to cope with the issues and challenges described in this paper related to client-side personalization and server-side personalization. Quality of the available context information is an important issue. It is not an easy to collect complete and accurate contextual information. Mobile services that require contextual information should be designed carefully with an understanding of the problems inherent in gathering valid context information. Imperfect context information can also create various usability issues. The problem of imperfect context information represents a significant obstacle to the success of context-aware applications and especially in personalizing the mobile services. Context modeling is a hard problem due to its complexity and the multitude of different applications.

A key challenge for service provider is to access the user model while delivering personalized services. At the same time, due to business competition and privacy issues, service providers are so far not willing to share their proprietary user modeling data. This is a big challenge for the provisioning of personalized mobile services using the server-side approach. Techniques of importing and integrating user model are another solution, but this may have other challenges in addition to privacy.

The support of lifelong user model is a key factor for lifelong personalization. Lifelong user models should be scrutable, meaning that the user can, when they want, scrutinize the user model to determine what information it holds about them. This is a foundation for enabling the user to control their model and its use, and in this way to control the personalization processes. Scrutability is as a foundation for user control over personalization. There is a need for solutions that aim for a balance between privacy and personalization. There is a variety of ways named pseudonymous personalization, scrutable personalization and dynamic personalization, they all address a handful of the main privacy concerns and achieve at least reasonably acceptable personalization^[32].

Mobile device is truly a personal device and remains with user most of the time. This makes it an ideal platform for client-side personalization. The current capability of mobile device has the potential to provide unique opportunities of real-time adaptation of services in a dynamic user environment. The key change that a lifelong user model can bring is that the user can carry their user model, for example, on their mobile device. This perhaps can reduce the need for acquisition of the user model. Therefore, the user model can then be reused in other contexts. To model the user's context, especially their location and relevant aspects of their activity and attention, there can be significant technological challenges, both in collecting relevant information from sensors and then interpreting it. This may run on the

user's carried device and/or an infrastructure of sensors^[14]. Client-side personalization can provide a valuable foundation for lifelong user modeling, in which a user can create, edit, reuse, and extend their user model throughout their digital life experiences^[27]. It seems that having an integrated, standard, personal "lifelong" user model can provide a starting point for personalization in several forms. The user model can be stored physically or logically on the user's mobile device, perhaps with parts made available to different domains. However, it is essential to be able to use user modeling data across domains^[14].

The personalization research area is somehow fragmented^[5]. We can clearly see that there is a requirement for a conceptual personalization framework in the context of mobile personalization. According to^[33], this is an increasing trend in the use of personalization technology. It is analogous to speeding up a train whose direction is unknown. Moreover, the author has stated that the first and foremost challenge for the personalization research community is reaching a consensus of a common frame of reference for personalization.

The shift of research focus from technology oriented towards the user-centered approach raises the issue of individual privacy and data protection^[21]. The information required to personalize the services has raised the concerns for "right to privacy". Mobile users are facing a dilemma: while they demand more customized services, they are increasingly concerned about privacy infringements and how their information is being used by mobile service providers. Therefore, mobile users are more suspicious of new personalized services^[29]. Acquisition, processing, and storage of personal data ubiquitously may require an intensified consideration of user demands to security, privacy, and anonymity^[34]. According to^[6], there is a need to find out what services, what personal information the users are willing to share with the surrounding services in order to encompass the service provisioning based on personal information. A tradeoff may require exploiting how much personal information a user is willing to share in order to continue using a service. However, it is difficult to achieve balance and guarantee of this tradeoff. One possible solution is to shift the control to the users over their personal information and make explicit the tradeoff between benefits and risks according to level of involvement. In this case, client-side personalization seems a better option for the personalization of mobile services.

V. CONCLUSIONS

Context-awareness and user modeling are enabling a number of services to support personalization. Both research areas have various applications in different domains. Personalization is another dimension of services enabled by these research areas. In addition to getting the benefits of these disciplines, personalization

of mobile services has also inherited the challenges. The challenges of these areas extend the problem space for personalized mobile services. However, there is a need to reduce these challenges and develop the solution possibilities by achieving tradeoff between the design choices. This paper aims at summarizing different approaches, solutions, issues and challenges so far for personalized mobile services. Summarizing the study and state of art of personalization in mobile services can lead to a number of high-level considerations for the next generation of personalized mobile services. This article is an attempt to investigate and compare client-side personalization and server-side personalization approaches to provide a way to the next generation of personalized mobile services.

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Paper 3

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Role of Personalization in Mobile Services Adoption

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Abstract - The role of personalization is overlooked in adoption of mobile services research so far. This study aims to explore how personalization can play a key role in mobile services adoption. To answer this, literature of mobile services adoption and mobile services personalization is reviewed to understand the commonality of the concepts, theories and models. The intention is to find common grounds from both research areas to provide a better approach for mobile services adoption. The basic challenge is to understand how and why people use mobile services. However, there are still many gaps regarding the adoption of mobile services in the existing literature. This study gives state of the art on mobile services adoption and describes how personalization can play a significant role to increase the adoption of mobile services. The main goal of this study is to identify the gap between adoption and personalization studies so far. Moreover, the study offers insights for researchers to look into the important aspects of mobile services personalization that can escalate the adoption of mobile services.

Keywords: Mobile services, adoption, personalization, technology acceptance

1. Introduction

The adoption of new professional mobile services has been much slower so far than expected, and the basic challenge is to understand how and why people adopt or do not adopt mobile services (Carlsson et al., 2006). However, many mobile services failed to generate revenue due to the lagging adoption of the services (Nikou and Mezei 2012). The possible reasons of slow adoptions are lack of user friendly interfaces, security and privacy issues, complexity of services, relatively high cost, lack of content quality, inappropriate business models, or that users' needs, and requirements have not been taken in account (Gao et al., 2010b; Nikou and Mezei, 2012). The present research in determining adoption and use of mobile services is significant but not appropriate enough. In many adoption and acceptance studies, technology and service characteristics are treated as a black box, and the service designers should pay more attention to the users' preferences (Nikou and Mezei, 2012). The understanding of why users accept mobile services can be helpful to understand the adoption factors.

Understanding the motivation of personalization can help to design those features that can promote acceptance and motivation of information and communication technology (ICT) (Oulasvirta and Blom, 2008). Both research areas (adoption and personalization) have significant contributions toward mobile services. Due to the importance of both research areas, there is a need to combine the efforts to excel in devising mobile services that are suitable and acceptable for users. Literature showed that personalization is taken as only a small factor in adoption of mobile services. We argued that personalization is a broad research area and has a great impact on mobile services research. Moreover, personalization should be considered as an approach instead of a single adoption factor.

Different theories are describing the attitude towards technology adoption. Authors (Carlsson et al., 2007) suggested that to overcome the limitations of diffusion research there is a need to understand the users' needs and requirements. On the other side, (Constantiou et al., 2007) suggested that technology and service adoption requires and instantiates continuous behavioral changes. Mobile services are mainly designed for individual users and can be perceived in different ways by different users. Moreover, users

can have different expectation and needs. Personalized mobile services can improve user satisfaction and can be valuable for the success of m-commerce (Kim et al., 2009). Authors further argued that although there is no study on the relationship of personalization and perceived value; it can be envisioned that personalization is associated with usefulness and can encourage users' perceived value. The development of mobile services is driven by user's behaviors. The success of mobile services lies in understanding users, their life styles, attitudes and needs (Ballon et al., 2004). The characteristics of mobile services such as personalization, context, and ubiquity make mobile services adoption different from other ICT services (Hoegler et al., 2006). These characteristics require exploring different adoption factors, in addition to the traditional ones. Many of the studies in mobile services adoption have ignored the users' needs. It is required to target the individuals' needs for successful adoption of mobile services in any domain such as m-commerce, m-learning, information service etc. Many researchers who are exploring m-commerce have ignored the users' needs (Chiang and Liao, 2012). However, mobility can also be a key adoption factor in mobile services (Nikou and Mezei, 2012). Moreover, the study showed that mobile services adoption depends largely on service functionality, service quality, usability, and accessibility. We believe that personalization can enhance all these adoption factors.

2. Motivation and Objective

Both personalization and adoption are significant areas of research on mobile services. The application of both research areas becomes more relevant to mobile services due to the inherited constraints of mobile devices. It can be productive to look how these two research areas are contributing towards mobile services and how personalization can bring improvements in adoption of mobile services. So far, the focus of mobile services acceptance research is to find out the factors that can affect the adoption of mobile services. On the other hand, the emphasis of personalization of mobile services is to target the individual needs. In addition, personalization is improving the user's experience with mobile services and enhancing overall productivity.

There is a variety of barriers and adoption factors are being studied in mobile services adoption. In our point of view, personalization can play a key role in adoption of mobile services but its role is overlooked so far. However, the literature of mobile services adoption research has revealed that personalization is not utilized properly. Due to the success of personalization and relevancy in mobile services, we envision that personalization should be an integrated part of mobile services adoption. Personalization features can align the psychological resources with the users' actions and can enhance users' experience which can lead to increase adoption (Oulasvirta and Blom, 2008). To address this, we have analyzed how and where personalization can play a significant role in mobile services adoption. We have analyzed the role of personalization on different adoption factors suggested in the Technology Acceptance Model (Davis, 1985) as an example.

The objective of this paper is to gather, analyze and link concepts and to fill the gap between two research areas: mobile services adoption and mobile service personalization. To address this, first we review and summarize previous research in both mobile services personalization and mobile service adoption. Then, we discuss how personalization is overlooked so far in various studies of mobile services adoption. In the end, we discuss how most common adoption factors can be influenced by personalization.

3. Overview of Personalization

This section gives an overview of the literature in personalization of mobile services and describes different perspectives of personalization that can play a key role in adoption of mobile services. Personalization has been recognized as an important element in a variety of mobile services. However, it has a variety of perspectives and dimensions in the literature. For the sake of conciseness, we have focused only on the literature of mobile services personalization. But we recommend studying other domains of personalization as well for a broader view of personalization. A limited set of articles are selected to present an overview of early accumulated knowledge regarding personalization of mobile

services. In general, personalization is about peoples' needs, their behaviors and due to this it is of an adaptive nature. Personalization is the ability to provide content and services that are tailored to individuals based on knowledge about their preferences and behaviors (Adomavicius and Tuzhilin, 2005). From technological point of view, personalization is a process that changes the functionality, interface, information access and content, or distinctiveness of a system to increase its personal relevance to an individual or a category of individuals (Blom 2004; Fan and Poole, 2006).

Personalization can affect the attitude towards the use on the intention to use mobile services. As argued by (Kargin and Basoglu 2006) that personalization is an indirect determinant of user's attitude towards using mobile services. It can infer that personalization can help to understand the attitude of the users. Authors (Sheng, Nah et al. 2008) studied the impact of personalization and context on users' intention to adopt mobile services. In this study, authors argued that personalization has a positive effect on user's intention to adopt a service. Here, personalization is not considered as an approach instead taken as a single adoption factor. Context, content and profiles are the significant attributes in personalized mobile services (Chen, 2011).

4. Perspectives of Personalization

Personalization can play a key role in delivering precise services to the potential users at the right moment. However, it has many facets and diverse applications. Fan and Poole (Fan and Poole, 2006) have described three dimensions of personalization from design perspectives: **1.** What to personalize (*content, user interface, channel or information access and functionality*) **2.** To whom to personalize (*individual or group*) **3.** Who does the personalization (*adaptive or adaptable*). Such kind of classifications can help to understand how and where personalization can be effective while designing mobile personalized services. Personalization can encourage autonomy of users i.e.; willingness to participate in an activity, provision competence by increasing the effectiveness of the users' actions, and maintain the need for relatedness. The authors have also discussed a number of optimistic effects of personalization, including engagement, performance, persistence, identity, social acceptance, and social status (Oulasvirta and Blom, 2008). In most of the studies, the focus of personalization is on the technical aspects of personalized mobile services. However, another stream of personalization research is to study user behaviors (Shuk Ying and Bull, 2010). Presentation and content personalization are the two most common types of personalization. However, in any personalization approach, the user model is of key importance. User modeling is playing a substantial role to understand users and their needs.

Table 1. Compiled chart of personalized mobile services attributes.

Attributes	Literature																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Context(Time, Location)	*		*			*	*	*			*	*	*	*	*		
Contents / Information	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Profile(Demographics)		*				*	*		*	*		*	*		*	*	*
Preferences/Needs	*	*		*	*		*	*	*	*	*	*	*	*			*
Interests	*				*	*	*	*	*	*	*	*		*	*	*	*
Device Profile	*		*	*													*
Trust			*						*	*				*		*	
Interfaces/Presentation			*	*			*		*	*	*	*			*		*
Cost/Price	*					*			*		*	*	*	*	*		
Information access/channels		*					*			*	*		*	*		*	
Privacy	*		*				*		*					*		*	

A:(Chen 2011)B:(Jong-Hyuk and Seunghun 2012)C:(Li et al. 2011)D:(Shoval et al. 2009) E: (Sela et al. 2010) F: (Vassilaras et al. 2008) G:(Asif and Krogstie 2011) H:(Panayiotou and Samaras 2006) I: (Coroama and Langheinrich 2006) J:(Papastathis et al. 2007) K:(Georgiadis and Stergiopoulou 2008) L:(Yeung and Yang 2010) M:(Yuan and Tsao 2003) N:(Decker et al. 2007) O:(Ravikumar et al. 2012) P:(Hardt and Nath 2012) Q:(Loeb and Panagos 2011)

5. Mobile Services Adoption – Overview

This section describes in brief the Technology Acceptance Model (Davis 1985) taken as an example of adoption studies to discuss the role of personalization. Moreover, the factors that might affect the adoption of mobile services are also investigated. There is a rich literature on technology adoption, but the Technology Acceptance Model (Davis, 1985) is widely accepted and applied model which much of later work in this area builds upon. The basic concepts used in TAM are:

- External Variables (EV): It is defined as variables that affect perceived usefulness (PU), perceived ease of use (PEOU), and Attitude toward Using.
- Perceived Usefulness (PU) means that a person believes that using the particular system/technology will improve his or her action.
- Perceived Ease of Use (PEOU) means that a person believes that using the particular system/technology will simple and not complicated
- Attitude towards use (A) is defined as the users' desirability to use the particular system/technology
- Behavioral Intention (BI) is anticipated by attitude towards use (A) combined with perceived usefulness (PU).

The TAM model has been extended, modified and applied in various studies. Perceived ease of use and Perceived usefulness are the most prominent concepts in most of the studies. TAM is applied in a variety of technologies, and mobile services adoption is one of the popular areas of its application. Authors (Phan and Daim, 2011) suggested that even though TAM is popular, its application is limited due to the constantly changing IT environment. There is also a need to look into more adoption factors due to the application of TAM in a variety of domains such as mobile services.

Theory of Reasoned Actions (TRA) (Fishbein, 1979) is extensively used in different adoption studies. It states that a person's belief decides his behavior, and other factors influence behavior through attitude, subjective norms or relative weights. It can be argued that the attitude and subjective norms of the people could be different from one another and in different situations. Therefore, the attitude and subjective norms of individuals should be reflected at personalized level in adoption studies to understand one's behavior towards adoption. We can argue that personalization studies can play a significant role here which seems overlooked so far in mobile service adoption studies. Similarly, Theory of Planned Behavior (TPB) (Ajzen 1991) focuses on the relationship among attitude, intention and behavior under the situation that an individual's behavior is in completely controlled by himself. The perceived behavioral control depends on perceived control and perceived convenience, which refers to an individual's perceived ease or difficulty of performing a particular behavior. Therefore, one can argue to address the behaviors at personalized levels. In a way, we can say that personalized services can have a positive effect on the behaviors of individuals. A study (Phan and Daim, 2011) has investigated factors affecting perceived usefulness such as cost, time, enjoyment, mobility, and content. Moreover service quality, speed and simplicity is factors affecting the ease of use. The technology and habits are identified as factors affecting the user's attitude.

6. Personalization in Mobile Services Adoption – A Brief Review

This section describes how personalization is discussed in the literature of mobile services adoption or acceptance. Various mobile services usage indicators are combined into a single factor called *relationship drivers* (Zarmpou et al., 2012). The relationship drivers include location and time personalization, and adaption to user's profile in addition to others. The study has investigated that the relationship drivers have a positive effect on behavioral intention and perceived usefulness.

Mobile services acceptance model (MSAM) (Gao and Krogstie 2010; Gao et al. 2010a) is an extension of the Technology Acceptance Model that found that user's context can have a direct positive impact on perceived usefulness and perceived ease of use. User's context is utilized in MSAM to personalize the mobile services, but has included only a few contextual elements. This study included only one aspect of personalization i.e.; location and has not studied the personalization impact comprehensively. A study (Kim et al. 2009) has investigated consumer behavior in mobile shopping. The

authors discussed *usefulness, ease of use, instant connectivity, and enjoyment* as determinants of *perceived value* which in turn can increase adoption intention of mobile shopping. In this study, authors have described that personalization and perceived value have a significant relationship; and personalization can increase consumer's perceived value. But this relationship is not evaluated in this study. Moreover, the results showed that usefulness with personalized service played a decisive role in the value of mobile shopping.

A similar study (Lee and Park, 2006) described that personalization is one of the essential factors of recently added mobile characteristics to increase its usefulness for consumers for future mobile business development. They have evaluated personalized mobile shopping application with the focus of security and data transmission time. This study has not evaluated personalization as an adoption factor instead it has only discussed this indirectly. A survey (Damsgaard et al, 2007) was conducted in the Danish mobile communication to understand the adoption of mobile services. The study demonstrates the connection between the user as a user of technology and as a user of mobile services to understand the adoption of mobile services. The authors argued that categorization of mobile users based on demographics, technology and service use and technology-service requirements are key indicators of mobile service adoption. A mobile service conjoint framework (Basoglu et al., 2008) describes factors influencing the adoption and preference of mobile services. The study describes personalization, content, cost, screen size, and a service speed as preference attributes of mobile services and discussed that how these factors effects the adoption of mobile services. The study found that personalization can affect the preferences of the users and can increase the adoption.

The effect of personalization on preference is also studied by (Kargin and Basoglu, 2006). The study has explored various factors that can affect the adoption of mobile services. But the most significant finding is that the personalization has a direct impact on the usefulness and indirect impact on attitude via usefulness. Some studies (Alafeef et al., 2012; Koenigstorfer and Groeppel-Klein, 2012) have targeted users based on personality measures and preference for technology adoption and use by behavioral acts. The studies have analyzed that how personality differences can affect the adoption behaviors. Demographic information such as gender, age, education, and income can play a critical role in mobile service adoption. We can say that mobile services adoption should be adaptive to users' profile and context to gain rapid acceptance. Trust is considered as another valuable mobile services adoption factor and analyzed in various studies (Gao et al. 2008; Shuk and Bull, 2010). Shuk and Bull have studied the impact of preference and location personalization on users' trust and attitude towards adoption of mobile services.

After exploring the literature of mobile services adoption, we have found that personalization is not considered earnestly in adoption. Prior research shows that the effect of personalization of mobile services is significant, and it can be evident that the personalization has become an essential feature of mobile services. There is a need to analyze the aspects of personalization for broad understanding of adoption factors that may have influence when looking for adoption factors. To address this, we have highlighted in the next section where and how personalization can affect utilizing the TAM as an example of adoption model.

7. Role of Personalization

This section highlights the application of personalization in various mobile adoption models. We have considered TAM as an adoption model and assess how personalization can have an impact on various constructs. We have discussed and analyzed personalization with respect to TAM briefly only for brevity, but it should be analyzed on larger scale to understand its full strength. Personalization aims to increase the usefulness and acceptance of digital information and applications, since the user can manage his/her own individual information and communication space so that he/she can select, configure, and arrange presented information individually (Arbanowski et al., 2004). Individuals are seen as having different attitude, abilities, and needs. User's concerns and needs can vary in different situations, and by meeting the needs of the user one can influence the willingness to use the mobile services. It is believed that user willingness and need can play a significant role in adoption of mobile services (Gao et al., 2010b). A

technology may be perceived as being innovative and advanced, but users may not adopt it if it does not fit into their daily routines and does not improve their daily tasks performances (Petrova and MacDonell, 2010). Individual characteristics such as life style, requirements and value have a significant role in adoption of mobile services. Moreover, users' service perception can vary depending on different contexts and situations. Therefore, we can say that personalization is inherently a human element and should not be disregarded.

A study (Bouwman et al., 2007) argued that research into user's preferences is of utmost importance to achieve a wide adoption of mobile services. Innovation adoption can be influenced by the adaptation of technology to individual needs (Kargin et al., 2008). However, mobile services should improve the productivity, efficiency, and effectiveness of the users and must be sensitive to personalization and adaptive to localization (Carlsson and Walden, 2002). Offering useful services by aiming at users' actual demands will be perfectly acceptable (Zheng et al., 2012).

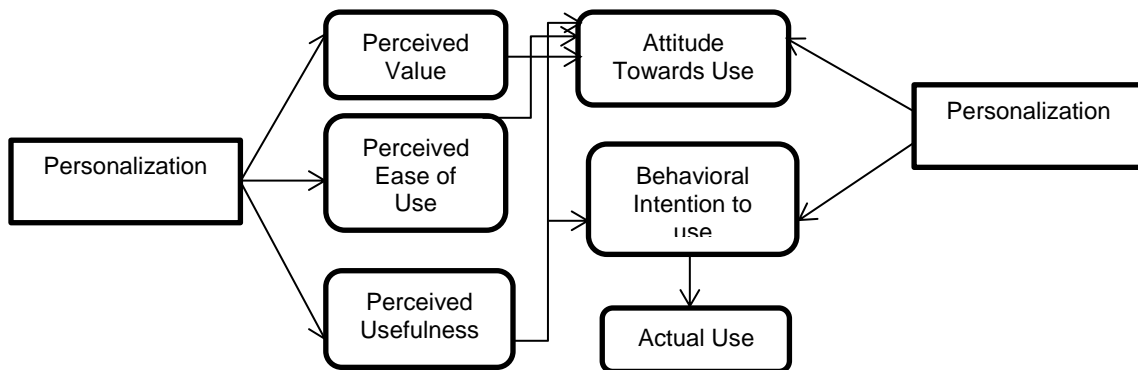


Fig 1. Role of Personalization.

Attitude: Attitude is considered as a key factor that can influence the adoption of mobile services. It has an impact (positive) on intention of use and actual use of mobile services. Here, personalization can play a role to understand the behavior or attitude of users. To have a positive impact of attitude, we need to consider it at individual levels. A study of mobile advertising (Xu, 2006) has revealed that personalization has a direct positive impact on users' attitude towards adoption of mobile services. Understand and utilizing the user's context can have a positive impact on users' attitude (Gao et al., 2008). So far, we have seen that very few adoption studies have utilized user's context. The contextual personalization (Asif and Krogstie, 2012) should be considered which can have a positive impact depending on the type of mobile services.

Behavioral Intention: It depicts a person's subjective probability that s/he will perform some behavior. The usage behavior of mobile service can be influenced by users' need and experiences. (Dabholkar and Bagozzi, 2002) argue that the users' differences arising from personality traits are highly relevant for validly predicting behavioral choices of new technology because such variation is a key to users' decision making process. Personal relevance can increase motivational appeal (Oulasvirta and Blom 2008) which can have positive impact on behavioral intention. However, behavioral research on personalization is significant to study the effects of personalization on users' decision making and satisfaction (Ho and Kwok, 2002; Blom and Monk, 2003). Trust is extensively studied in personalization and can have effect on users' behavior towards adoption intention.

Usefulness: Usefulness is a key and highly validated construct in adoption studies. Usefulness can be enhanced by delivering personalized contents. To deliver personalized contents user profile, preferences, and context are the key attributes. A study (Ho and Kwok, 2002) has showed that personalized mobile advertisement has a positive impact on perceived usefulness and decision making of users. Moreover, authors found that users showed a tendency towards the service providers who provide personalized services.

Ease of use: Mobile devices are offering a variety of features which makes it possible for different users to utilize mobile services with ease. However, its intrinsic limitations, such as small screen, limited input, battery consumption and low speed of data transfer, etc. is affecting the adoption of mobile services. Interfaces and presentation of contents can play an important role in the adoption. Since the personalization has a role in adaptive interfaces and personalized contents. Therefore, we are further extending that the personalized adaptive interfaces and presentation of contents can have a significant impact on adoption.

Perceived value: If users will feel that using a mobile service is providing some value in any form (enjoyment, extra benefit or economic/cost etc.) then they will accept it and will pay for it. It represents the benefits of using the mobile services as compared to the other technologies. A mobile service can be accepted and used by users if that particular mobile service offers value to its users. According to (Nikou and Mezei 2012) it can be a key factor for users to make adoption decision.

If the users find mobile services useless and bring no value, then the intention of use will be less, and users may stop using that service. Users of mobile services will only use new services if they see the value or are positively affected in some way by a service (Kargin et al. 2008). So to increase the value for a user there is a need to understand and address their requirements. A study (Nikou and Mezei, 2012) argued that research on mobile service adoption should not solely rely on traditional adoption theories, but also bring other relevant methodological approaches into practice. In another study (Zarmpou et al., 2012), authors suggested that relationship of users with mobile services is an important factor for successful adoption. This relationship can be achieved by providing personalized mobile services.

Mobile services are highly sensitive to the user's environment and the requirements. Personalization has a user centric nature and can address the sensitivity of the environment and user's needs. While studying adoption of mobile services, it is not wise to ignore the personalization aspects. Moreover, adoption is not a one step process rather it is a continuous process, and personalization can improve the process of adoption. With the proper application of personalization, the adoption of mobile services can be increased if it fits according to the needs of users. Despite the benefits of personalization, if it is not addressed properly it can increase the complexity and annoy the users as well. Since the objective of personalization is to enhance users' experience therefore its role in adoption of mobile services cannot be ignored.

8. Conclusions

Prior research has confirmed that personalization influences users' attitude and behaviors; however, our understanding of its effectiveness in mobile services adoption is far from conclusive. The purpose of the research was to investigate whether the conventional acceptance studies and theories have considered personalization sufficiently to study users' adoption intentions and behaviors. To discuss this, we have analyzed literature regarding mobile services adoptions. It is revealed that using the conventional acceptance theories as the sole research approach does not provide sufficient insights to understand user behavior and intentions to adopt the mobile services. The present paper contributes to the discussions in mobile services adoption on how personalization is overlooked so far and how it can play a substantial role in diffusion of future mobile services. We believe that if personalization is engaged properly in mobile services adoption, it can upsurge the probability of adoption of mobile services.

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Paper 4

Asif, Muhammad and Krogstie, John: “**Mobile Client-side Personalization**”. International Conference on Privacy and Security in Mobile Systems, Global Wireless Summit, 2013, ISBN: 978-87-92982-51-3

Mobile Client-side Personalization

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Abstract—The recent development of powerful mobile devices is encouraging people to take them as a computing platform. Users are expecting to personalize services to meet their individual needs and will no longer accept “one size fits all” approach. On the other hand, there is contention between personalization and privacy. This leads to the question of how to maximize the user’s experience of personalized mobile services while keeping their privacy. One possible solution is to provide user’s control of their personal data by keeping their user model on their personal mobile devices. In this way, a user can scrutinize the data while sharing with service providers depending on her/his requirements. The client-side personalization approach can shift the control of privacy to the users and can involve them in personalization process. In this paper, we have proposed a solution with the objective of scrutable client-side personalization while keeping the user in control of both privacy and personalization. Moreover, the objective is to provide a conceptual layer of privacy enhanced personalization for future mobile services.

Keywords- *mobile services, personalization, user model, scrutability, privacy.*

I. INTRODUCTION

In this modern era of computing, mobile devices are used as a personal computing platform to store and share information. A user may have a variety of mobile services on a single device and can share his/her personal information to the service providers for mobile services personalization. Mobile personalized services are highly sensitive to the context and the requirements of the user. The context and the user model are the corner stones of mobile services personalization. Not every mobile service may require the same level of personalization. Different levels of personalization are needed in mobile services depending on types of service and user’s requirements [1]. Contextual personalization is the most complex level of personalization which requires both user context and user model. According to [2], the effectiveness of the mobile services depends on their ability to offer relevant context sensitive information while shielding the user from information overload. Depending on the current requirements of personalization of mobile services, we have defined it as “Personalization is a controlled process of

adaptation of a service to achieve a particular goal by utilizing the user model and the context of use” [1].

There are two key issues regarding the personalization of mobile services; the business competition and the privacy of users. This can be a reason for the service providers to not to share the user model [3]. Privacy is an integrated part of personalization. Every person may have different priorities for privacy. Some people may not want to share much information as they don’t have trust or they are more curious about their personal information. Some people may want to share more personal information to gain more personalized experience.

This problem can be solved if a user keeps his/her user model and share according to his/her own requirements. This work is an attempt to build architecture to fulfill the following purposes: (a) scrutable client-side personalization with dynamic privacy control (b) re-usability of the parts of a user model across different mobile services. This can help to reduce the “cold start” problem as existing user information can be re-used by the newly subscribed mobile service.

Scrutability describes the ability of users to understand and control what goes into their user model, what information from their model is available to different services, and how the model is managed and maintained [4]. Scrutability is a key in enabling reuse and sharing of user model [5][15]. There is a variety of methods to collect information about users (implicit or explicit). The collected information is used to create user models for personalization. The approach in this research is bit different in that a user should build his/her model and share according to the requirements. A user can share his/her model with different services according to his/her requirements of personalization. The users will remain in complete control of his/her model on the mobile device [17][20]. The approach can have two significant benefits. First, the model will be more accurate and up to date that is a key to the personalization. Second, the model can be scrutinized by the user. It can be annoying and inconvenient to repeat the personalization process for the mobile users [6] and repetition can be reduced from the reusability of the user model [22].

Privacy is a big challenge for personalization [16]. It is very difficult to achieve a balance between privacy and

personalized experience of users. A variety of studies [4][19] has discussed various approaches to reduce the privacy risks in personalization. The authors consider the client-side personalization and user control as separate approaches. In this work, we have combined both client-side personalization and user control as a single approach to provide privacy enhanced scrutable personalization. We are following the same philosophy as [7] that a user is an owner of their user model. The user should have access to their user model and the processes that created it. The transparent personalization process [12] is a key in this regard. In a study [8], authors suggested that users should know when personalization is happening and how they are perceived by the system. In this paper, we advocate a solution to share scrutable partial user model we called it *persona* [23] here for client-side personalization while keeping the user's privacy.

Section II describes the proposed architecture and the major components of the architecture. Section III describes basic work flow of the overall approach. The proposed approach can have some challenges and in section IV we have discussed these in brief. Section V describes some conclusions and further work.

II. PROPOSED ARCHITECTURE

In general, there is a tradeoff between privacy and personalization. It is essential to put the user in control to achieve the personalization of a required level. The more information a user reveals more personalized experience can be achieved. It is a difficult task to achieve the desired level of personalization and privacy at the same time. To address this challenge, there is a need to develop an architecture that can address privacy and personalization together. Moreover, the architecture is needed to put the user in control of his/her personal information. The purpose here is to provide an architecture that can meet the above mentioned objectives in a flexible and scalable way. Moreover, the architecture will support the end users to (a) check, what information is in the persona, (b) modify the

information in the persona, (c) scrutinize, when other services access or attempt to modify their persona and, (d) understand how their persona affects the service personalization and their experience. Fig. 1 shows the basic architecture of a client-side personalization to convey the essence of privacy, scrutability and personalization together. A brief description of the four layers along with high level components is as follows:

A. Data Gathering Layer

The data gathering layer has the primary role to collect and store the data.

UserPersona: It represents the transactional data of the user for a service. It also keeps track of the different versions of personas used for a service. Sometimes, it may require using the recent version of a persona instead of constructing and configuring the new one. Each version of a persona will correspond to a certain level of personalization so that a user can quickly switch to a desired persona and the level of personalization.

User Agent: It is responsible for communication with the scrutiny layer to provide for access the persona of subscribed services. This component will also be responsible for logging the usage history of the service as well. Any updates to the user's persona made by this component must be authorized by the user.

B. Management Layer

The management layer works on top of data gathering layer. The purpose of this layer is to provide different modules for managing different aspects of user's persona.

Profile Manager: Profile manager plays a key role in providing the user data required for a service to personalize. It keeps track of factual data about the users and provides privilege to add or remove preferences and interests of a user for a service.

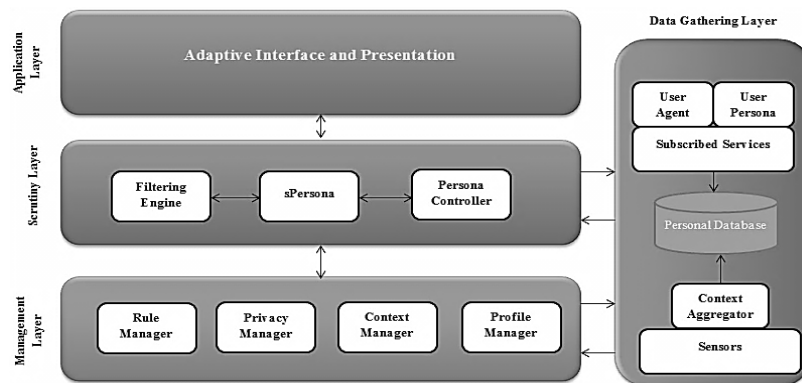


Figure 1. Proposed architecture

Privacy Manager: Four privacy levels are adapted from [28] to put a user in control of revealing her/his data. The flags are *Always (A)* - to give a data element without asking the user, *Check(C)* - check user profile and priority rules and *Ask(R)* - ask the user before delivering the data. We are adding one more flag *Never (N)* - with this flag the data will never be shared with any service or application. The idea here is to provide privacy information readable by both users and system.

Rule Manager: This component is in charge of provisioning the rules required to describe the user's behavior [26]. The main purpose of this module is to provide personal rules for service persona to be delivered and, to allow users to access and modify rules through an intuitive user interface. The behavioral rules defined by the user will be more accurate and reliable, and there will be no need to validate those rules separately [29]. After defining a rule by the user, the rule manager will deliver it to the scrutiny layer to put it to the user's persona. An example of a rule to describe the behavior of a user to receive news can be: "I want to receive news about latest films on weekends only". The user should be able to define basic rules by making easy selections.

C. Scrutiny Layer

This layer provides scrutability of a user's persona to be delivered to personalize a mobile service. The core of scrutability is that people should be able to scrutinize their user model and aware of personalization process. Scrutability although a desired feature but has significant challenges to achieve. Authors in a study [4] also suggested that the desirability of scrutability from a privacy point of view, its implementation and control is currently a challenging task due to the user's lack of understanding of these notions and of effective and efficient user interfaces to support them. To address this challenge, we added this dedicated layer to handle scrutability with the support of adaptive interfaces at application layer. The layer consists of following components:

PersonaController: This component is responsible for interaction with the user through an adaptive user interface. It controls the delivery of persona from the lower layers to a service provider. It acts as a gateway with the help of a user between the system and the service provider.

sPersona Module: This module is the backbone of the scrutiny layer. It prepares the user persona depending on the information received from the coordination layers and components. It also takes the real-time user feedback via *persona controller* component to scrutinize the persona and prepare it for delivery.

Filtering Engine: It is in-charge of asking the decisions and enforcing it. It asks from the respective managers at the management layer for certain decisions to include an element to the persona or not.

D. Application Layer

The application layer represents the adaptive user interface required to access the personalized service and presents personalization contents. This layer provides an intuitive user interface to work with the user persona.

E. Basic workflow

The service deliver a stereotyped persona [24][25] with some default attributes as an initial persona. After that, the user can adapt stereotyped persona through an easy to use interface to receive personalized contents or recommendations. The stereotyped profile can be adapted by the user through learning and filtering techniques. Once the profile is initiated, the user may continuously make updates to the persona to make it more precise and reflect new preferences or change of preferences [27].

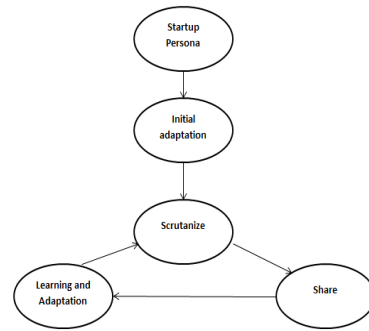


Figure 2. Basic workflow

III. DISCUSSIONS

The personalization process should be transparent and non-obtrusive. In addition, the user should be involved and given control of the personalization process. The specification and the implementation of a full-fledged architecture to achieve the objectives is a long-term goal. However, the implementation of the architecture will focus the following issues:

Degree of Complexity: Since the user will be in charge of the whole personalization process, the complexity of handling all aspects of the persona and the service can be difficult to manage. To tackle this challenge, a stereotyped persona can give users a quick start.

Control and convenience: Users may lose the interest if the provision of personalization will be cumbersome and complex. Therefore, it is indispensable to provide intuitive user interface to perform the required tasks to achieve the required level of personalization with good performance.

Adaptive and adaptable: There is a need to distinguish the adaptive and adaptable parts of the complex process of personalization. Some parts of this architecture require more user interaction, and some tasks will be handled by the system. The data gathering layer and management layer may require remarkably less user interaction and can be considered as the system's task. However, the scrutiny

layer will involve the user more as compared to the lower layers. In a way, the whole approach is blending the personalization and the customization [21] together to achieve more effective personalization.

Generality and extensibility: The architecture presented is quite general and can provide personalization to a variety of mobile services of different domains. In a way, it may provide a layer of scrutability personalization conceptually to any architecture for providing personalized mobile services.

IV. CONCLUSIONS AND FURTHER WORK

Mobile client-side personalization approach allows a single system to develop and maintain a life-long user model that can be applied to a variety of mobile services. The objective of this paper is to introduce a client-side personalization architecture that incorporates privacy and scrutability of a user model as an integrated part of the personalization process. It has been attempted to combine both adaptive and adaptability within one architecture. However, mobile devices have issues of limited bandwidth, processing power and storage capacity which can be a challenge for this approach. The cross platform availability of the user model will remain an open question for this approach. The next step is to develop and evaluate a prototype which will demonstrate the approach. The contribution illustrated in this paper is a first step in this direction. The focus of the prototype will be to hide the complexity from the user. The adaptive interface will play a key role to reduce the complexity. We will evaluate the system with a variety of mobile information services after developing a prototype.

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Paper 5

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Externalization of User Model in Mobile Services

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Abstract—In most personalized mobile services, the user model remains invisible, and users do not have control over it. Externalization of user models can allow users to get an overview the user model that is used for personalization, and adjust the profile and personalization effects to their needs and preferences. We have evaluated the interactive user model with 42 users, which were exposed to a prototype of interactive user model of personalized news service, for determining whether the proposed externalization, scrutability and privacy privileges were acceptable to the users. The purpose of the study was to find out if it is appropriate to present a user model on the mobile device and to control the sharing of the user model with the service provider. The conclusions show that the users expressed their general approval of the proposed privileges while making useful suggestions regarding improvements to the presentation and interface to the system.

Index Terms—Mobile Services, Personalization, Privacy, User Control, User Model.

I. INTRODUCTION

The increasing popularity of mobile devices has opened new opportunities for personalized mobile services. There is a variety of personalized mobile services ranging from simple personalized interfaces to more complex context-aware personalized mobile services. User model is a key to personalization which may vary from simple user's demographic data to more detailed information about the user such as context, interests, preferences, expertise, traits etc. User model has become central in a number of classes of systems that are currently of considerable interest: recommender systems, customized documentation, teaching systems, information filtering and other tailored interfaces [1].

In many personalized systems, the user model is considered as purely internal system information, and it is partially or completely hidden from the user [2-4]. Most of the personalized systems are generating user model from implicit feedback from the users' search and browsing history, and explicitly from the classical interfaces that allowed people to express their preferences by browsing along the set of well-defined categories of contents. Users are not only concerned about their private information being used, but also about unintentional flow of information [21]. In UM community, there is a debate on the tradeoff between the user control and the intelligent agents that learn about the user [16, 17]. A user should be aware of her/his user model used by a system or a service. In addition, user should have control over her/his user model to personalize a mobile service [15, 16]. Currently, in most personalized systems, the user has no way to discover the details of their user models and the associated personalization [18]. The user model should be visible and accessible to the user so that they may have insight of it.

However, user must be able to view and alter the user model to increase the acceptance of the personalized systems [2].

There is a variety of issues related to the user model such as incorrectness, inconsistency and incompleteness that makes personalized mobile services unacceptable for the users. In addition to this, user has issues of privacy and no control over the user model. We believe that if user models can be externalized on mobile devices, it can alleviate the issues of invisibility and inconsistency. A study [18] has suggested scrutable user models and described it as a basis for understanding and controlling personalization. This approach can be difficult for mobile services due to the inherited constraints of mobile devices. In this study, we wanted to explore if simple user models can be presented on mobile devices and if users are willing to adopt it as a part of mobile service. The proper presentation of a user model on mobile devices can play a key role. The user model should be presented in a simple way so that the user can understand and modify it easily. It can help to make adaptation decisions, to inspect, and modify the values stored in user models. Hiding user models may occlude the system status and hinders control on the adaptation, which might lead to errors, e.g. issuing irrelevant recommendations [2]. However, there is long standing debate about to what extent users should give up control of their interactions [7]. Control on the user model can provide a fine tuning mechanism to obtain a flexible and accurate interest or preferences [8]. Besides this, personalization has also amplified the privacy risks and concerns. Different studies [21-23] have described increasing concerns about privacy in the context of personalization. This problem can be alleviated by giving more control to the users of their user models.

Although there has been research in user modeling, there is a gap between research with the themes of accessibility, ownership, scrutability, and user control; and the practical application of these themes in working prototypes that have been evaluated by end-users [24]. We conducted this study to understand the users' opinion about the externalization of user models along with representation and visualization modalities. The experiment was conducted with a working prototype of an interactive user model of a news service. This is a first study that presented a user model on mobile devices for users to play with and collected users' responses through a post-study assessment questionnaire. We believe that the results of this study will guide the development of future mobile services. Section II describes the motivation and objective along with research questions. Related work about externalization and user modeling are described in section III. Section IV gives an overview of the interactive user model and its elements. The results of the study, discussion and evaluation are described in section V. Section VI concludes the study.

II. MOTIVATION AND OBJECTIVES

User has the right to know which information is being shared with service providers. Invisible user models could raise usability issues which can affect the acceptance of the personalized services [16]. The externalization of user models can assist the users to know what information system is utilizing to provide personalization. This can give an opportunity to complete/correct the user models. Moreover, it can facilitate users to have a sense of control over the adaptation of systems by controlling the user model and, the way that the model is interpreted and the way that it used to perform the personalization. It can help people to become more self-aware and avoid self-deception. Externalization can increase user's understanding of how their user model and feedback contributes to personalization and thereby enhancing their experience of the system. It can also motivate people to share user model data because they feel confident about its meaning and use. Understanding, accepting and trusting a personalized system can improve the user-system interaction [9, 19]. Our research questions in this setting are:

Q1. *Do users feel that it is useful to inspect, modify and control their user models?*

Q2. *Is it appropriate to present a user model in a comprehensive and user friendly way on mobile devices?*

The aim is to verify whether the commonly used visual metaphors can present user model by giving a specific user model representation (in this case we are using a user model of personalized mobile news service). We hypothesized that existing visualization modalities or metaphors of mobile services can be used to externalize a user model. This can be verified by providing an interactive user model visualization and see how people feel about it. The goal is to find a way to represent user models to the users and to allow the user to modify her user model on mobile devices. Moreover, the visualization modalities chosen to present the user model can have an impact on the comprehensibility of the user model itself.

III. EXTERNALIZATION OF USER MODELS AND RELATED WORK

User model is a key to personalization of mobile services. Currently, the personalization process and user models remain invisible in most of the personalized systems [2, 6]. Making user models accessible to the users is a key requirement to the acceptance and success of adaptive systems. To ensure acceptance by users, these models need to be scrutable, i.e., users must be able to view and alter them to understand and if necessary correct the assumptions the system makes about the user [2]. Externalization is a first step towards the scrutability of user models. Jameson [10] argued that allowing inspection and parameterization of user models is essential to achieve predictability, transparency, and controllability of an adaptive system. According to Cook and Kay [1], the user needs to be able to understand the provenance of information in her user model, e.g., the user needs to understand why the system believes she is interested in a certain topic. We have not found any research work on externalization of user model related to provision of mobile services so far. Usually, the focus of externalization of user models was on larger systems. In this section, we briefly describe some of the work on externalization of user model and scrutability.

The term scrutability in user modeling signifies that every user's model can be inspected and altered by its owner in order to determine what should be modeled about him/her and how that modeling and following personalization process will be conducted [4]. Introspective views were used to represent user knowledge or interest [2]. According to the authors introspective views can help the user to gain an overview of the entire user model and zoom into a certain part of the model to get a better view on it. Moreover, it can enable the users to filter out unwanted items in order to focus on the relevant ones. A similar study [3] has proposed an approach to control adaptive behavior of the recommender system by allowing users to view and adjust the profile. It also allows users' to see the effects of personalization and modify the interests or preferences accordingly. The um-view interface [1] allows traversing through a user model by expanding the tree of leaves and viewing detailed information about the items in the model. VIUM [11, 12] and its successor SIV [12] are capable of visualizing large user models and enable users to get an overview of the whole model, view a subset of related beliefs, filter items by relevance, and obtain detailed information about the displayed items.

Understanding the goal of externalization of user models in mobile services and the means for how to achieve that goal is vital. Here, the goal is to provide reflection and improve the accuracy of the user model. Moreover, the purpose is to provide control to users of their models and improve privacy. SMILI (Open Learner Modeling Framework)[13] has described various issues to consider for externalization of user models. A brief description of the few relevant issues is as following:

- *Extent of model accessibility.* To what extent the model will be accessible (completely or partially).
- *Presentation:* How the model will be presented (graphically or textually). In addition, how the model will provide the information (summary, overview, targeted detail or all details).
- *Access Initiative:* How the model will be accessed. Either the system or user will initiate access.
- *Control over accessibility:* Who will control (System, User or Others) and how (complete, partial, or none)
- *Awareness of effect of model on personalization:* How much the user (complete, partial or none) will be aware of the effect of the model on personalization?
- *Flexibility of access:* How much (complete, partial or none) it is flexible to access the user model.

IV. AN INTERACTIVE USER MODEL

Externalization of user models provides an opportunity to view and access the user models. Moreover, it can help users to understand the behavior of personalization depending on their models. Therefore, one objective to externalize the user's model is to alleviate the invisibility of user model and personalization process. If the model is simple or easy to understand then the complete access to the user model can improve accuracy and in case of large and complex models, partial access can be more effective[13]. An incorrect user model is a major issue in personalization [18]. We believe that externalization of the user model can enable users to inspect their models and modify if there are any errors. In current systems, users have little or no control of their personal information

and user models [18]. With the externalization of user models, users can view and manage their own user models, and this can help to give control to the owners of the data.

We believe that by externalizing the user model, the problems of errors in a user model and invisibility can be solved. An interface is an essential part to externalize the user model. Such interfaces are extremely important because users are ignoring or tolerating obvious errors in user models and personalization, as they are obliged to do in more interfaces they use [18]. In addition to viewing the contents of user models, the interface enables users to edit them and to change interest degree. It provides flexible, multidimensional and browse-able user model. The interactive user model has the following capabilities:

A. View

In this user can view the user model in a variety of ways either in a graphical form or a textual form. This may provide users a chance to reflect on and enhance user knowledge. It can help in raising their awareness of what they do not know. Fig 1 provides an overview of the user model from two perspectives. The first Fig 1(a) gives an overview of the user's interest in particular categories of news. The graphical view gives a summary about the user's news interests which may increase her/his awareness. Moreover, user can view the details of the news interests as well. Fig 1(b) provides an overview of the privacy elements (context and permissions) used by the service. This part describes which context and permissions are utilized by the application. We believe, it can provide a quick overview of privacy elements and can enhance awareness of the privacy.



Figure 1. (a) View-Interests (b) View-Privacy

B. Manage

Control on the user model is becoming the desired feature of externalization. Fig 2 is showing how the user can edit (add, remove and modify) the preferences, interests and other parts of the user model. It provides the user an opportunity to manage their preferences. We wanted to explore whether users will be willing to manage their preferences or interests and how often. Moreover, we wanted to see if it is easy and useful for users to manage preferences explicitly.



Figure 2. Manage preferences



Figure 3. Control Privacy

C. Privacy

This can help to manage the privacy of the user model. For example, user can disable his/her location. It can also help to control the personalization by users themselves. Privacy is always a crucial issue in user modeling and privacy components should be included in every UM solution. Users should be given the option to set the status of their information and allowed to decide who can see which part of their user models [4, 14]. Fig 3 is showing two perspectives of privacy context and permissions. The context part is meant to provide an opportunity to the users to control their context. The permission part is representing the permissions used by the service and users have the opportunity to control the permissions used. Here, we wanted to explore how users feel about controlling the privacy.

Through the interactive user model, users can see what they are sharing with the system and how this information is used for personalization. Moreover, users can edit that information and control what they are sharing that can help to understand personalization and control on their privacy. The interactive user model is providing externalization of the user model as well as an opportunity of scrutability of the user model to some extent. It means users can inspect and correct the data that are held about them, and implement privacy policies so that the users can control how their models are accessed and used.

V. EVALUATION AND RESULTS

To understand the impact and users' perceptions, we have evaluated the approach to externalize the user model of mobile services. In order to do this, we have utilized a working prototype of an interactive user model of a personalized news service and collected 42 responses from a variety of users. Before commencing the test, the participants were given a brief introduction to the prototype of the interactive user model and the services it may provide. A mobile device with the application preinstalled was handed out. The participants were also informed that the data being collected would be part of a research study.

A. Study Design and Procedure

The study was designed to obtain quantitative feedback regarding the externalization of user model with specific questions mentioned in section II. The experiment consists of three tasks *viewing, managing* and *controlling* the

privacy of the user model of a news service. The participants have to go through each task and provide feedback on the questionnaire provided.

The estimated time of the experiment was 45mins in which participants have to perform all the three tasks. We handed over three things to the participant at the same time; a mobile device with preinstalled application, a printed user guide and a questionnaire. We have given the flexibility to the participants to fill the questionnaire either after completing each task or after completing all the tasks. All questions in this study are statements to which a user can indicate his/her level of agreement on a five-point Likert scale, ranging from -2 (strongly disagree) to +2 (strongly agree); 0 is neutral. The statements in the questionnaire were designed to address the research questions mentioned in the Section II.

B. Participants

The user study was carried out over a period of three weeks. The study collected 42 users' responses (see Table 1). There were 13 females and 29 males, with 64% being aged between 25 and 30; and 36% older. We have seen diverse experience in using mobile services such as 17% users have less than a year; 45% users have experience between 2-5 years, and 38% have more than 5 years' experience in using a different type of mobile services.

TABLE I.
PARTICIPANT DEMOGRAPHICS

Total	42
Gender	Female: 13 Male: 29
Age	25 - 30 years: 27 > 30 years: 15
Experience in using mobile services	< 1 year: 7 2-5 years: 19 > 5 years: 16

C. Results and Discussions

The whole experiment was divided into three main tasks of *viewing*, *manage* and *control of user's privacy* elements. We have asked 4 questions in each category and received interesting responses as presented below:

Task 1: Viewing the User Model

We have showed a user's interests of personalized news services to the users on a mobile device and asked if it was easy to understand/view it on a mobile device. We got 29% neutral responses on this question; and 50% users were agree that user model is easy to view and understandable on the mobile device, and 21% users strongly agreed that it is easy to view the model, and it is understandable. We did not get any disagreement on this. The second question was if it was easy to keep track of preferences/interests. We got 64% agreement on this and 36% of the users strongly agreed. The third question was asked specifically on if it was easy to keep track of privacy elements, and we got 67% agreement and 33% strong agreement on this which shows that it was not difficult for users to keep track of privacy elements when needed. The last question was about if it was useful to know the permissions used by the service. We got mixed responses here: 12% users did not know show agreement or disagreement on this while 62% marked agree and 26% marked strongly agree that it was not difficult to view permissions used by the service. The results on this part is summarized in Fig. 4

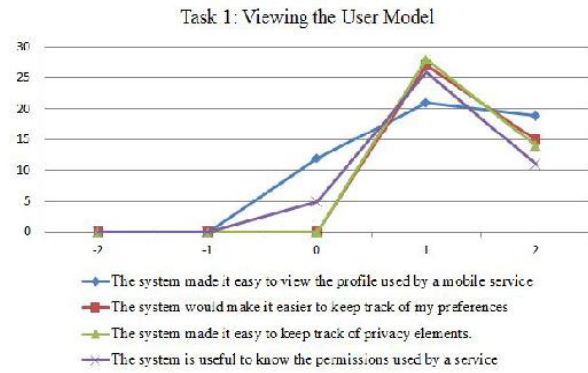


Figure 4. Viewing the User Model

Task 2: Managing the User Model

In task 2, users were asked four questions related to edit or modifying their users' models which includes interests or preferences of news service. We asked the users if it is easy to modify or correct the values in the user model. We got diverse response, 21% users neither agreed nor disagreed, 43% marked agree, and 29% marked strongly agree. However, we have seen that 9% were disagreeing with the easiness of modifying the interests. The second question was about managing the overall profile, and 31% gave neutral response. 41% agreed, and 28% strongly agreed on that it was easy to manage the profile on the mobile device. The next question was about the interface if it was intuitive and clear to understand. The agreed response was 41%, and 22% were strongly agreed. We got 37% neutral response about the intuitiveness of the user interface to manage the profile. The last question in this category was about if the system was useful to control the preferences shared with the service. We got 38% agreed and 39% strongly agreed response on controlling the preferences. However, 23% gave neutral response on this. From the results, it is revealed that interface for managing the profile required improvements to make it understandable and easy to use. The results on this part is summarized in Fig. 5

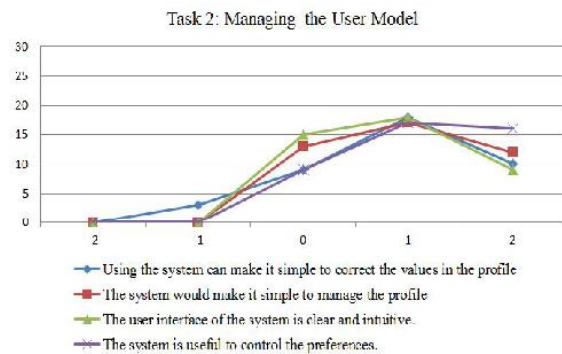


Figure 5. Managing the User Model

Task 3: Privacy of the User Model

The last task was about the viewing and managing the privacy elements of the user model. We asked four questions related to control the privacy of the context and permissions elements used by the service. The first question was to ask if users are willing to control the privacy elements on the mobile device. We have seen that 22%

agreed, and 88% strongly agreed to take control of privacy elements shared with the service. The second question was if the system was useful to manage the context elements (location, time, etc.) shared with the service. 29% of the users agreed, and 71% strongly agreed that it was easy to manage and control the context elements. The next question was specifically about if it was easy to manage the permissions and 33% agreed and 67% strongly agreed on this. The last question was about the overall usefulness of the system to control the privacy elements (context and permissions). Results showed that 36% users agreed, and 64% strongly agreed on the usefulness of the system to control and manage the privacy elements. The results from this part are summarized in Fig. 6.

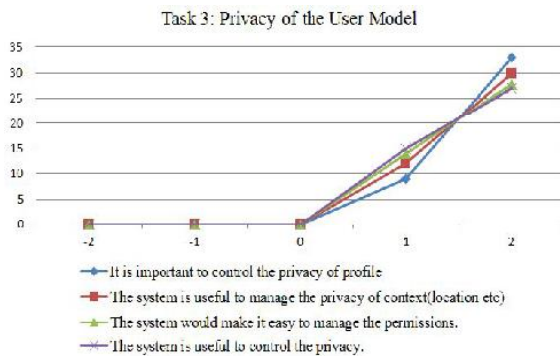


Figure 6. Privacy of the User Model

The first research question was to know *if users really feel that it is useful to inspect, modify and control their user models*. If we look at the results of task 1 (see Figure 4), it shows that users are willing to inspect their user models. Users showed great interest in inspecting the preferences and privacy elements shared with a mobile service. It can also be observed that users were at ease to use the system. Similarly, the second task was if users really feel comfortable to modify their interests or preferences. We received a considerable positive response on that users are willing to manage or correct their preferences. Only 9% disagreed on this (see Figure 5). The third task was to know if users are interested in controlling privacy elements (context and permissions). If we look at the results (Figure 6), it can be observed that users strongly agreed to take the control of the privacy elements they shared. The second research question was to know *if it is appropriate to present a user model in a comprehensive and user friendly way on mobile devices*. We have presented a user model with very few elements and used common GUI elements to present it. The results showed that it was not difficult for users even with limited experience in the use of mobile services to handle such kind of user model on the mobile device (see Section V). Although, the presentation of the user model was not intuitive, users liked the idea to have user model under their control.

The main focus of the study was to find the subjects opinion about the possibility to inspect, modify and taking control of their user model. From the results, it is revealed that users agreed to view, manage and control the privacy of their user model. Moreover, it is evident that users strongly agreed on taking control of their privacy elements and willing to manage their user models. The second

objective was to find out if it is appropriate to present a user model on a mobile device. Although, we used common GUI elements to present the user model but still there were responses on the difficulty of using it or subjects did not give any response. It is revealed that the interface requires more improvements to make it more understandable, intuitive and easy to use. On the other hand, it is critical to know which elements of the user model should be externalized and what should be the main objective of the externalization.

VI. CONCLUSIONS

Most approaches to scrutable user modeling have primarily focused on allowing users to view information stored in the model. Little research has been conducted to know the perception of users to provide control over the user model of mobile services. The ownership, accessibility, scrutability and user control are the important concerns of user modeling. We have conducted this study to learn how users respond to our visual displays of a user model on a mobile device. We describe an experimental evaluation that seeks to answer if it is appropriate to present user model of a service on a mobile device in a controlled lab situation using a running prototype of an interactive user model. It was found that users are willing to control a user model of a mobile service, particularly the privacy elements. It was also found that externalization of the user model can help the users to increase their awareness and control of their user model. However, this study has a limitation that the user model presented contains few elements. There is a need to do another study to verify the idea with large user model of a mobile service. This is an ongoing work in connection to mobile application and services in the Wireless Trondheim Living Lab [25].

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Paper 6

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Mobile Services Personalization Evaluation Model

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Abstract

The proliferation of personalized mobile services is emphasizing the need to determine the users' perception of how successful personalization is, and how it can be improved and in which facet. For some users, personalization can be useful; others may find it confusing and prefer to turn it off. The motivation of the article is to explore and understand the success criteria of delivering personalized mobile services. The goal of this research work is to develop a theoretical model called Personalization Evaluation Model (PEM) to measure the effectiveness of personalization of mobile services. The main purpose of Personalization Evaluation Model (PEM) is to improve the understanding of the effectiveness of personalization of mobile services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM should provide the theoretical basis for practical testing of the effectiveness of personalized mobile services. The constructs developed for PEM are primarily adapted from the previous research of personalized mobile services.

Keywords: *Personalization, Mobile services, User satisfaction, Evaluation, User modeling, User acceptance*

1. Introduction and Motivation

Nowadays, mobile information services are delivering more than a user perceives to need. One size fits all approach seems not effective especially for mobile services. Instead, this approach may cause dissatisfaction or can annoy the users. To overcome this challenge, personalization can play a key role to deliver a personalized experience. It is providing a mean of fulfilling users' needs more effectively and efficiently and, thus increasing users' satisfaction. By providing successful personalization, a high level of user satisfaction and a pleasant user experience can be achieved. On the other hand, some features of personalization can cause problems and may outweigh the benefits of personalization. Therefore, there is a need to measure the effectiveness of personalization of mobile services.

It is evident that existing literature has not provided adequate theoretical and empirical evidence to show whether the user likes personalized services [1]. It is also necessary to examine the impact of personalized services on user satisfaction and the factors that affect the satisfaction with these services. Although, the effectiveness of web personalization is evaluated, but there is little attempt to evaluate the effectiveness of personalization of mobile services [2]. According to [3], personalization is iterative processes that can be defined by the three stages understand, deliver and measure cycle. The purposed personalization evaluation model focuses the "measure" phase of the process. Personalization is a multidimensional concept, and measuring such a multidimensional construct is always a challenge [4]. Few of

the studies have investigated whether personalized services can enhance user satisfaction, or why user satisfaction is increased. In order to take full advantage of personalization technology, we need to have a better understanding of how users respond to the service and its theoretical basis [1]. During evaluation of personalized services, the perception of personalization should not be asked directly as *do you like personalization* or *what is your perception about personalization* [5, 6]. It is not easy for a user to perceive personalization as a whole. Instead, it should be posed in terms of variables it is supposed to serve.

The main objective of this work is to explore and identify the success criteria of delivering personalized mobile services. Moreover, the objective is to propose a comprehensive evaluation framework to measure the effectiveness of personalized mobile services. It is hoping that the proposed personalization evaluation model will help to understand and evaluate the user's perception of the quality of personalization.

The measuring constructs used in this work are mainly adapted from previous research on personalization of mobile services. Since the main objective of personalization is to increase the user satisfaction; therefore, the primary construct to measure the personalization is user satisfaction. Varieties of constructs are used in previous research to measure some aspects of personalization. We have proposed PEM to provide a comprehensive approach to evaluate the effectiveness of personalization of mobile services. Section 2 provides a brief literature review and theoretical basis for PEM. The proposed personalization evaluation model is presented in Section 3. It also elaborates the measuring constructs and hypothesis development process. Section 4 concludes the paper and describes further work.

2. Literature Review and Related Work

The purpose of this section is to analyze the existing empirical literature on the evaluation of personalization. The literature reviewed is primarily drawn from the domain of mobile services especially having a focus on personalization. The objective of the analysis is to (1) understand the state of the art of mobile services personalization and research pertaining to the evaluation of personalization; (2) identify existing personalization variables that may lend support to the proposed model, and (3) determine the extent to which the proposed model goes beyond the existing research. The literature review has reflected a broad variety of personalization variables. However, it is observed that similar constructs were given different names in different studies. We have analyzed the conceptual and operational similarity among the constructs and make it possible to adapt the diversity of constructs.

Personalization of mobile services has a primary goal of reducing information load and delivering highly relevant contents to the users. Personalization is considered as a key factor of success of mobile devices and services [7]. For example, in [8] preference based news are delivered to mobile devices and filtered according to the preferences of a user and by tracking the user's behavior. Furthermore, contents can be adapted according to the device profile so that users can easily navigate and browse. According to [9] user satisfaction depends also on the technical quality, usability, and design of the mobile services. The measuring phase of personalization process [3] focused on measuring the impact of personalization by determining how much a user is satisfied with the personalization. Authors also suggested that there is a significant demand to develop appropriate metrics to determine personalization impact. Moreover, it is suggested that measuring the impact of personalization can help to understand the deficiencies of methods of personalized delivery. It can also help to serve as feedback for possible improvements to other components of personalization process. Jameson [10] has discussed predictability, comprehensibility, controllability, unobtrusiveness, privacy user experience, and system competence as usability issues of personalized systems.

A literature review [11] showed that different studies have used 44 different variables related to user-centered evaluation of personalized systems. Though, different names were used by the different authors, but the concept was identical. The key terms used were usability, perceived usefulness, and appropriateness of adaptation (detailed list can be found in [11]). A prototype evaluated in a study [12] used only two metrics to measure the personalization; effective rate as a quantitative metric and overall success factor as a qualitative metric. The effective rate represents the percentage of times the system was successful in providing what the user wanted. The overall success factor denoted the average of “actual success factor” for all provided results. The ratio between overall success factor and desired success factor provides an indication if a personalization system meets the given quality restrictions. However, limited evaluations cannot provide a complete overview of the effectiveness of personalization perceived by users.

Personalization has become an essential feature of variety of mobile services and few studies have measured the effectiveness of personalization. Mobile advertising is a popular research area where personalization is playing a prominent role. General attitude towards mobile advertising was measured by five key attributes [13], personalization, entertainment, informativeness, irritation and credibility. In this study, authors measure attitude of users in general; and made an assumption that perceived personalization of mobile advertisement affects the attitude towards mobile advertising. Again, asking users about personalization as a whole will not give the true evaluation of personalization. The metrics, like accuracy, consumer lifetime value, loyalty value and purchasing experience were suggested [3] to evaluate the effectiveness of personalization in m-commerce. However, much more work is needed to develop more ways to measure personalization impact [3]. In a case study [14], perceived relevancy and expectancy are utilized as evaluation factors to understand the attitude and behavior of users towards personalization. The author found that the relationship from perceived relevance to attitude, intention and actual use was significant. There are four kinds of user motives for using personalized systems under different theoretical perspectives of personalization [4]. These include aesthetic value for architectural personalization, social welfare/psychological well-being for relational personalization, productivity/efficiency for instrumental personalization, and material and psychic wellbeing for commercial personalization. Authors also argued that it is not reasonable to measure everything of personalization using a single yardstick. Other measurement constructs should be developed to suit different contexts of personalization.

A study has investigated the effects of location-based mobile personalization on user’s trust and distrust of mobile services and looked at two aspects: preference personalization and location personalization [15]. Personalization goal is to increase the usefulness and acceptance of information and services [7]. According to [16], personalization is about correct guessing about what the users perceive as added value. Therefore, there is a need to evaluate the personalized offerings in terms of user satisfaction. An empirical study [17], found that perceived enjoyment and perceived ease of use are the most decisive factors in adoption of personalized mobile services.

Personalization can bring user satisfaction, but it can also be irritating for users as well. According to [18], the negative consequences of personalization have rarely been investigated. Therefore, there is a need to evaluate to develop a comprehensive view of the success of personalization. A similar work [1] has evaluated personalized services and measure user satisfaction with four dimensions- information content, personalized service, user interface, and system value.

Supporting Theories

Theory of information load [19] and theory of uses and gratification [20] is briefly described in this section. The information overload theory implies that user satisfaction increases when the recommended content fits user interests. This theory focuses on the principles of least effort and information load. Zipf's principle of least effort [21], states that each individual will adopt a course of action that will require the least average work from the person. The principle of least effort predicts that information seekers will minimize the effort required to obtain information.

An alternative to the least effort theory is information overload, which means users are given more information than they can manage within a given time frame. That is the user would prefer to remove some information in order to reduce the required effort for finding the target. We can say that personalized services can increase user satisfaction by reducing information overload if such services can provide accurate service delivery.

Theory of uses and gratification indicates that motivations for information access affect user satisfaction. According to this theory, users' access information with a specific purpose and play an active role in selecting the source and information they like. User's gratification with a personalized service is vital for effective personalization. Different users may have different goals to personalize a service. It is quite natural that user's satisfaction increases with the achievement of the goal. The following Table 1 gives an overview of research variables and conceptual descriptions derived from the literature studied.

Table 1. The Conceptual Definitions of Research Variables

Research variables	Conceptual descriptions	References
Perceived information load	The degree to which a person believes that the information is filtered and reduced information load	[23, 25-28]
Perceived Relevancy and Accuracy	The degree to which a person believes that received information is according to the user's profile, preferences and context.	[5, 7, 8, 14, 15, 25, 26, 29]
Perceived Effort	The degree to which a user utilizes her/his effort to personalize a service.	[1, 30]
Perceived Trust	The degree to which a user has trust on personalized service.	[15, 18, 31, 38]
Perceived Privacy and Security	The degree to which a user has confidence that his/her personal data is secure.	[18, 27, 39]
Perceived Goal fulfillment	The degree to which a user believes that s/he has achieved the goal.	[4, 17, 32, 33]
Perceived User Control	The degree to which a user feels that s/he has control over her/his personal data.	[23, 30, 34]
Perceived device adaptability	The degree to which a user feels that her/his performance is increased due to device adaptability.	[29, 32, 35]
Perceived Effectiveness	The degree to which a user feels that overall personalization is effective.	[29]

3. Personalization Evaluation Model

Measuring the effectiveness of mobile services personalization is highly important. It is said by [3] that you cannot manage what you cannot measure. Personalization is not a single variable rather it is a combination of several complex variables. It is required to evaluate all personalization related variables to assess the impact of personalized services. Moreover, studying different personalization variables can help to identify which variable requires modification to increase the user's experience. In the literature studied, most of the services or systems have treated personalization as a single variable. For example, a study [22] has treated personalization as composite variable called relationship drivers used to express personalization in terms of time, location and adaptation to user profile. Treating personalization as a composite variable can lead to a variety of challenges to measure it. In a study [15], authors argued that the impact of mobile personalization is still inconclusive. According to [23], there is no science if personalization methods, techniques and algorithms cannot be effectively evaluated. User's evaluation feedback can play a key role in measuring and enhancing personalization. The use of feedback can be used to adjust preferences and can improve the user satisfaction [24]. Based on the theories and partially evaluated variables of personalization in different studies, we have proposed some constructs (see Table 1 and Figure 1) to evaluate different aspects of personalization.

Purposed Research Model and Hypotheses Development

This section describes mobile services personalization evaluation model in brief. The identified constructs are mainly derived from the literature of personalized mobile services.

User satisfaction and improved user experience are the main goals of personalization. Personalized mobile services can improve users' experience by personalizing different aspects of services. Identification of measuring constructs for the evaluation of personalization can be valuable and useful for the community. The personalization metrics can be different in different domains. For example, in personalized search engine, the metrics of success should be measured by means of perceived relevance of search results. However, it is difficult if not impossible to produce a definite set of metrics for successful personalization. In order to evaluate those aspects and measure the overall user satisfaction with personalization, we have proposed the PEM to measure the effectiveness of mobile personalized services.

User Satisfaction: User satisfaction is a common term used to represent overall satisfaction of a user with a service. It is quite natural that if a user is satisfied with a service, s/he will continue to use the service. In a way, we can say that user satisfaction has a strong correlation with use intention. These two constructs are particularly common to assess the success of various services or systems in different domains such as e/m-commerce, e-Government, and e/m-learning [39]. Personalization has the direct impact on user satisfaction, and it is essential to measure this construct to evaluate the effectiveness of personalized mobile services. Users can get frustrated if satisfaction metric is low and people can stop using personalized systems [3]. It is essential to determine the variables which are irrelevant for a personalized service and should be replaced with more relevant metrics.

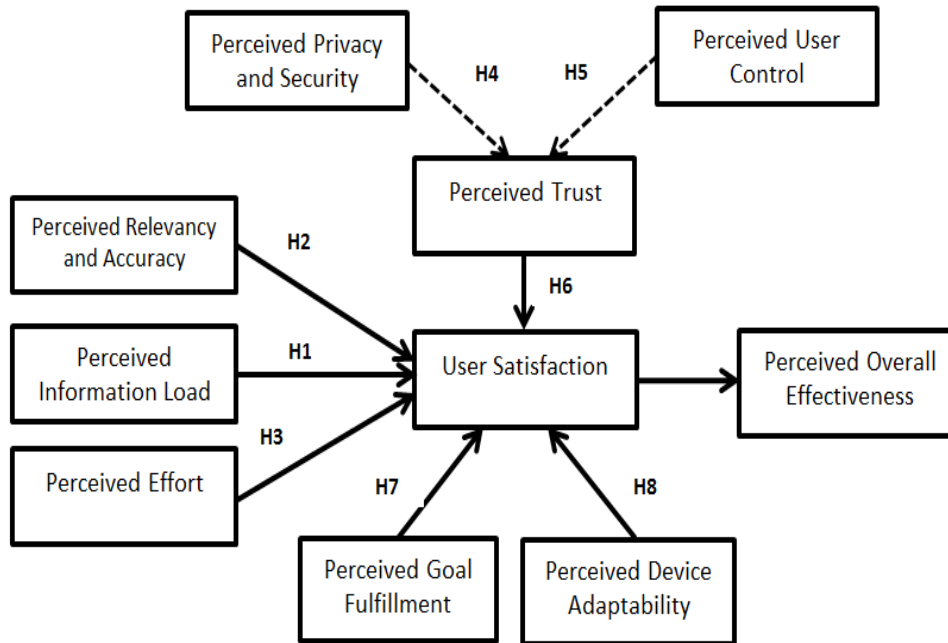


Figure 1. Purposed Research Model (PEM)

Perceived Information load: Information overload is an increasing problem as more and more data is available. Personalization can play a key role in reducing the information load. In case of personalized mobile services, reducing the information overload is a key feature of personalization. It is essential to exploit the knowledge about the situation of the user, the adopted channel and the environment to reduce the information load [25]. According to Herbert A. Simon, “What information consumes is rather obvious: it consumes the attention of its recipients”. Hence a wealth of information creates poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.” An empirical study [27] has investigated the effects of numerous irrelevant messages and found that information load has a direct impact on user’s satisfaction. Depending on the existing studies of personalization, it can be expected that the following relationship can hold.

H1: Perceived reduced information load has a direct positive effect on user’s satisfaction.

Perceived Relevancy and Accuracy: It describes the contents validity whether the received information is according to the user’s profile and context. This construct has significance in personalization and requires careful measurements. Perceived relevance is used to measure the success of personalization as a positive effect [5]. Perceived relevance is a key factor to measure the personalization [5]. However, it should not be the only construct to measure the effectiveness of personalization. User profile and context are playing a key role in personalization of mobile services [7, 25]. Therefore, perceived relevancy construct requires measurement. Users appreciate relevant and accurate information and can satisfy the users [14, 15, 26]. The construct describes how closely the information is related to a user’s interests and needs. We anticipated that the following relation can hold.

H2: Perceived relevancy and accuracy have a direct positive effect on user's satisfaction.

Perceived Effort: One purpose of personalization is to support a user to reduce the effort required to operate a system or a service successfully and effectively. Perceived effort is a fundamental construct to measure how much effort utilized to retrieve personalized contents. In addition, it also describes how much user was convenient to personalize a service. The measurement of this construct is important in the context of mobile services due to the limitations of mobile devices. An effort requires to adapt and utilize the personalization feature has a considerable effect on user satisfaction. It is related to the ease of learning and understanding of personalization feature by a user. In our opinion, the focus of perceived ease of use is different from perceived effort. Perceived ease of use has the expectation of positive intentions, whereas perceived effort has the expectation of adverse intentions. In a study [30], the authors have used a term perceived convenience to describe the same purpose.

Moreover, it is essential to consider how much a user is supported to complete a task without making so many mistakes. Personalization can help in taking over parts of routine tasks that may place heavy demands on a user's time and effort [10]. An adaptive interface is a key feature to support the user in reducing the effort and time to accomplish a task. In case of mobile services, personalized and adaptive interfaces are of high importance. Feedback intrusiveness [3] requires a lot of effort from users and can affect the user satisfaction. Here, the aspect of 'effort' also includes the setup and configuration to make personalization features functional.

H3: Perceived reduced effort has a direct positive effect on user's satisfaction.

Perceived Privacy and Security: This is another key construct to measure for evaluation of personalization. Since users shared their personal and sometimes financial information, security and privacy concerns are natural. Enhanced privacy and security can increase the trust of a user which in turn can raise user satisfaction. Privacy related intrusiveness in personalization is a challenge [3, 27]. For successful personalization, it is desirable to achieve a balance between usefulness of personalization and the extent of privacy a user wants to reveal. Privacy is an integrated part of personalization. Every person may have different priorities for privacy. Users may not want to share much information as they do not have trust or they are inquisitive about their personal information. Some people may want to share more personal information to gain more personalized experience [27]. We hypothesized as follows

H4: Perceived privacy has a positive effect on a user's trust.

Perceived User Control: Personalization is not meant to take control away from a user rather it puts a user more in control while using a service. It is quite natural that if a user feels more in control over her/his data and adaptation process; s/he will trust more and this ultimately will result in user satisfaction. As described by [36], user is responsible for initiation of the adaptation process and should have control over it. The user may be willing to control adaptability, modifiability and re-configurability of personalization process. In a survey [23], authors recommended that to achieve a right balance between privacy and personalization put people in control. Users' trust will rise if services allow control over their information. The tradeoff between benefits and risks of personalization should be explicit depending on the level of user's involvement. In a study [2], authors described that it is a proactive approach to protect the data on user's side which will put the user in more control. Sundar [30] has also advocated that perceived user control can increase the user satisfaction. We have anticipated the following hypothesis.

H5: Perceived user control has direct positive effect on a user's trust.

Perceived Trust: Trust is a fundamental requirement in a personalization process. User satisfaction and trust have a natural relationship. According to [31], trust has a significant impact over personalization. The tradeoff between privacy and personalization is a challenge. In a study [18], the authors suggested that trust can be a mediator between personalization, privacy and adoption intention. In PEM, we proposed that both privacy and user's control over her/his personal data can enhance trust and ultimately can increase the user's satisfaction. Another study [37] described that privacy concerns can lead to lack of user's trust and could result in dissatisfaction. We anticipated that the following relationship holds

H6: Perceived trust has a direct positive effect on user's satisfaction.

Perceived Goal Fulfillment construct describes the realization of a user's goal by personalized service. The main purpose of personalization is to fulfill user's goals and needs. Without the fulfillment of goal, personalization will be of no use. In addition to getting things done, users also have a need to "simply enjoy things" [4]. Further, authors argue that personalization systems may not only fulfill the functional aspects of human needs but also their entertainment aspects. Users are more focused and precise on their goal (finding a specific piece of information) in mobile services [32]. Playfulness or joyfulness can also be a goal to use a personalized service. We can say, perceived goal fulfillment has a direct positive impact on user's satisfaction.

H7: Perceived goal fulfillment has a direct positive effect on user's satisfaction.

Perceived Device adaptability: A variety of devices can be used to access information and services. It is significant that a service can adapt the personal preferences of a user's device. It can play a significant role in personalization and can make it convenient and efficient use of a service. As suggested by [32], the interface, layout and contents can be modified depending on the various conditions; including the user's preferences, the limitations of the device and the environment. Device adaptability can lead to increase the performance which in turn may increase the user satisfaction.

H8: Perceived device adaptability has a direct positive effect on a user's satisfaction.

Perceived Overall Effectiveness: Measuring the overall effectiveness of personalization of a mobile service is a central construct here. This construct describes the effectiveness of user's actions while using a personalized service. One of the main purposes of personalization is to enhance productivity of users. This construct describes to reduce the overall effort and completion of a goal in a short time, or can improve overall efficiency of a user. It reflects the overall usefulness and effectiveness of the personalized service.

Table 2. The operational definitions of research variables

Research Variables	Operational definitions
Perceived Trust	TR1: I feel confident when sharing personal data. TR2: I feel using personalized service is trustworthy.
Perceived Goal Fulfillment	PG1: I achieved my goal using personalized service PG2: Personalized service increase my efficiency
Perceived Effort	PE1: Personalized service reduce my effort PE2: It is easy to use a personalized service PE3: It is easy to become skillful with personalization.
Perceived relevancy and accuracy	PR1: Service is personalized to my context. PR2: Information is relevant to my interests. PR3: Information is accurate according to my profile.
Perceived Information load	PL1: I am receiving necessary information. PL2: I feel obtrusiveness is decreased. PL3: I am not missing crucial information.
Perceived User Control	PC1: I feel in control over my personal data. PC2: I feel in control over my privacy for personalization.
Perceived Privacy and Security	PP1: I feel privacy is correlated with desired personalization level. PP2: I feel personalization is not invading my privacy.
Perceived Device adaptability and performance	PA1: Personalized service is adaptable to my device profile. PA2: I feel device adaptability enhance my performance. PA3: I think device adaptability is efficient enough.
Perceived Overall Effectiveness	PO1: I feel personalization increase my performance PO2: I feel service personalization is useful.

4. Conclusions and Future Work

Personalization is a multidimensional construct. Providing personalized services is highly sensitive to user's context and needs. There is a need to evaluate and optimize personalization. The main objective of this work is to explore and identify the success criteria of personalization of mobile services. In this study, we have proposed an evaluation model to measure the impact of personalization. Different constructs are adapted from partially evaluated personalized systems or services performed by different studies. User satisfaction is utilized as a central construct in the research model due to its high relevance to personalization. Different hypothesis and measuring instrument is proposed to measure the impact of different variables of personalization. The next phase of the research is to evaluate the personalization evaluation model with a variety of personalized mobile services. We are hoping that the evaluation phase will help to improve the research model.

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Paper 7

Asif, Muhammad; Salimi, Neberd and Krogstie, John: “An Empirical Study of a Mobile Services Personalization Evaluation Model” Submitted to a Journal

An Empirical Study of a Mobile Services Personalization Evaluation Model

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Abstract. The proliferation of personalized mobile services is emphasizing the need to determine the user's perception of how successful personalization is, and how it can be improved. The study aims at investigating a research model, called Personalization Evaluation Model (PEM) along with 8 hypotheses to measure the effectiveness of personalization of mobile services. The proposed research model and hypotheses were empirically tested using data collected from a survey of 47 users of a personalized mobile news service. The findings indicated that the fitness of the research model is good and strong support was found for the research hypotheses. The main purpose of PEM is to improve the understanding of the effectiveness of personalized mobile services by providing new theoretical insights of measuring key variables of personalization. Moreover, PEM provides the theoretical basis for practical testing of the user satisfaction of personalized mobile news services.

Keywords. Personalization, Mobile services, User satisfaction, Evaluation, User modeling, User acceptance.

1 Introduction

Many mobile information services are delivering more than a user perceives to need. A one size fits all approach seems not effective especially for mobile services. Instead, this approach may cause dissatisfaction or can annoy the users. To overcome this challenge, personalization can play a key role to deliver a better experience. Personalization is providing a mean for fulfilling users' needs more effectively and efficiently and, thus increasing users' satisfaction. By providing successful personalization, a high degree of user satisfaction and a pleasant user experience can be achieved. On the other hand, some features of personalization can cause problems and may outweigh the benefits of personalization. Therefore, there is a need to measure the effectiveness of personalization of mobile services.

It is evident that existing literature has not provided adequate theoretical and empirical evidence to show whether the user likes personalized services [1]. It is also

necessary to examine the impact of personalized services and the factors that affect the users' satisfaction with these services. Although the effectiveness of web personalization is evaluated, there are few attempts to evaluate the effectiveness of personalization of mobile services [2]. According to [3], personalization is iterative processes that can be defined by three stages *understand, deliver and measure* cycle. The purposed research model (PEM) focuses on the "measure" phase of this process.

Personalization is a multidimensional construct and measuring such a multidimensional construct is always a challenge [4]. Few of the studies have investigated whether personalized services can improve user satisfaction, or why user satisfaction is increased. In order to take full advantage of personalization technology, we need to have a better understanding of how users respond to the service [1]. The perception of personalization should not be asked directly as "Do you like personalization" or "what is your perception about personalization" [5, 6]. It is not easy for a user to perceive personalization as a whole. Instead, it should be posed in terms of variables it is supposed to serve. The main objective of this work is to explore and identify the success criteria of delivering personalized mobile services. Moreover, the objective is to verify the validity of Personalization Evaluation Model (PEM) [7]. The measuring constructs used in this work are mainly adapted from previous researches on personalized mobile services. Since the main objective of personalization is to increase the user satisfaction with the mobile services; therefore, the primary construct to measure the personalization is user satisfaction.

The remainder of the paper is organized as follow: Section 2 discusses the research model (PEM) and hypotheses with a brief overview of constructs used. In section 3, the method and process of an empirical study to test the model along with results are presented. This is followed by discussions of findings and limitations of the study. Section 4 concludes the research work and points out further work.

2 Measuring Personalization

Personalization is not a single variable rather it is a combination of numerous complex variables. Measuring personalization as a single variable will not give a full picture as [3] described "you cannot manage what you cannot measure". Instead, it is required to study all the variables involved in personalization of a service to verify if personalization is successful or not. Moreover, studying different personalization variables will help to identify which variable requires modification to satisfy a user. In the literature studied, most of the services or systems have treated personalization as a single variable. For example, in a study [8], personalization is treated as composite variable called "relationship drivers". This term is used to express personalization in terms of time, location and adaptation to user profile. This kind of treatment with personalization will lead to different challenges of measuring personalization. In a study [9], authors argued that the impact of mobile personalization is still inconclusive. According to [10], there is no science if personalization methods, techniques and algorithms cannot be effectively evaluated. User's evaluation feedback can play a key role in measuring and enhancing personalization. The use of feedback

can be used to adjust preferences and can improve the user satisfaction [11]. Personalization can bring user satisfaction, but it can be irritating for users as well. According to [12], the negative consequences of personalization have rarely been investigated. Therefore, there is a need to develop a comprehensive view of the success of personalization. A similar work [1] has evaluated personalized services and measure user satisfaction with four dimensions- information content, personalized service, user interface, and system value.

2.1 Purposed Research Model and Hypotheses

Different mobile services focused on different aspects of personalization ranging from user interface to highly complex services. The constructs used in PEM are mainly adapted from previous studies and practical examples of personalized services (Fig 1). The identified constructs are presented in Table 1. User satisfaction and improved experience are a major goal of personalization. Different personalized services can improve users' experience by personalizing different aspects of services. Identification of measuring constructs for the evaluation of personalization would be valuable and useful for the community. As mentioned in [13], such metrics in different domains can be different, e.g.; in case of personalized search engine, the metric of success should be measured by means of perceived relevance of search results. Since the measurement of success is dependent on a specific goal, it is difficult if not impossible to present the definite set of metrics for successful personalization. In order to evaluate those aspects and measure the overall user satisfaction with personalization, we have proposed PEM to measure the effectiveness of personalized mobile services.

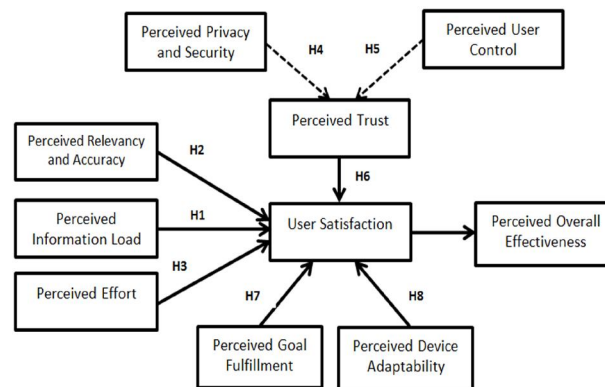


Fig. 1 Purposed Research Model

User Satisfaction: User satisfaction is a common term used to represent overall satisfaction of a user with a service. It is quite natural that if a user is satisfied with a

service, s/he will continue to use the service. There is a need to evaluate the personalized offerings in terms of customer / user satisfaction [14]. The construct is particularly common to assess the success of various services or systems in different domains such as e/m-commerce, e-Government, and e/m-learning. Personalization has the direct impact on user satisfaction, and it is essential to measure the construct to evaluate the personalization of mobile services. Users can get frustrated if the satisfaction metric is very low and people can stop using personalized systems [3].

Research variables	Conceptual Descriptions	References
Perceived information load	The degree to which a person believes the information is properly filtered giving reduced information load.	[10, 15-18]
Perceived Relevancy and Accuracy	The degree to which a person believes that received information is according to a user's profile, preferences and context.	[5, 9, 15, 16, 19-22]
Perceived Effort	The degree to which a user utilizes her/his effort to personalize a service.	[1, 23]
Perceived Trust	The degree to which a user trust the personalized service.	[9, 12, 24]
Perceived Privacy and Security	The degree to which a user has confidence that his/her personal data is secure.	[12, 17]
Perceived Goal fulfillment	The degree to which a user believes that s/he has achieved the goal using the system.	[4, 25-27]
Perceived User Control	The degree to which a user feels that s/he has control over her/his personal data.	[10, 23, 28]
Perceived device adaptability	The degree to which a user feels that her/his performance is increased due to device adaptability.	[22, 25, 29]
Perceived Effectiveness	The degree to which a user feels that overall personalization is effective.	[22]

Table 1. The conceptual definitions of research variables

Perceived Information load: Information overload is an increasing problem as more and more data is available. Personalization can play a key role in reducing the information load. In case of personalized mobile services, reducing the information overload is an essential feature of personalization. It is essential to exploit the knowledge about the situation of the user, the adopted channel and the environment to reduce the information load [15]. According to Herbert, "What information consumes is rather obvious: it consumes the attention of its recipients. Hence, a wealth of information creates poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it." An empirical study [17] has also investigated the effects of numerous irrelevant messages and found that information load has a direct effect on user's satisfaction. A similar study [18] has evaluated the obtrusiveness of services and described different levels of obtrusiveness required for different services to cope with information load. Depending on the existing studies of personalization, it is can be expected that the following relationship can hold.

H1: Perceived reduced information load has a direct effect on user's satisfaction.

Perceived Relevancy and Accuracy: It describes the contents validity whether the received information is according to the user model. This construct has significance in personalization and requires careful measurements. Perceived relevance is a key

factor to measure the successful personalization [5]. However, it should not be the only construct one use to measure the effectiveness of personalization. User profile and context are playing a key role in delivering relevant contents [15, 19]. Users appreciate relevant and accurate information which can satisfy the users [9, 16, 21]. This construct describes how closely the information is related to a user's interests and needs. We anticipated that the following relationship can hold.

H2: Perceived relevancy and accuracy have a direct positive effect on a user's satisfaction.

Perceived Effort: One purpose of personalization is to support a user to reduce the effort required to operate a system or a service successfully and effectively. Perceived effort is a fundamental construct to measure how much effort that is utilized to retrieve personalized contents. This construct is of highly importance in the context of mobile services due to the limitations of mobile devices. An effort requires to adapt and utilize the personalization feature has a considerable effect on user satisfaction. It is related to ease of learning and understanding of personalization feature by a user. In our opinion, the focus of perceived ease of use is different from perceived effort. Perceived ease of use has the expectation of positive intentions, whereas perceived effort has the expectation of negative intentions. In a study [23], the authors have used a term perceived convenience to describe the same purpose. Moreover, it is essential to consider how much a user is supported to complete a task without making so many mistakes and effort [30]. An adaptive interface is another key feature to support the user in reducing effort and time to accomplish a task. The personalized interface is more relevant in case of mobile services. Feedback intrusiveness [3] requires a lot of effort from users and can affect the user satisfaction as well. Here, the aspect of 'effort' also includes the setup and configuration to make personalization features functional.

H3: Perceived reduced effort has a direct positive effect on user's satisfaction.

Perceived Privacy and Security: This is another key construct to measure for the evaluation of personalization. Since users shared their personal and sometimes financial information, thus security and privacy concerns are natural. Enhanced privacy and security can increase the trust of a user which in turn can raise user satisfaction. Privacy related intrusiveness in personalization is a big challenge [3, 17, 31, 32]. For successful personalization, we have to achieve a balance between usefulness of personalization and the amount of privacy the user want to reveal. Privacy is an integrated part of personalization. Every person may have different priorities for privacy. Users may not want to share much information as they do not have trust or they are more inquisitive about their personal information. Some people may want to share more personal information to gain more personalized experience [17]. We hypothesized this relationship as follows:

H4: Perceived privacy has a positive effect on a user's trust.

Perceived User Control: Personalization is not meant to take control away from a user rather it puts a user in more control while using a service. It is likely that if a user feels more in control over the data and adaptation process, s/he will trust the service more and this ultimately will result in user satisfaction. As described by [33], the user is responsible for initiation of the adaptation process and should have control over it. The user may be willing to control adaptability, modifiability and configurability of personalization process. Users' trust will increase if services allow more control over

their own information and make explicit the tradeoff between benefits and risks according to the level of user's involvement. In a study [2], authors described that it is a proactive approach to protect the data on user's side and Sundar [23] has also suggested that perceived user control can increase the user's trust. We have anticipated the following hypothesis.

H5: Perceived user control may enhance a user's trust.

Perceived Trust: Trust is a fundamental requirement in a personalization process. User satisfaction and trust has a natural relationship. According to [24], trust has a significant impact over personalization. The tradeoff between privacy and personalization is a challenge. In a study [12], the authors suggested that trust can be a mediator between personalization, privacy and adoption intention. In this research context, we proposed that both privacy and user's control over her/his personal data will enhance trust and ultimately will increase the user's satisfaction. A similar study [34] also described that privacy concerns can lead to lack of user's trust and could result in dissatisfaction. We anticipated that the following relationship holds

H6: Perceived trust has a significant effect on user's satisfaction.

Perceived Goal Fulfillment construct describes the realization of a user's goal while using a personalized service. One of the purposes of personalization is to fulfill user's goals and needs. Without the fulfillment of a goal, personalization will be of no use. In addition to "getting things done," users also have a need to "simply enjoy things" [4]. Further, authors argue that personalization systems may not only fulfill the functional aspects of human needs but also their entertainment aspects. In case of mobile services, users are more focused and precise to their goal such as finding a specific piece of information [25]. Playfulness or joyfulness can also be a goal for using a personalized service. We can say that:

H7: Perceived goal fulfillment has direct positive effective on user's satisfaction.

Perceived Device Adaptability Different mobile devices are used to access mobile services. It is important that a service can adapt the personal preferences of a user's device. It can play a significant role in personalization and can make it convenient and efficient use of a service. As suggested by [25], the interface and layout including information can be modified according to various conditions, including the user's preferences, the limitations of the device and the environment. Device adaptability can lead to increase the performance which in turn may increase user satisfaction.

H8: Perceived device adaptability has a direct positive effect on user's satisfaction.

Perceived Overall Effectiveness: Measuring the overall effectiveness of personalization of a mobile service is of highly importance. This construct describes the effectiveness of user's actions while using a personalized service. One of the main purposes of personalization is to enhance overall productivity of users. This construct describes to reduce the overall effort and completion of a goal in a short time, or can improve overall productivity of a user. It reflects the overall usefulness and effectiveness of the personalized service depending upon the overall user satisfaction.

3 Methodology and Results

3.1 Personalized Mobile News Service

A personalized mobile news service was developed at a Norwegian University to deliver personalized news depending on user's context, preferences, interests and device profile. The application has various features such as latest news and users can add or remove news categories based on their own interests or preferences. In addition, the news are presented based on user's context such as location, time etc. Figure 2 shows a few screen shots of the application illustrating its functionality. The users' actions in the application are recorded in order to determine which categories of news articles they prefer reading. Each news category is assigned a numerical weight that increases as the user reads news articles. This is a simple algorithm that increases the news category with if the article belonging to the selected news category is read. Based on this, the users have the opportunity to see the overall statistic of how many articles they have read in the various categories. The statistics are shown in the form of graphs to provide awareness to the user.

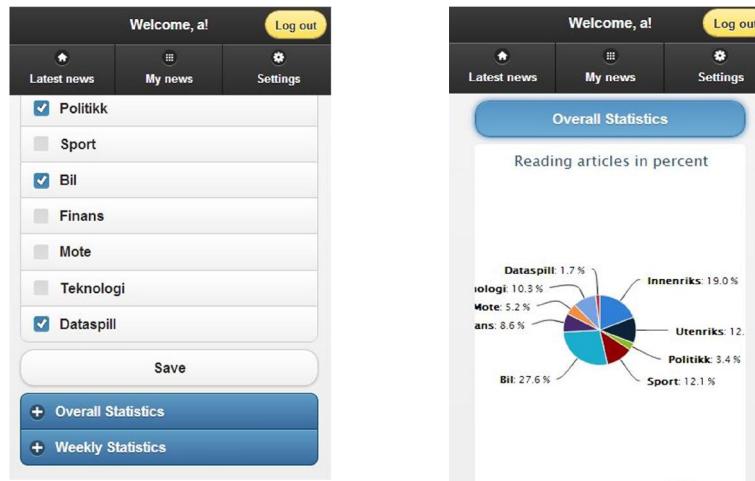


Fig. 2. Screenshots of the service

3.2 Study Design and Procedure

Operational definitions of the study instruments are shown in Table 1. For each variable, a multiple-item scale was developed where each item was measured based on a 5-point Likert scale, ranging from 1—"Strongly Disagree" to 5—"Strongly Agree". Data were collected through a structured questionnaire both in a hard-copy and an electronic form. The electronic version was uploaded on a website for a month,

from November 10th to December 15th 2013. Additionally, contacts from various mailing lists were asked to fill in the questionnaire, as well as members of two popular social networks—Facebook and Twitter—were encouraged to participate in the survey. Users were asked to download the application from a given link and use as long as they wanted to perform given tasks. The questionnaire was based on prior surveys approved for their validity and reliability and few questions were newly added to get a complete insight. We received 47 responses in total. The demographic profile of respondents is presented in Table 2.

Total Responses	47	Percentage
Gender	Male: 32 Female : 15	Male: 68% Female: 32%
Age	Less than 25 : 4 Between 25-35: 29 Above 35 : 14	< 25 : 8% Between 25-35: 62% Above 35: 30%
Length of Experience in using mobile services	2-5 year : 6 2-5 years: 20 More than 5 years : 21	2-5 years : 12% 2-5 years: 43% > 5 years: 45%

Table 2. Demographic profile of respondents

3.3 Test of Measures

To test the reliability and validity of each construct in the mobile service personalization evaluation model (PEM), the Internal Consistency of Reliability (ICR) of each construct was tested with Cronbach's Alpha coefficient. For the purposes of testing the research hypotheses, partial least squares (PLS) analysis was used. PLS is a regression-based technique, with roots in path analysis [35, 36]. It has emerged as a powerful approach to studying causal models involving multiple constructs with multiple measures [37]. PLS allows people to do a combined regression and principal components factor analysis within the same statistical technique. In this study, the collected data was analyzed using the statistical software Smart PLS 2.0 and SPSS Version 18. Table 2 presents the reliability coefficients for each of the constructs in our measurement model.

Reliability analysis of constructs		
Constructs	Number of Items	Cronbach's Alpha
Perceived Relevancy and Accuracy	3	0.725
Perceived Information Load	3	0.622
Perceived Effort	3	0.751
Perceived Goal Fulfilment	2	0.743
Perceived Device Adaptability	3	0.828
Perceived Privacy and Security	2	0.835
Perceived User Control	3	0.796
Perceived Trust	2	0.836
User Satisfaction	2	0.821

Table 3. Reliability analysis of constructs

According to previous research work [38], a reliability coefficient of 0.6 is marked as a lowest acceptable limit for Cronbach’s Alpha for exploratory research. Moss [39] also suggested that an alpha score of 0.6 is generally acceptable. All Cronbach’s Alpha values of the constructs in our model are above threshold 0.6. Thus, the scales were deemed acceptable to continue.

3.4 Structural Measurement Model

Figure 3 presents the structural measurement model using the PLS algorithm. The number in the circles in Figure 3 means R² (R square), which denotes to coefficient of determination. R² provides a measure of how well future outcomes are likely to be predicted by the model, the amount of variability of a given construct [40]. In our PLS analysis, the R² coefficient of determination is a statistical measure of how well the regression coefficients approximates the real data point. Table 4 shows the path coefficients, which are standardized regression coefficients, generated from the PLS analysis. As such, the eight hypotheses were supported. In addition, all the eight hypotheses were statistically significant ($p < 0.05$ or $p < 0.01$).

Test of Hypothesis based on Path Coefficient			
Hypothesis	Path Coefficient	T Value	Hypothesis Results
H1: Perceived Information Load to User Satisfaction	0.112*	3.312	Supported
H2: Perceived relevancy and accuracy to User Satisfaction	0.394*	5.452	Supported
H3: Perceived Effort to User Satisfaction	0.103*	4.243	Supported
H4: Perceived Privacy and Security to Trust	0.294**	4.261	Supported
H5: Perceived User control to Trust	0.211**	5.233	Supported
H6: Perceived Trust to User Satisfaction	0.171*	2.432	Supported
H7: Perceived Goal Fulfillment to User Satisfaction	0.183*	3.452	Supported
H8: Perceived Device adaptability to User Satisfaction	0.121*	2.737	Supported

* $p < 0.05$; ** $p < 0.01$.

Table 4. Test of Hypothesis based on Path Coefficient

4 Discussions

The findings of this empirical study provide some insights to both researchers and practitioners of personalized mobile services. This study contributes to the literature on mobile services personalization and adoption. The findings demonstrated the appropriateness of the research model and hypotheses for measuring the effectiveness of personalization. In addition, the statistical results of the research model provide insights to better design personalization features for mobile services. The personalized mobile news service used in this study makes an ideal case to validate the personalization evaluation model. The application used was developed by using

mobile client-side personalization approach [32] to deliver new services. The results showed that the most important construct was relevancy and accuracy of news service delivery.

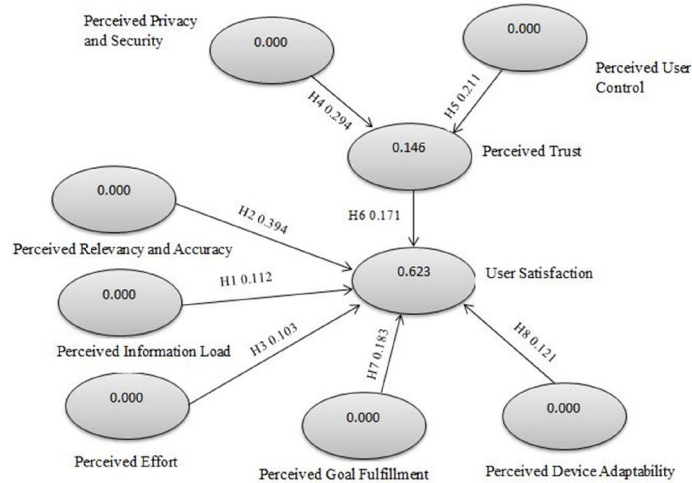


Fig. 3. The Structural Model

As shown in Table 2 this application was used by experienced users and has positive direct effect on user satisfaction. User's goal fulfillment (receiving personalized news) has the second highest score which indicates that it has direct positive effect on user satisfaction. In the case of trust it seems that users were not much concerned about their privacy, but willing to control the preferences and showed direct positive effective as well. But this can be of high concern in personalized mobile service where more sensitive information is being used. Device adaptability was also required to verify that if it can have some effect on personalization. Users were free to use the application on any kind of mobile device. The results showed that the device adaptability has some direct positive effect on user satisfaction. It was also found that the construct perceived effort and reduced information load was also observed by the users and validated the hypotheses. This study also provided some practical implications. The results of this empirical study can provide guidelines and suggestions to mobile services providers and developers in providing personalized mobile services. The findings suggested that the personalization should not be treated as a black box instead it requires careful consideration of different variables.

However, this study has some limitations. Firstly, we have only tested the research model and hypotheses on a single mobile information service (news service). Therefore, the generalizability of the results to other personalized mobile services remains to be determined. In addition, the findings of this study may be limited due to the relatively small sample size. Last but not least, the subjects in the study were

asked to download the application on their mobile devices and this study didn't collect the type of devices used for the testing.

5 Conclusions and Future work

The main objective of this work was to explore and identify the success criteria of personalization of mobile services. A research model developed earlier with eight hypotheses were presented and empirically tested. From a survey of 47 users of a personalized mobile news services, we found that perceived relevancy and accuracy, perceived information load, perceived effort, perceived goal fulfillment and device adaptability has direct effect on the user satisfaction while user control and perceived privacy and security has direct effect on trust. The results indicated that the fitness of the research model is good and all eight research hypotheses were supported. Concerning future research, a longitudinal study is needed to re-validate the research model. By choosing a longitudinal method, the research can more closely examine the constructs measured in the research model. Another possible extension to this research is to examine the applicability of the research model to the personalized mobile services of different domains.

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List of Secondary Papers

1. **Asif, Muhammad and Krogstie, John:** Identifying Problem Frames for Location based Services. *Proceedings of the 6th International Conference on Ubiquitous Information Management and Communication*. Association for Computing Machinery (ACM) 2012 ISBN 978-1-4503-1172-4.
2. **Asif, Muhammad and Krogstie, John:** Mobile student information system. *Campus-Wide Information Systems* 2011 ;Volum 28.(1) s. 5-15
3. **Gao, Shang; Krogstie, John; Asif, Muhammad; Kuadey, Noble.** An Empirical Study of Mobile Information Service Adoption at Norwegian University. *Proceedings of the International Conference on Electronic Business* 2010 s. 463-470



NTNU – Trondheim
Norwegian University of
Science and Technology

To the evaluation committee

Co-authorship regarded publication included in “Muhammad Asif’s” PhD thesis titled “Personalization of Mobile Services”

(cf. the PhD regulations § 7.4, section 4 and the dr.philos regulations § 3, section 5, <http://www.ntnu.edu/ime/research/phd/forms>).

Candidate’s described contribution to:

Asif, Muhammad and Krogstie, John: “**Taxonomy of Personalization in Mobile Services**”. Proceedings of the IADIS International Conference e-Society 2012. IADIS Press 2012 ISBN 978-972-8939-67-0

Asif’s Contribution: under the competent guidance of Prof. John Krogstie, I “Muhammad Asif” is the first author of this paper.

Statement by the co-author:

I hereby confirm that the doctoral candidate’s contribution to this paper is correctly identified above, and I consent to Paper 1 including it in his PhD dissertation.

Trondheim, 24.04.2014

Prof. John Krogstie (Main Supervisor)



NTNU – Trondheim
Norwegian University of
Science and Technology

To the evaluation committee

Co-authorship regarded publication included in “Muhammad Asif’s” PhD thesis titled “Personalization of Mobile Services”

(cf. the PhD regulations § 7.4, section 4 and the dr.philos regulations § 3, section 5, <http://www.ntnu.edu/ime/research/phd/forms>).

Candidate’s described contribution to:

Asif, Muhammad and Krogstie, John: **“Research Issues in Personalization of Mobile Services”**. International Journal of Information Engineering and Electronic Business 2012;Volume 4.(4) s. 1-8

Asif’s Contribution: under the competent guidance of Prof. John Krogstie, I “Muhammad Asif” is the first author of this paper.

Statement by the co-author:

I hereby confirm that the doctoral candidate’s contribution to this paper is correctly identified above, and I consent to Paper 2 including it in his PhD dissertation.

Trondheim, 24.04.2014

Prof. John Krogstie (Main Supervisor)



NTNU – Trondheim
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To the evaluation committee

Co-authorship regarded publication included in “Muhammad Asif’s” PhD thesis titled “Personalization of Mobile Services”

(cf. the PhD regulations § 7.4, section 4 and the dr.philos regulations § 3, section 5, <http://www.ntnu.edu/ime/research/phd/forms>).

Candidate’s described contribution to:

Asif, Muhammad and Krogstie, John: **“Role of Personalization in Mobile Services Adoption”**. Proceedings of the International Conference on Multimedia and Human Computer Interaction. International ASET Inc. 2013 ISBN 978-0-9867183-8-0.s. 1-10.

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Statement by the co-author:

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I hereby confirm that the doctoral candidate’s contribution to this paper is correctly identified above, and I consent to Paper 6 including it in his PhD dissertation.

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Statement by the co-author:

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