Hybrid Service Provision Model for Mobile Users: Prospects for the DYNAMOS Project

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Abstract. This paper outlines a two-tier model of providing services for mobile users. On one hand, the model exhibits personalized service provision from a service provider to users. This presupposes that the system is aware about the users' profiles and available services and has capabilities to match these with each other. Also, since we are concentrating on mobile users, contextual details are relevant in service provisioning. On the other hand, the developed model harnesses user-to-user communication for the purposes of service provision. This helps in overcoming the problem of the system not having enough information about its users in order to achieve useful service personalization.

1 Introduction

The ways of finding content in the web and utilizing it are evolving constantly. Using a desktop PC and a web browser to access HTML-based content used to be the only mode of operating. However, other ways to use the content are emerging and in some application areas fast replacing the browsing in its traditional sense.

This paper gives a general description of a recently launched research project called DYNAMOS[1], in which the emerging novel modes of operating with web content are in a central role. Two specific phenomena can be extracted to motivate this. First of all, the web is changing from a collection of web pages into a set of services [2]. These services that provide dynamic content are often better accessible with other types of applications than a web browser. Secondly, web content is nowadays accessed with other devices in addition to desktop PCs with large displays. Perhaps most visible phenomenon is the mobile Internet, which means accessing web and other material available in the Internet with relatively small wireless terminals, such as mobile phones and PDAs.

The intersection of these two phenomena brings about interesting but challenging research topics. One of the most challenging is to address the notion of *context*. Mobile users equipped with wireless devices go through several contextual changes as they move around in physical and social surroundings. These contextual changes should be taken into account when providing the mobile users with web services.

Solving the above challenge presupposes access to the users' contexts, their static profiles, and the available services. Based on these three components the service provider decides just what services to provide to various users. However, sometimes the service

[1] Dynamic Composition and Sharing of Context-aware Mobile Services

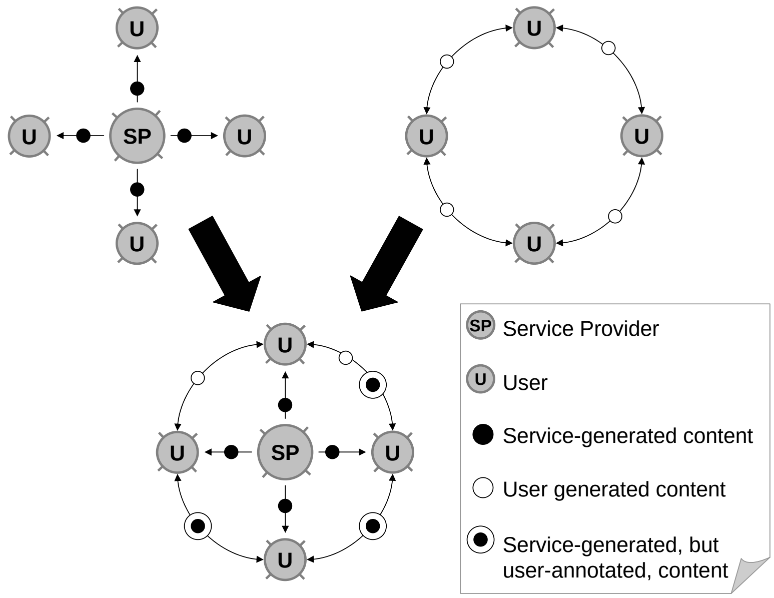

Fig. 1. Hybrid approach for service provision

provider has insufficient knowledge about the users' contexts and profiles. For example, people are often poor in providing the system with their profile data. This can be due to reluctance based on privacy issues or just plain laziness. Therefore, there exists a huge amount of *implicit profile data* not accessible by the system. However, other people such as friends, colleagues, or family members typically have knowledge about some of this implicit profile data. Thereby, we will provide the users with a possibility of sharing information about services with each other. This forms a hybrid service provision model consisting of service to consumer interaction on one hand, and consumer to consumer on the other. Figure 1 depicts the approach.

The rest of the paper is organized as follows: In the next section we describe the context-aware service provision model. The section after that concentrates on the users working with service descriptions. It is followed by recognizing some related work and finally by drawing concluding remarks.

2 Context-aware Service Provision

This section describes the context-aware service provision model. It concentrates on the service to consumer part of the developed model. We discuss how services, user profiles, and contexts are described, and then consider integrating them in order to achieve relevant service provision.

2.1 Describing Services

The web is changing from a collection of web pages with static content into a set of services with dynamic content [2]. However, current web service technologies such as SOAP, WSDL, and UDDI do not address the semantics of the services, i.e., what the services do and how do they do it [1].

Emerging technologies such as BPEL4WS [3] and OWL-S [13] (formerly DAML-S [1]) are addressing this semantics question. Perhaps the most important part in both these languages is describing the process of a web service. Such process description includes the subprocesses the service consists of, in what order are the subprocesses executed, and what are the IOPEs (input, output, precondition, effect) of the subprocesses. A central differentiating feature is that OWL-S builds upon existing Semantic Web technologies such as RDF and OWL, whereas BPEL4WS is based on plain XML.

Describing services semantically is important in the DYNAMOS model, since one of the project's goals is to facilitate the users by providing them with appropriate services. This "appropriateness" is based on matching the users' current needs with available services. The needs can be expressed either explicitly by the user or implicitly by reasoning based on the user's context and profile data [12].

2.2 Describing User Profiles

We adopt the distinction between the user profiles and the users' contexts so that the profiles concern somewhat static data characterizing the users, whereas contexts concern the users' situational details [5]. Example information found in user profiles are name, sex, age, friends, affiliation, and contact details. Among the most important profile data, as far as personalized service provision is concerned, are interests and hobbies. This is because those help in segmenting the people into groups that can often be straightforwardly mapped with certain service types. If people have not explicitly stated their interests, the system can try to perform the segmentation based on reasoning about other profile data such as age and sex, or based on previous behavior of the user in question. Sometimes such reasoning fails to achieve appropriate results, and that is one reason why we provide the users with functionalities to store the service descriptions and share them with each other. This is described in Section 3.

It should be noted that sometimes the interests of users can be quite context-dependent. For example, I might be interested in ice hockey when it is winter and when I am not at work, whereas during the summer and/or when I am working it is of no interest to me. This will be recognized in the DYNAMOS model.

2.3 Describing User Context

Context information can be used to characterize the situation of an entity, which can be a person, place, or object that is relevant to the interaction between a user and an application, including the user and the application themselves [14]. Since we are mostly considering mobile users with wireless terminals, also the network context, especially the network's quality of service (QoS), can be taken into account [20]. However, DYNAMOS model will mainly concentrate in describing the user contexts.

Time, location, weather conditions, social context, activity and *mood of the user* are among the relevant contextual information to be used in DYNAMOS model. Some of these information, for example time and location, are easier to automatically retrieve, while others, such as activity and mood, presuppose active input by the user [21].

In addition to describing the users' current contexts, also predicting their future contexts is useful in some cases. For example, by predicting where the user is heading to, it is possible to provide her with services *ahead* of her rather than behind [9]. This information can be retrieved for example from an electronic compass or calculated with a certain probability from a set of locations of the user.

2.4 Bringing it Together

To bring together the rich context data characterizing the users' situational details, their static profile information, and appropriate available services, all of these components must be translated into a common format capable of expressing their semantics. In DYNAMOS system Semantic Web technologies will be used in expressing these components, and software agent technologies in performing the reasoning based on them.

The reasoning engine in the center of the DYNAMOS model will work on what we call *service queries*. With such queries it is possible to include wide variety of material in service descriptions, ranging from single service entries to large groups of services being instances of one or more service types. Typically the queries are tuples consisting on information about the user, the context, and the services. For example, the fact that I like ice hockey related services during the winter could be expressed as a triple $\{Santtu, Winter, IceHockey\}$. This general triple would provide me with all services in the category of *IceHockey*, when am in the "winter-context". Instead of the general *IceHockey* service category, there could also be a reference to a single service in the triple, or a more specific category such as *NHLResultsService*. It is also possible to include logical operators in the triples. For example, a triple $\{Santtu, \{Winter \wedge \neg Working\}, IceHockey\}$ would translate that I am interested in *IceHockey* services as long as it is winter *and* I am *not* working.

In addition to performing the above-mentioned semantic match, the services should be provided to the user in an enjoyable way. The typical limitations of mobile devices—small displays, low processing power, weak connections, and the like—pose special requirements for describing services. The number of services provided at once should be quite small, the service descriptions should be compact and space saving, and the access to the services via the service descriptions should be as effortless as possible. Depending on the variety of the devices, an ontology for describing their features can prove to be useful [4].

3 Working with Service Descriptions

This section will continue where the previous left off in describing the functionalities of the DYNAMOS model. When appropriate services are provided to the users in a pleasant way, the users go about and do various things with the service descriptions. They can naturally use the services denoted by the descriptions. In addition, we provide the users

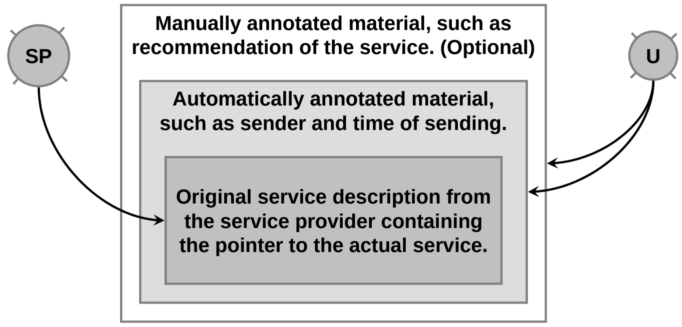

Fig. 2. Layered service descriptions

with a possibility to store the service descriptions for possible future usage in the same or similar enough contexts. The users can also share the service descriptions with other users they feel that might take interest in the services denoted by them. Storing and sharing service descriptions are preceded by service annotation. These functionalities are described in the next subsections.

3.1 Using Services

The most evident usage for service descriptions is naturally to use the services they refer to. This is essentially why the service descriptions are created in the first place. Often the service references are hyperlinks to some further material characterizing the service in question. However, they can also encapsulate additional functionalities. For example, a parking meter service description can contain a link, and following it provides the user with a valid parking ticket.

The nature of a service often has impact on the type of service reference found in the description. If the referred service provides its products in the "virtual world", such as a weather forecast service or a ring tone distributor, the reference can easily encapsulate several functionalities. Instead, if the referred service is in the "physical world", such as a restaurant or a movie theatre, the references in the service description are often mere hyperlinks to menus, movie schedules, etc. However, sometimes this is not the case. A pizza restaurant can provide a service for ordering pizzas via a web interface, and the above-mentioned parking meter service can provide the parking tickets either in an electronic form to be stored in the user's mobile device, or printed in paper for picking up in a nearby kiosk.

3.2 Annotating Service Descriptions

After receiving service descriptions, besides using the services denoted by the descriptions, the users can annotate them. The motivation for such annotation stems for the other two functionalities of the DYNAMOS model, namely storing and sharing the service descriptions.

Service annotations can range from very light additions to very rich comments on the service. The light annotations can sometimes be automatically generated without the active input by the user [10]. For example, if a user decides to forward an interesting service description to his friend, he can do so without any active annotating. Still, when sending the description, it is annotated for example with the fact that it is he who sent it. And when his friend receives it, she will notice that the service description did not come straight from the service provider, but from a friend instead. This is a kind of information that people often wish to know. For example, some people believe their friends more in restaurant recommendations than professional food critics. And of course, some do not. Figure 2 depicts these layered service descriptions.

3.3 Storing Service Descriptions for Future Usage

Besides using a service once, a user might find it potentially usable in the future as well. We thereby provide the users with a possibility for storing service descriptions. The importance of storing a service description can range from somewhat insignificant to highly critical. For example, while waiting for a taxi to arrive, someone can store a recommendation about a restaurant she visited just to kill time. On the other hand, a notification about a gas station on a remote desert highway might be extremely important if the next refueling possibility lies 100 kilometers down the road. Sometimes a service can also assist the user in performing some cognitive task. For example, a weather forecast service can help in route planning. Recognizing this and storing the service description can be seen as an active mode of distributing cognition by the user.

Storing service descriptions does not necessarily mean, that the exact same service is provided to the users in the future. This is especially true if a description is tied to a service type rather a specific service instance. For example, if I decide that a weather forecast service of any kind is important to me in this particular context, but do not specify just which one, next time I am in this or similar enough context, I can get a notification about a different weather forecast service than in the first time. And naturally, even if the description is tied to a specific service instance, the content it returns in different times varies—like weather forecasts do.

Service descriptions can be stored using various technological solutions, each of which have their own drawbacks. One possibility is to store the service descriptions in the user's own mobile device. However, the storage capabilities of mobile devices are typically quite limited. A solution at the other extreme would have one centralized repository for all service descriptions of all users. However, this solution would likely not scale, should the number of users increase. Likely some approach in between would be the most feasible. For example, one user or a community might have one repository for his/its service descriptions in a proxy outside—but accessible with—mobile devices. Or alternatively, one repository might be responsible of a certain geographic area.

3.4 Sharing Service Descriptions with Other Users

In addition to storing service descriptions for their own usage, we provide the users with a functionality to share them with each other. In principle storing and sharing service descriptions are realized through the same activity. In both cases a service description is

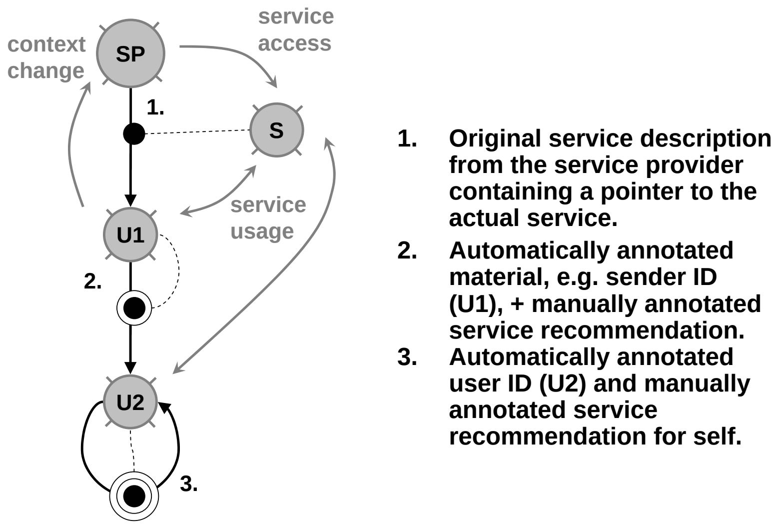

Fig. 3. Working with semantic descriptions

stored in a certain context. The only difference is that in the former case the notification in the future is sent to oneself, whereas in the latter case to someone else. However, the latter case brings about some challenges not present in the former. First of all, there is the technological challenge of interoperability of the systems of the users who exchange service descriptions and other content. In DYNAMOS model this is addressed by adopting Semantic Web technologies, which are intended for enabling machine-to-machine interoperability in the web [7]. When the users provide the system with their profile data, it is translated into a semantic form corresponding to a predefined ontology. The same applies for service descriptions and even context data, in spite of its richness and high heterogeneity.

Secondly, there is the challenge of protecting the users from receiving too much service descriptions from other users. We want avoid spamming and possible "denial-of-service-attack" kinds of situations. This encourages us to look into things such as trust networks [6] and privacy with respect to contexts [5].

3.5 Example Course of Events

Figure 3 depicts an example course of events exhibiting the functionalities described in previous subsections. In the example the service provider (SP) has access to the service (S). Also, although not visible in the Figure, the service provider is aware of the users' (U1 and U2) personal profiles. Say that first U1's context changes. A notification of this is delivered to the service provider. Based on U1's profile and her current context, the service provider decides that U1 might be interested in the service S. It formulates a compact description about the service and sends it to U1.

U1 decides to try the service out. After usage, she thinks that her colleague U2 might be interested in the service. When sending the service description to him, in addition to the automatic annotations such as an ID of her, U1 decides to manually annotate the service description with a positive remark.

U2 uses the service as well. Furthermore, he likes it so much that he decides to store the service description for future usage. In the future he will be notified by the service whenever he is in similar enough context. Such notifications will include the information that they are generated by U2 himself. Note that a “recommendation” could also be negative in nature. In that case the users would be notified *not to* use some service. A negative recommendation, or rather a warning, naturally differs from a positive recommendation, but also from not notifying at all.

4 Related Work

This section describes some national related work around the area of DYNAMOS project. The three corners of DYNAMOS, namely Semantic Web Services, context-awareness, and support for peer-to-peer activities, are gathering significant interest both in academia and in industry at the moment. Around Semantic Web Services, a project at HIIT called Intelligent Web Services (IWebS) [8, 12] concentrates on adding semantics on the existing web services, especially directory services. DYNAMOS extends the scope of IWebS by concentrating more on mobile users and contextual details, and also by providing a peer-to-peer environment for the users to share interesting service compositions.

Context-awareness can be investigated at various levels. On one hand there is a possibility to sense the context with multiple sensors attached to a device, such as a mobile phone, which is connected to the network. The sensors can sense for example temperature, velocity, and humidity. Currently such sensors, for example the SoapBox developed by VTT Electronics [17, 22], are separate from the commercial mobile phones. In the future, however, these functionalities can be attached to the phone itself. On the other hand there is the context information entered actively by the users. Examples are the activity and the mood of the user. A recent project carried our at VTT Information Technology called Kontti [11, 21] investigated such contexts. Depending on the use cases, DYNAMOS can utilize at least location, time, direction, and weather conditions as automatically derived context-data. In addition, the manually entered context information such as activities and mood can be taken into account.

Rotuaari, a project conducted by the Unversity of Oulu, is also investigating context-aware mobile services [15, 16]. Rotuaari provides the users with context-aware services and also some other functionalities such as BuddyCom for the users to find out the locations and presence information of their friends. The most important differentiating feature of DYNAMOS with regard to Rotuaari is in providing the users with a possibility to seamlessly communicate about the services. The same interface which is utilized for informing the users about the services, can also be utilized by the users to share information with each other. Among other, this information can be the service descriptions, either in a “raw form” or annotated—for example ranked based on personal opinions.

The Fuego Core project at HIIT can provide an open source middleware platform for delivering the context information of the user to the system [18]. The relevant middleware services specified and implemented in the Fuego Core project are the Fuego event and presence service. The event service provides support for asynchronous and anonymous one-to-many communication, and support for expressive user-defined filters that are applied to published notifications [19]. In essence, the system realizes a content-based information delivery service. The presence service uses the event service to manage and deliver user presence information. There are also other relating projects in the Fuego research theme of HIIT. However, none of them has as explicit interest in integrating existing services, rich context data, and user-to-user communication as DYNAMOS does.

5 Conclusions and Future Work

We presented an model for two-tier service provision model to be utilized in the recently launched DYNAMOS project. The model includes service provision from the service provider to the users, and also service notifications between the users. The target group of DYNAMOS project are mobile users. This makes describing the users' contexts also extremely important besides describing their profiles and available services. Equally important in the DYNAMOS project as personalized and contextualized service provision, are the functionalities for the users to store service descriptions for their own future usage and to share them with other users.

Our immediate future work around the area begins with selecting the target user group and developing usage scenarios to be later on tested with a user trial. Usage scenarios will help us in extracting the relevant services, context categories, and profile information. After that the ontologies for describing this information will be defined followed by implementing the system. Finally, the system will be tested in a user trial.

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