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 scrutatable 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 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) scrutatable 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.
**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) - to check user profile and priority rules and Ask (R) - to 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 the 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.

**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].

**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.

**REFERENCES**


