Designing Personalised Information Access to Structured Information Spaces

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Abstract. The paper presents an approach to personalisation of structured information spaces that builds around a set of services. Structured information representation is increasingly being used to improve the organisation, search, and analysis of information spaces provided on the Web and is very popular in digital libraries, classification-based search engines, information directories, and subject gateways. In a service-oriented approach, the application behaviours contained in the various systems are defined as services which are "open" and can be consumed by other applications. The paper identifies relevant personalisation services, discusses their expected behaviours, and explores the dimensions of individual differences that should be included in a user model specification to meet personalisation services requirements and create personalised information access.

1 Introduction

The concept of information spaces on the Internet spans over various domains, such as hypertext documents, digital libraries, subject gateways, web directories, newsgroups and mailing lists [6]. The diversity, organizational heterogeneity, immense size and dynamic expansion that characterize Web information spaces have made information searching, navigation and browsing quite challenging tasks: (i) some information spaces are not clearly delimited; (ii) users' abilities can vary greatly and their level of domain understanding may grow differently during interaction as it depends on their knowledge background and expertise; (iii) sometimes information services have been developed by content providers without enough thought given to interface design considerations, information presentation and organization; (iv) users may be affected by errors and omissions that were made during construction of the space, as they may experience situations like not being able to locate the information they need or "being misled" when browsing through the search results or the information categories..

This paper focuses on information spaces that adopt a structured information representation approach. In a highly structured virtual information space, all

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information related to the same topic can be found under the same subcategory. Pieces of information that relate to multiple topics will appear under several distinct subcategories. Most of existing structured information spaces comprise a structure for the organisation of the content, metadata descriptions regarding the semantics of the content and their access properties [28]. In a structured information space personalisation can exploit user metadata and resources metadata. A personalised view of the information space can be created by matching user model attributes with resources attributes. This matching process can be also considered as an inference mechanism, such as those based on rules, to determine whether a service is recommended, identify relevant resources or support user navigation thought the content by generating tailored navigation paths.

Integration of adaptation techniques in existing systems is considered the next challenging step in the evolution of personalised services. To this end, several approaches have been proposed so far, such as those explored in the context of web-based instructional systems [2], e.g. standard-based reusability, resource discovery architectures and semantic web technologies for learning [7]. Towards this direction this paper adopts a service-oriented approach, [32], as a common framework to personalise the access in an integrated information space. This approach facilitates the integration of commercial, in-house and open source components and applications within organisations and regional federations by agreeing upon common service definitions, behaviours, data and user models, and protocols. The rest of the paper discusses a subset of these issues: the next section identifies and defines personalisation services for information spaces. Then aspects of the user are considered and data models for user profiling are discussed to support these personalisation services. The paper ends with discussion and future work.

2 Service-oriented Approach for Personalised Information Spaces

Service-oriented approaches provide several benefits, such as support for planning technical and interoperability specifications and standards development, enable alignment with business processes and support business models, offer flexibility to accommodate evolving organisational requirements, provide a flexible and modular technology base, make information sharing of applications simpler and allow collaborative organisations to deploy applications that meet their common needs.

Service-oriented approaches for personalisation allow the development of modular and flexible personalised systems, [1], where the components can be added, removed or replaced more easily than in traditional models of adaptive hypermedia systems, and where new applications or systems can be composed from collections of available services. They also enable faster deployment of personalisation technologies as long as the needs of new components are compatible with the existing component interfaces. This approach is different from integrating directly at the user interface level (e.g. by using portals) or at the data level (e.g. by creating large datasets or data warehouses). For example, a student record system may provide services for enrolment and registration processes which can also be used by an cross institutional library system to allow registered students to access online course materials and related information resources to collaborating institutions. Another example is a personalised recommendation service that can be utilised by a variety of applications to recommend web content, learning objects to study in a virtual learning environment, or learning opportunities in a professional/personal development system.

A service-based architecture may provide personalisation on the basis of well defined service behaviours and interfaces and allows various open specifications, open source toolkits and standards to be used in implementing the services. From the functional definition and scope of a specific service an abstract model of behaviour and data can be developed, which describe the expected behaviour of a realisation of this service and the data model (e.g. using XML) it deals with or exchanges. A service can be realised in a number of ways, such as a Web service (e.g. using WSDL) and Application Programming Interfaces for particular programming languages. The various services interact to provide the complete functionality [1].

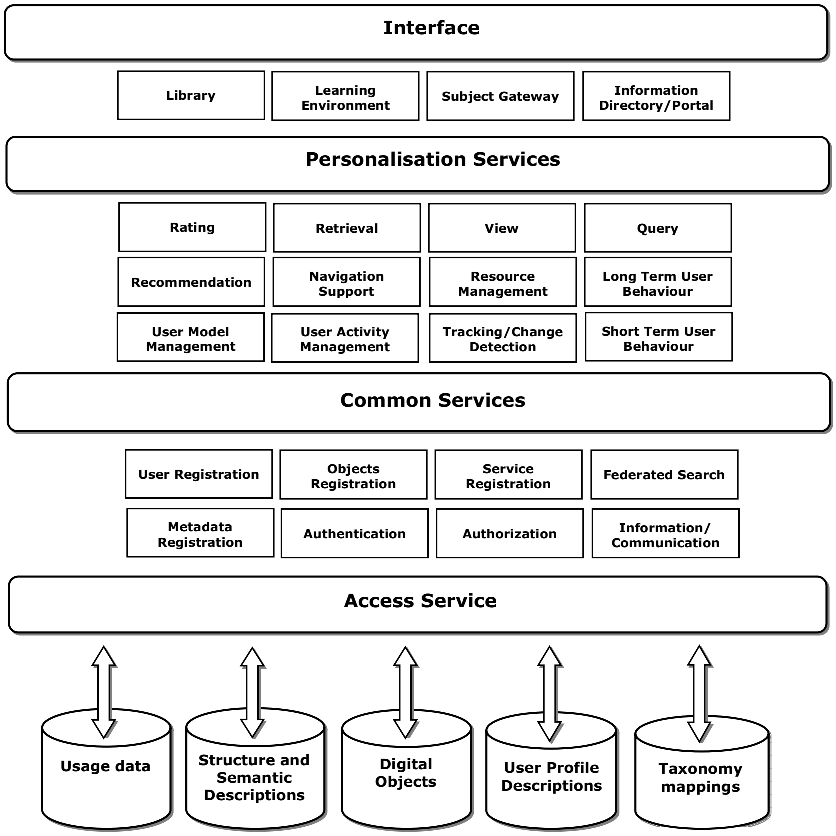

Fig. 1. A set of identified services for personalised access.

The model of Fig. 1 shows a proposed set of fundamental services for structured information spaces. The services are organised into logical groups but no explicit association among service functional definitions is implied. The “Personalisation” group identifies services that can be used to support functionalities for personalisation of the integrated information space (see Table 1). For example, a Retrieval service may provide personalised information seeking by allowing users to browse digital objects or conduct augmented keyword-based searching. This type of functionality may exploit taxonomies descriptions or metadata properties of the objects as well as user profile elements, such as goals, preferences, cognitive style etc. A service that monitors user Long Term Behaviour can collect user's general preferences so that decisions can be made for the presentation, layout and content of the pages he/she visits. This can be used for example to map digital objects and activities against specific competencies, and allow applications, such as a simple portal (see top level of Fig. 1), to automatically configure themselves for particular user(s) as well as to alleviate manual entering of user preferences into multiple application interfaces, such as portal, library, learning environment etc.

Personalisation Service	Expected functionality
Rating	Support for the use of secondary metadata (user ratings and text annotations) for resources.
Retrieval	Browsing though the digital objects based on taxonomies descriptions.
View	Generate personalised views over the digital objects and schemata.
Query	Provide query facilities over structured and semantic descriptions.
Recommendation	Recommend information content based on application-specific user history and behaviour, and metadata descriptions.
Navigation Support	Support navigation though the information space.
Resource Management	Automatically determine information about appropriate search terms and the structure of metadata records that will be returned to them; support retrieval, description, and organisations of resources.
Long Term User Behaviour	Support the mapping of digital objects and activities against specific competencies; persistent between sessions.
User Model Management	Support the management of individual and group user models. Includes policies for updating and registering user models.
User Activity Management	Initialise services with user preferences information.
Tracking/Change Detection	Track/detect changes in the objects descriptions/metadata as well as in the user model specifications; may call other services to translate changes from one schema to another as well as other access services.
Short Term User Behaviour	Collects information about user model attributes that correlate with functions of the application and the behaviour of the user.

Table 1. Overview of personalisation services for information access.

The "Common Services" group identifies services that may be common across different application domains; e.g. a Search service that supports finding information resources either using a simple query grammar or multiple search types (when search results are collected from across multiple types of search then a Federated Search service is used).

3 User aspects and User Data Models for Personalisation

Personalised access to information is offered on the basis of "understanding" the user. Users seeking for information increasingly need support in order to avoid disorientation. Particularly when browsing an information space, users may fail to develop a holistic understanding of how all the information fits together and as a consequence may formulate unsuccessfully their search goals, information needs, and miss locating relevant content [29]. Moreover, as virtual spaces tend to be immense, dynamic, and fragmented, understanding their organization or the organization of the search results may lead to an ongoing learning process for the user.

Although a variety of data models are available for describing user aspects, such as OUNL-EML, PALO, PAPI, IMS-LIP, ARIADNE, there is no standard way to represent application-specific user models on the Web [10, 12]. Nevertheless, the provision of personalisation services requires creating and updating a user model for each user or for each user group, where the dimensions of the different user models may differ in their semantic descriptions. Hence we identify below nine dimensions of a user data model for structured information spaces. Our choices have been informed by suggestions made in [15] and include:

(i) Personal data, such as gender, age, language, culture, affect the perception of the interface layout, and should be taken into account when designing personalisation services. For example, the preferences of males and females differentiate remarkably in terms of navigation support [4], attitudes [11], information seeking strategies [16,31] and media preferences [22].

(ii) Cognitive or learning styles refer to a user's information processing habits and have an impact on user's skills and abilities, such as preferred modes of perceiving and processing information, and problem solving [3, 19]. They can be used to personalise the navigation support, the presentation and organisation of the content and search results. [20].

(iii) Device information concerns the hardware used for access and affects personalisation services in terms of screen layout and bandwidth limitations [5].

(iv) Context-related data capture the physical environment from where the user is accessing the information and can be used to infer the user's goals [18].

(v) User history data capture user past interaction with the system, e.g. visited pages that contain pointers to specific keywords [23], or browsing habits [25], and can be used under the assumption that users' future behaviour will be almost similar to their past behaviours.

(vi) User preferences and interests are usually provided in the form of keywords or topics of interest for that user [23, 27].

(vii) Goal-related data indicate the reason for which that user is searching information for that particular session [14, 24]. For example it is not the same to search information about China as a tourist or as a student writing a school report.

(viii) System experience indicates the knowledge of that particular user about the information space. For example, system experience may depend on users' familiarity with a digital library features and functionalities [26], or with her familiarity with learning environments [21, 30]. It can be used to personalise the navigation, the search results or provide intelligent help.

(ix) Domain expertise relates to the existing level of understanding of a particular user on the domain knowledge. The level of expertise of a user can vary with the domain and influences the navigation behaviour [9,17].

As already mentioned, it is unlikely that all the information required by any particular personalised information space can be captured in the elements of a specific data models. Models, such as PAPI and IMS-LIP include elements for covering dimensions such as user history data and goal-related data but other dimensions of the user model may require mixing, adapting and sometimes extending a data model to meet specific application requirements for the personalisation functionalities [10,12,13]. This has also been considered in the context of semantic web to enable semantically enhanced educational systems to provide personalisation services [7,8]. Encoding user profiles in RDF provides flexibility to include elements from multiple schemata, to enrich them with additional elements, when necessary, and to maintain interoperability with other systems [7,8].

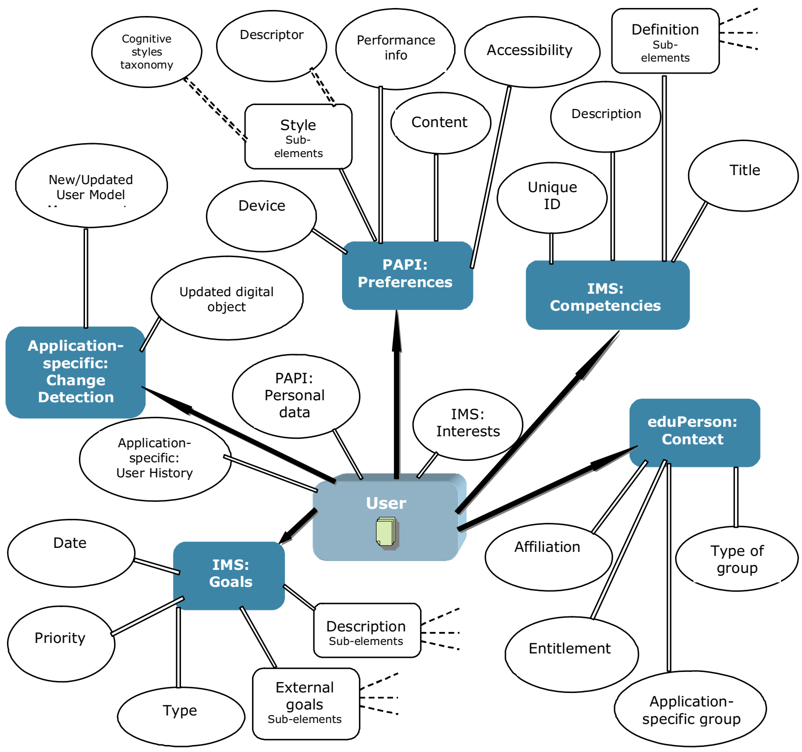

Fig. 2. A fragment of the user model schema.

Fig. 2 adopts this approach providing a simplified view of a user model using an RDF-like encoding. The schema of Fig. 2 uses elements of the PAPI (Personal and Private Information) standard, the IMS (Instructional Management System) metadata specification, as well as application-specific elements, such as the Change Detection element. Also, the Style element, shown in Fig. 2, provides an example of how cognitive styles can be incorporated in the user model schema by extending the PAPI shema (or the *catalog* and *entry* elements of the IMS schema). The style *taxonomy* can include several cognitive style categorisations, such as Witkin; Honey-Mumford and so on; while the *descriptor* element can take values in the set of field dependent/field independent or reflector/theorist/activist/pragmatist respectively. Moreover, the user model may include elements of the eduPerson schema which defines how a subset of the user information might be represented in an enterprise directory. Whilst, the IMS specification defines application independent structured data models for representing various pieces of user information, the eduPerson elements of the user schema allow authorised users and services to access information regardless of where or how the original information is stored. Not all user model elements are necessary in order to implement a given service.

3 Discussion and Future Work

The service-oriented approach models an information space on the basis of services, which work on data structures/objects, and processes that describe sequences of steps and the services and data involved in each step, in order to tailor the information and the interface to the needs of the individual. This is visualised as layered software architecture in Fig. 3, in an attempt to provide an overview of this approach.

One key challenge of this approach is defining what components are needed and how they should be connected so that they have minimum dependencies in order to be recombined for different purposes. (Components can consist of objects, services and processes that are related to each other, e.g. a component can organise the operation of other components.) Another challenge is identifying what services components should offer. (A service can be used to connect one component with another, or as a method applied on an object.)

Personalisation in this context emerges through the aggregation of a set of services that implement a personalised function. It can also be materialised by creating, managing and storing "personal views" or relationships between information from a diverse set of existing applications (see Application delivery layer in Fig. 3). These can be tailored to the needs of individual users by combining components (which will provide the necessary functionality) and assembling services from a set of components to reduce implementation cost. For example, new types of "personal" information spaces can be composed, multiple user interfaces or portals, tailored to specific users or tasks, can be produced in this way (see Application delivery layer in Fig. 3). This of course requires a framework for the user interface, which as shown in Fig. 3 can take different forms to that to manage the communication between layers, support navigation and content presentation to each user. The user interface is supported by Application and Personalisation Services as shown in the Services layer of Fig. 3.

In general, the Services layer creates the mapping between applications, systems and data, and the "service-oriented model". Two levels of services can be envisaged: (i) high-level services include services, processes and objects/data structures that are shared across applications, aggregate low level services functionality, manage user/application data, define processes, control objects/services etc. For example, a personalisation service can translate application functionality into user interface features. This may depend on the state of an application and/or previous user activity. The personalisation service may behave differently when the user is not authenticated (see Common Services in Fig. 1). Certain personalisation services may be offered to the user only when an application is at a particular state or when previously called services have performed certain actions. Low level services, such as an authentication service, can be considered as general purpose; they do not rely on other services, and are standardised across all applications. For example, these may include services for object/data registration, communication (cf. Fig. 1).

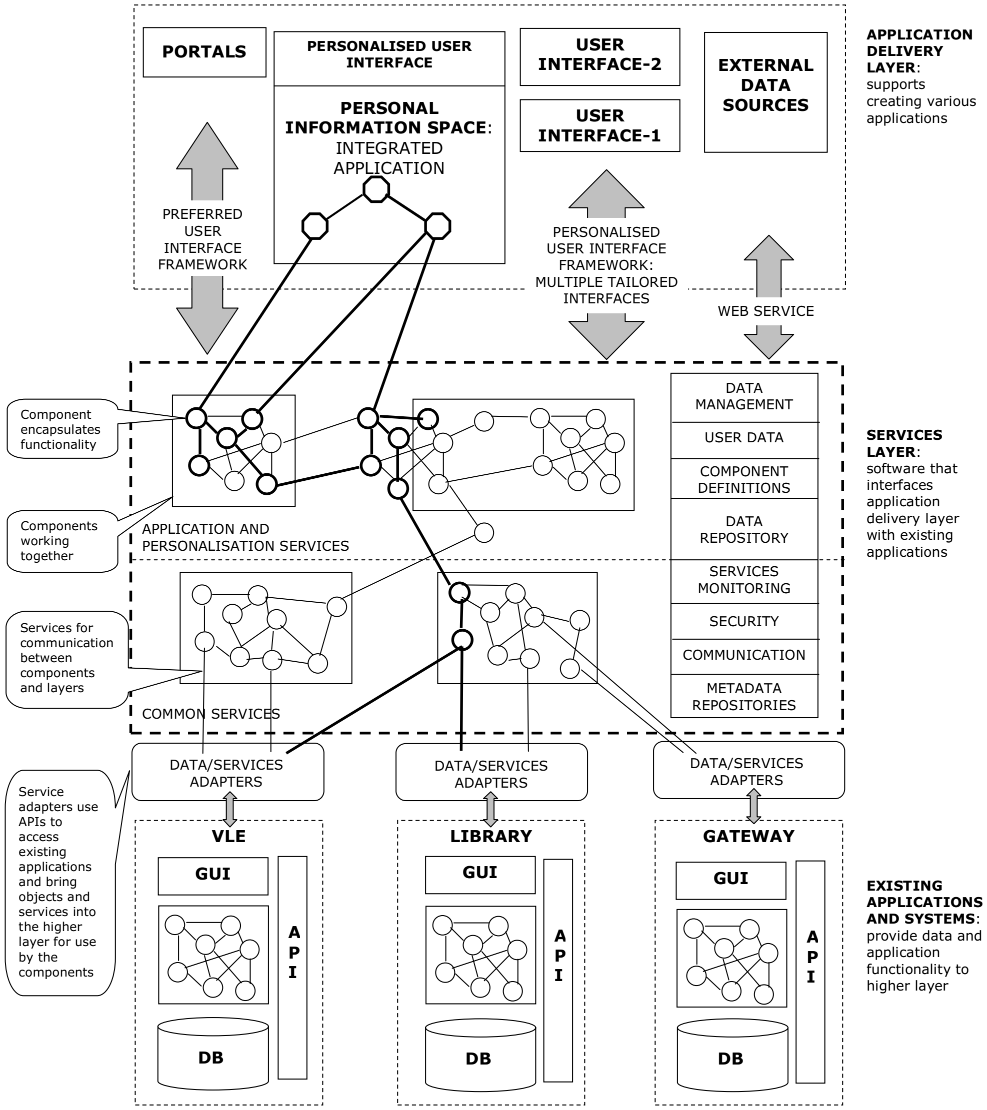

Fig. 3. High level description of generic service-oriented architecture that supports various types of personalisation.

In personalised information spaces this could take different forms: (i) personalisation of content, making possible for each user to create a "personal" information space that contains only the information that is interesting and relevant to that user, (ii) user navigation support though the information space (iii) tailored information retrieval, filtering and recommendation, simplifying the process of locating and filtering the vast amount of information that a user can access. In our future work we are planning to explore in detail several aspects of this approach.

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