Supply Chain Optimization towards Personalizing Web Services

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***Abstract*—Personalization, which has the ultimate goal of satisfying user's requests, can be perceived in terms of QoS measurement. As one of the means for the success of Semantics Web, many techniques have been effectively used in modeling and developing web service personalization. However, most of these methodologies relied heavily on detailed implicit and explicit information supply by users during initial and subsequent interactions with the systems. We propose in this paper a novel approach using the supply chain management (SCM) technique in personalizing web services as against the conventional notion of applying SCM only to product manufacturing. Our user-model based framework uses multi-agent system (MAS) components in taking requests from users and working towards their satisfaction including seeking for additional information outside the system as the need arises. Only basic stereotype information furnished by potential users at initial contact is required for personalization during subsequent interactions with the system. The system is adaptive and aimed at high quality autonomous information services where users are successfully presented preferred web services with minimum information request.**

***Index Terms*—Multi-Agent System, Semantic Web, Supply Chain Optimization, User Modeling**

I. Introduction

Web services have gained huge popularity in both industry and academe. Web services technology affords a means of interaction and coordination of service entities that are distributed across different providers in offering robust services to users. Their usefulness in a wide variety of domains includes business-to-business integration, business process integration and management, e-sourcing and content distribution, etc. [1]. Despite the huge benefits from the services in the Web, it is faced with two major challenges which have attracted research interests lately. They are automated service composition and service personalization [2]. Current web services technologies are primarily limited to services where each operation is independent. In addition, most services are provided to different consumers exactly the same way. This paper focuses on the latter problem of service personalization.

Personalized web services refer to those services that can be tailored to the needs and favorites of individual service consumers. Service personalization involves providing user's preferred service with least detail information supplied by the user during interaction with the system. Unlike in customization where user's explicit information is required for meeting the demands by the system, little of such pre-supplied information is needed in personalized web services. Personalization of services is said to have occurred when the content adapts itself based on the person's profile, and provides something new, different, and maybe unexpected results for the user [3]. At times, yet, information required for this personalization need not only be implicit and static. For instance, an individual who like to get personalized services for his family will not be satisfied if the results do not cover all its members. It is possible that the implicit information on the family is captured during registration or first interaction with the system. Thus, there may be need for additional information to be sought for outside the system. We adopt the use of supply chain (SC) technique in tackling this problem.

The SC is a network of suppliers, factories, distribution centers, warehouses and retailers, through which raw materials are acquired and transformed, and products are made and delivered to customers. Previously, components of this chain such as marketing, distribution, planning, manufacturing, and the procuring organizations operated separately partially due to different and sometimes incompatible objectives [4]. The concept of SCM is an effective way of managing this network of activities in creating preferred products for customers. It has enjoyed wide acceptance in the manufacturing industry where modern advancement in ICT has made it more effective.

We propose in this paper a MAS framework of SCM for personalizing web services. This contribution builds on [5], where we modeled agent-based SCM in analogous to the digital ecosystem. Here, the SC technique is optimized at each stage to achieve this objective. The system interacts with external heterogeneous databases in getting updated information about users, personalizes user's request and seeks for this personalized service from the semantic web using registry system discuss in [6]. The user eventually gets the preferred service in a satisfactory way.

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The remainder of the paper is structured as follows. Section 2 discusses the concept of web service personalization as it differs from customization. We survey related work in section 3. Details of proposed architecture are discussed in section 4. Section 5 presents user modeling concept and our approach in the system. In section 6, we further illustrate how the SC sequences are optimized to achieve our objectives. An algorithm and a sample scenario is highlighted in section 7. We draw conclusions and brief outlook on our future work in section 8.

II. Agents And web Service Personalization

One of the major challenges and promising advantages of the Semantic Web is service personalization [2, 7]. The goal of personalization in the Semantic Web is to make it easier to have access to the right resources. It entails that systems providing this service should have the capabilities of maintaining user model that contain data about his or her needs, interest and preferences. Besides, such system should possess reasoning capabilities in adapting to each specific user [8]. This makes personalization different from customization. In customization, user has a lot of impact and control in configuring and determining the ways result would be presented by the system in a preferred manner. On the other hand, the system is more active in result presentations in personalization. The system delivers contents to the user based on profile and modeling rules as well from user interaction history captured during initial and subsequent use of the system.

The user models enable interactive system to support a wide range of users by adapting to their behaviors. Specifically, user models are useful to systems that assume responsibilities for ensuring the success of system-user communication [9]. Generally, systems without a user modeling component make great demand upon their users. Particularly, these systems expect the users to have detailed knowledge about the system [10]. Even when electronic help facilities are available on these systems, the help information is presented in a standard format (language and content) to all categories of users.

The design of an adaptive interactive system requires a complex architecture where specialized components of the system cooperate with one another to obtain the overall system behavior [11]. Specifically, tasks such as identification and classification of users, acquisition of user profiles during interaction, and personalization of system services are usually performed concurrently. These requirements make multi-agent architecture suitable for implementing user-modeling systems. An agent is a software entity in a network, which is able to do flexible autonomous actions to satisfy its design objectives [11]. Multi-agent systems are characterized by several interacting agents, which cooperatively achieve some overall system aims.

III. Related Work

The SEA system [12] was proposed to view information services in terms of customization, situation and quality of services. This was necessitated as a result of non-expert users wishing to get quality service from various locations but having difficulty in choosing suitable service providers. This customization is based on user's requirement in producing flexible and real-time service variation according to levels of importance of request. The work discussed in SeAN [8], museum exploration [13], and MyEar [7] aimed at personalization that involve active participation of users during interaction and is tailored towards meeting specific requests.

Our approach differs significantly from those highlighted above. Apart from the SCM techniques proposed in the paper which has been successfully used in product manufacturing, the system is intended to produce something new, different, and possibly unexpected results for the user, which is the main goal of personalization as discussed in section 1. Moreover, it is not restricted to a single type of service but can be adapted to accommodate many services based on the design of the knowledge base and the inferential rules of the user modeler.

IV. Proposed Architecture

In this section, we discuss our proposed multi-agent framework. We have identified seven agents: Personal Agent (PA), Interface Agent (IA), Control Agent (CA), Service Agent (SA), Update Agent (UA), User Knowledge Base Agent (UKBA), and the User Modeling Agent (UMA). Apart from the PA which acts on behalf of the system user, we collectively describe the remaining six agents as system agents. System agents cooperatively perform the functions of the system under the control of the CA. The roles of these agents are described in Fig. 1 below.

A. Personal Agent

The PA makes requests for a service on behalf of users through the IA. The PA is aware of the user's beliefs, goals and preferences. Results or responses received from the IA may be further processed to suite the user when a preliminary personalized service is returned for user's validation. Here the user has the opportunity of optimizing his choice at this point in time (see section 7). It also registers new user on his/her behalf. Users may proceed to some other tasks while awaiting results from their PAs.

B. User Modeling Agent

The UMA is responsible for interpretation of user's request and resolution of ambiguities relating to such requests in collaboration with the UKBA and the CA. It likewise interacts with the UKBA for the personalization of services and results. The UMA also unobstructively gathers usage pattern and builds knowledge base of user models. The UMA obtains user information by consulting the UKBA. Reasoning and learning are essential characteristics of the UMA.

C. Interface Agent

The IA is the only system agent that communicates with the environment. It receives requests from the environment through the PA and submits the requests to the CA for processing. Results are also forwarded to the IA from the CA for onward transmission to the requesting PA in the environment.

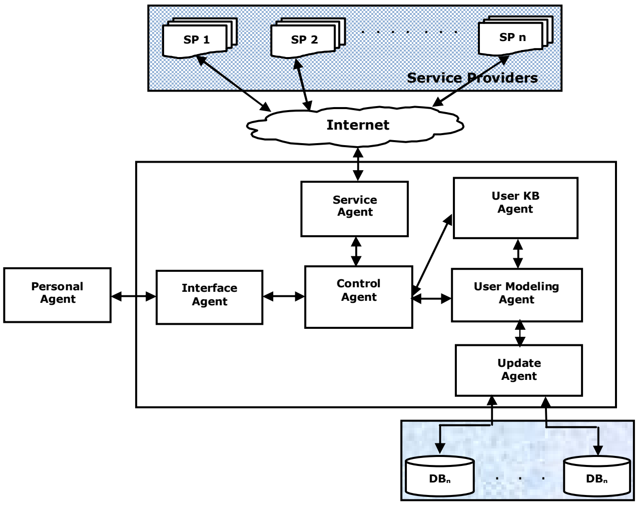

Fig. 1. System architecture.

D. Control Agent

The CA coordinates the activities of other system agents. It receives user requests via the IA and interprets these requests in conjunction with the UMA. Interpreted requests are forwarded to the SA for servicing or execution. The CA receives personalized results from the SA and forwards them to the IA. The CA also interacts with the UKBA to obtain user profile information (say for user authentication), and sends records of interaction to the UKBA for updating.

E. Service Agent

The SA processes personalized requests obtained from the system agents through the CA. The SA sends the personalized service request to registry-based OWL-S directory web service [6]. The SA may also request disambiguation of directives from the CA. The results from processing are passed to the IA, and finally to the PAs.

F. Update Agent

The UA interacts with the external databases to obtain additional information about users that may not be available with the UKBA. With the help of the brokering and translation services, query is sent to the respective databases and results are obtained in the appropriate format. Details are discussed in section 6.

G. User Knowledge Base Agent

It UKBA stores and maintains user profiles. These profiles typically contain descriptive and predictive features of users and user groups. The UKBA obtains descriptive properties from stereotypical information while predictive information is updated in conjunction with the UMA (section 6 for detail).

V. User Modeling

The concept of user modeling which distinguishes service personalization from customization plays a very important role in achieving the personalization goals discussed in Section 2. User modeling is described as a process of constructing models of users that provide information on user characteristics such as user's domain knowledge, goals, plans, preferences, interests, and even misconception [13]. The existence of user models relieves users of the burden to have detailed knowledge about and how the system will meet these objectives [10]. A typical user modeling component of an interactive system amongst other things must acquire information about the user during interaction, maintain the information (e.g. resolution of conflicting facts and overriding of default assumptions) and infer additional assumptions (through reasoning) possibly concurrently. User models may be constructed in two basic ways. The first is through the acquisition of stereotypical information and the alternative is through the analysis of user-system interaction history [14, 9]. Our proposed system makes use of these two options. Fig. 2 depicts the user modeling component of our system as earlier discussed in [15].

A. Initialization and Classification

The knowledge base is made up of two categories of information: stereotype and interaction history. Stereotype information is used in creating initial model for a first-time user. Data used for this and subsequent group classification is elicited from prospective users with an initial survey seeking for basic information like gender, color preference etc., and identification to access the external databases.

B. Updating and Adaptation

Interaction history of a user is also stored in the KB. For example, if a user initially stated a particular color as preference during initialization and after some interactions, a particular new color is persistently stated as part of his or her request, the later will override the default. The KB likewise keeps tracks of services provided to users for onward usage during similar requests.

C. Predictions on Interests

Interests and service requests prediction is most effective when huge information about the user is available to the system. The additional data used by the UMA in service personalizing depends on type of service. For instance, in personalizing a user request for buying a car, size of car, type, prices etc are taking into consideration. It uses the stereotype, interaction data, and sometimes *supplied* data from external sources, in determining the way personalized requests are constructed, and subsequently sends such request to the SA via the CA for service production.

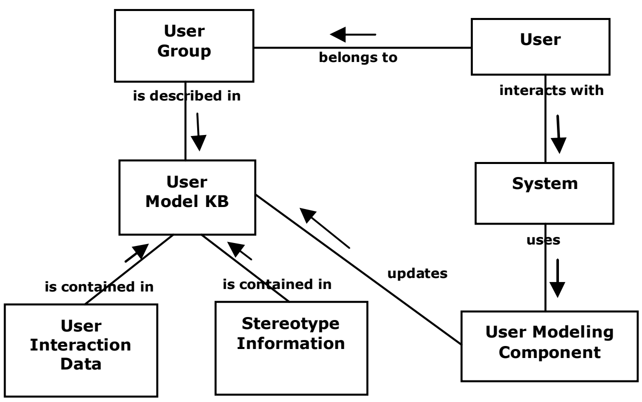

Fig. 2. The user modeling component.

VI. Supply Chain Optimization

Depending on the nature of product/service requests at hand, SC could have five or less key components/stages. These stages include demand (ordering, delivery), logistics (planning), manufacturing (production), and sourcing (supply, return, or support). For instance, an enterprise that receives order for a product/service and can conveniently meet this request internally on its production line will comprise three stages only – ordering, planning, and manufacturing. Fig. 3 shows the four key components in our model. These are ordering, logistics, supply and production.

The six system agents that participate in meeting the system's goal in the stages of SC are also highlighted. While the logistic and production stages involve two agents, the ordering and the supply stages are coordinated by one agent each. The IA manages the ordering sequence of the SC. The CA, together with the UKBA, is involved in coordination and planning of the system agents. The UA, which connects with the external database for additional information, manages the supply sequence. Both the SA and the UMA coordinate the service manufacturing (production). Fig. 4 depicts the interaction diagram of the system.

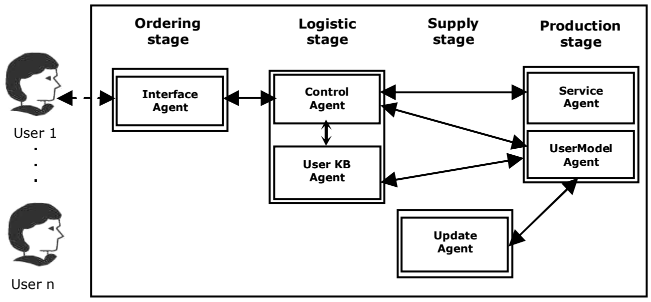

Fig. 3. Agents in supply chain management.

The six system agents that participate in meeting the system's goal in the stages of SC are also highlighted. While the logistic and production stages involve two agents, the ordering and the supply stages are coordinated by one agent each. The IA manages the ordering sequence of the SC. The CA, together with the UKBA, is involved in coordination and planning of the system agents. The UA, which connects with the external database for additional information, manages the supply sequence. Both the SA and the UMA coordinate the service manufacturing (production). Fig. 4 depicts the interaction diagram of the system.

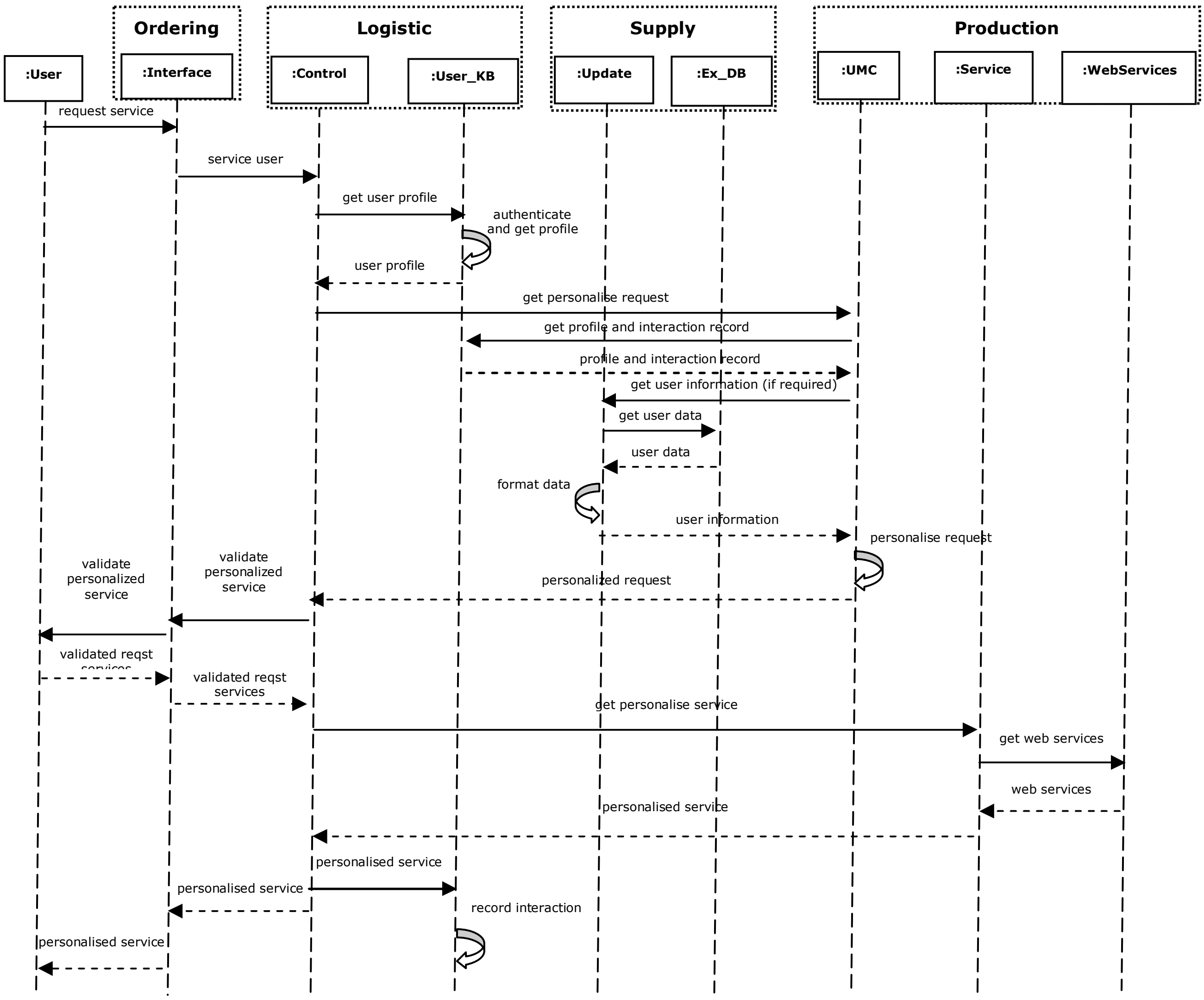

Fig. 4. Interaction between software agents during personalization.

The bold and dotted lines represent request and result obtained, respectively. User sends a service request and he gets a personalized request for him to validate (and possibly customized) in meeting his present preference. Thereafter, this validated requested is eventually sought for from the web service. The ordering, logistic, supply, and manufacturing sequences of the SC as optimized in achieving the personalization are as follows.

A. *Ordering*

The IA is responsible for taking service requests from a user and communicates the personalized service to him. It is also capable of delivering the result in different media (text, graphical, etc) to the PA. This delivery format depends among others, on the educational level of users as identified in the KB.

B. *Logistic*

The CA, in collaboration with the UKBA, effectively controls the system agents towards achieving optimum personalized results. Identification and authentication of user are made prior to using the system. Likewise potential users are registered with the system as coordinated by the CA.

C. *Supply*

Since only basic information about users resides in the internal knowledge base, sometimes additional data needed for the personalization are required. Firstly, all information about users will be too numerous to be effectively managed by the system. More so, the data are often updated periodically. Thus, we assume that these data reside in some databases outside the system. There is need for the system to relate with these external heterogeneous information sources to fetch needed data. The system source data is represented in RDF (resource description framework) format. The UA sends query requesting for the data through the brokering service which identifies the external source(s) where such data reside via the metadata. The ontology also assists in resolving differences in meaning of terms. This query is translated to the format in which the data is stored in the external sources using the wrapping service. We illustrate this with Fig. 5. The external source can be structured, semi-structured, and unstructured file, with each storage format having its own corresponding translating service module. The major advantage of the method is that the system only needs to manage fewer translating services corresponding to the various external data repositories accessed by the system.

D. *Production*

The user modeler (UMA) makes sure that the request is personalized to meet or even exceed user's expectation. The UKBA is contacted, and if sufficient data required for this personalization is not available, the UA is liaised with as described above. The information sought for is sent to the UKBA for updating and future usage. Our system described in [6] has two mechanism of service discovery when the SA puts a query on its registry. One is through using Inquiry API and second through Subscribe API. While the former uses the traditional pull model, the latter uses a push model approach for service discovery where results are returned as soon as it's published. Matchmaking is used to match available services with the request.

Service requester that queries the registry does this using the same ontology as described in the advertised service present in the ontology database. Thereafter, registry matches the request and the advertisement, and returns the matched advertisements in the relevance order. The SA ranks all the results that match the query using certain degree of match. The user is returned top ranking result based on the request.

VII. Basic Operation and Sample Scenario

Below are the algorithm and a sample scenario to explain the overall operation of the system.

A. The Algorithm

1. A user logs in and clicks a service request
2. System's registry is check for user profile information
2.1. While user is not authorized to use the system
2.2. User is requested to provide basic required information in step 1 (register as new user)
2.3. End While
3. The request is personalized based on user profile in the registry
3.1. While profile information is not adequate
3.2. Added information is sought for (from various heterogeneous databases outside the system)
3.3. End while
4. System's KB is updated
5. User validates personalized service request
5.1. While user is not satisfied with the personalized service
5.2. User customizes to meet his latest choice
5.3. End while
6. Personalized service request is sent to the service providers in the Web
7. System gets personalized services
8. System ranks the returned services
9. System's KB is updated
10. User gets personalized service envisaged format

B. A Usage Scenario

A user by the name of Mike is interested in purchasing a car. He logs onto the application and clicks on 'Auto Service' icon. Thereafter, he chooses 'Buy a Car' option among available other ones including 'Rent a Car', 'Refurbish' etc.

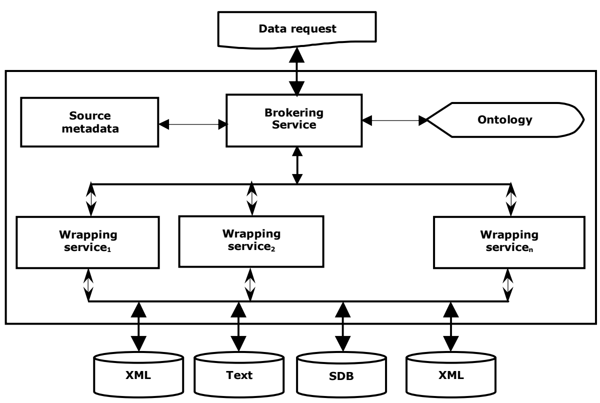

Fig. 5. Supply optimization

1. *Ordering* for the service commences immediately after the user is authenticated to use the system.
2. The CA starts the *planning* after the authentication by forwarding Mike's raw request to the user modeler (as discussed in section 4) who gets in touch with the UKBA to elicit Mike's profile (like past similar request, preferred color, etc). More importantly, Mike's social security number is fetched to be used in sending query to the external databases.

Other necessary information such as number of the family members, income and car allowance about Mike is also needed for the personalization. However, since this additional information is not available, the modeler contacts the update agent who gets this data from external databases (the *suppliers*). These supplied data is reformatted using wrappers to meet the system specification which uses RDF. The system registry is updated accordingly.
3. The initial *production* of the service starts with the personalization of the request by the modeler using the profile and the additional information. At this stage, Mike is presented with personalized request and he is expected to make any modification if he so wishes. Thereafter, this personalized request is forwarded to the service agent via the control agent. The service agent communicates with the service provider(s) and sends Mike's personalized car request. Cars of different price range, brands and models are returned. The system decides (after ranking the returned results) which of the personalized services best meets Mike's preference based on earlier validation of request.
4. The control agent gets this personalized car request of Mike, update the system's registry and forwards this service eventually to Mike through the interface agent.
5. Mike gets a navy-blue Toyota Camry of 2006 and 2007 models, with price range of USD 7,000 – 9,000 appearing before him.

VIII. Conclusions and Future Work

We have approached web services personalization using SCM techniques in this paper. The four stages of the chain comprising ordering, logistic, supply and production have been optimized using agents to achieve this. We have assumed that part of user's information needed for this personalization is not static and often external as well. Thus, the system has sought for these data from external heterogeneous databases to accomplish this. An algorithm together with a scenario has been used to describe how the proposed architecture interacts with the user, the databases and the service providers outside the framework. The user modeling component, which is crucial in the personalization, has been described as used in the system. Our generic framework based on SCM gives room for all forms of web services personalization. We have commenced work on a prototype system and the results are encouraging. Both the stereotypical information acquisition and the analysis of user-system interaction history construction models are being considered especially in the user-modeling subsystem.

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