From personal mobility to mobile personality

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Difficulties in using and accessing new services have been the most frequently mentioned reasons for slow service acceptance in the past. For future mobile services to succeed, it is therefore critical that users are able to get intuitive and convenient access to the services they personally need in a given situation or context. We introduce the concept of Mobile Personality, which allows the mobile user to develop her own online personality in terms of personal preference, usage and service profiles over time, as well as the offered services to acquire a unique proactive behavior. This vision of adaptive personalized services is essentially based on the advanced profiling and personalization concept, context-aware computing as well as flexible and evolvable service support middleware. Through a practical use case and a detailed explanation as well as an interrelation of the essential enablers, this paper gives an insight into the foreseen transition from personal mobility to mobile personality.

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1 Introduction

Systems beyond 3G (B3G) are considered to encompass heterogeneous access networks to provide a best availability of mobile connectivity to the customers. These systems are not only considered to integrate several network platforms, they also strongly encourage the vision of a substantial richness of services and applications. On the other hand – with the complexity of services constantly increasing – we can only grasp a vague impression of how most end-users will soon be confronted with a broad variety of services and multiple ways to combine them. Difficulties in using and accessing new services have already been the most frequently mentioned reasons for slow service adoption in the past. This might even be more so for novel multimedia-type services and context-aware applications in the future. As a consequence, it is critical that users are able to get intuitive and convenient access to the services they personally need in a given situation, environment or context.

This work is motivated by ongoing research activities at DoCoMo Euro-Labs which are focusing on key concepts to enable personalized service provisioning in systems beyond 3G. In projects such as [7] or [11] we have identified, together with European operators, manufacturers and vendors, several system concepts and application domains that promise to be key drivers of future mobile communications systems. We advocate that an effective use of future services can only be achieved through adequate personalization concepts and proactive service advertisement and adaptation. It will essentially be new concepts for service provisioning and deployment together with new service paradigms that attract customers and bring mobile communication beyond voice applications to the mass market. In the following we sketch our concept of an evolving virtual personality, which is not limited to users, but can also be applied for other entities of a mobile system to implement adaptive personal services that develop their own initiative spawning a Personality Space (see Figure 1). Over service deployment- and usage-time, such a "Mobile Personality" allows different users to develop their personal preference profile and typical service usage patterns according to their personal demands, as well as the offered services to acquire unique proactive behavior.

2 Towards personalization in systems B3G – a glimpse of the future

Personalized services and applications are considered to be among the most compelling features for mobile communication systems. They promise high customer benefit through selecting specific services from a rapidly increasing diversity of mobile service offerings, and adjusting these services to their individual needs. Taking the example of a business traveler, in [27] and [12] we have already sketched some of the key personalization issues in future mobile communication systems through application scenarios. In the following we revisit these scenarios particularly with regard to an evolving Mobile Personality.

Let us consider a sample user, named Michael, who plans and takes a business trip from Boston to Paris including many different steps and various responsibilities. Setting up all the necessary preparations is a complex matter and manually finding adequate services can already be quite time-consuming. But communicating personal requirements and preferences to many services – that might not even be feasible to fulfill Michael's needs at all – will definitely become tedious. For the sake of simplicity, let us assume that in Michael's case the personalization and planning tasks for the business trip "only" consists of

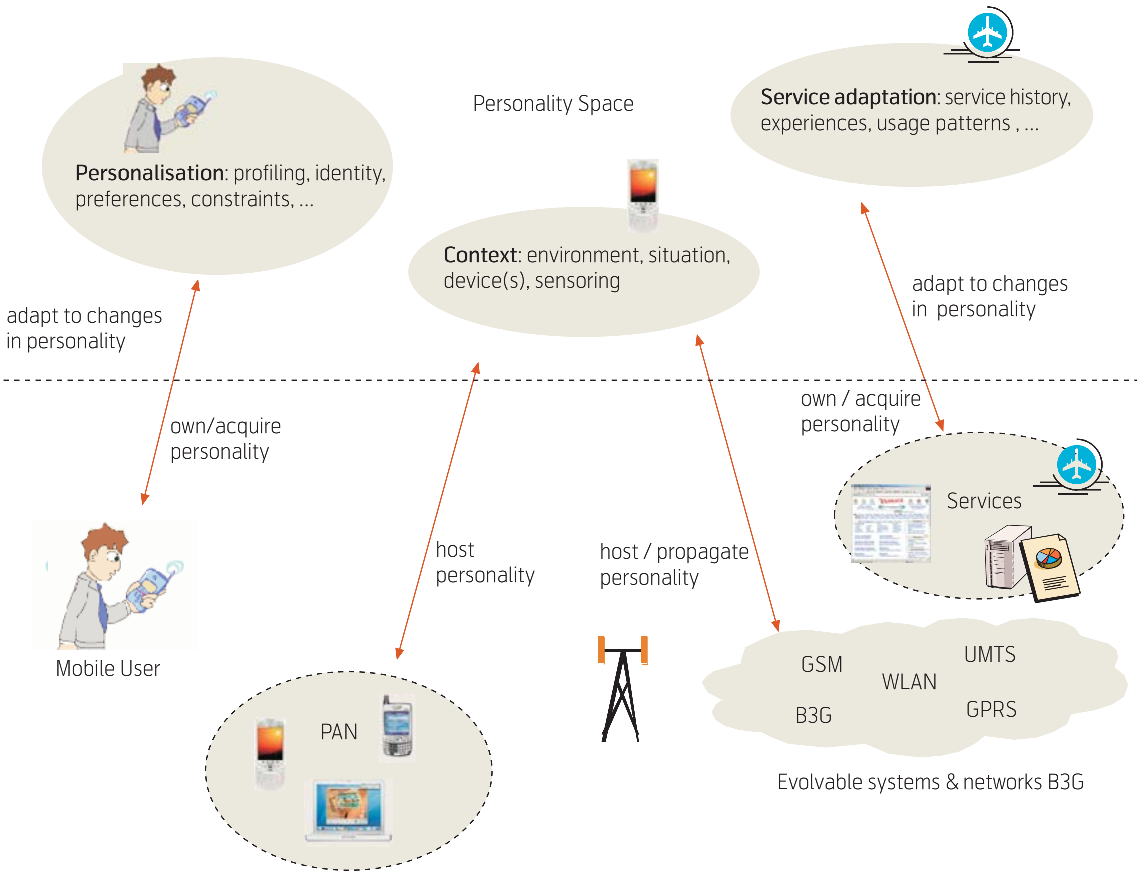

Figure 1 Vision of mobile personality in systems beyond 3G

- setting up the necessary transportation
- guidance to the meeting place
- adaptation of services and user devices to changing environments.

Obviously, Michael's trip will start with a flight from Boston to Paris. A flight booking agent, e.g. initiated through an interactive Web portal and later monitored on a mobile terminal, might try to buy a plane ticket in accordance with Michael's personal preferences. In this case, all available airline services need to be discovered that allow performing the task of booking a flight. This could be done either manually through the travel portal or by the activated travel agent. In either case, a flexible and intuitive way to model and express user preferences should be supported. In Michael's case, his user profile might contain hard constraints on the departure and arrival date and the class of the ticket, e.g. Business Class, together with soft constraints on the preferred airline ("I prefer to fly Air France to Delta Air Lines"), the type of flight ("non-stop") and the route ("as fast as possible"). Preferences associated with Michael are stored in his personal profile which can either be stored on his primary personal device or distributed in the network [1].

In the same way his air ticket is booked Michael's travel agent might also take care of reserving a rental car at his destination. Having successfully booked a flight Michael finally arrives at his travel destination. He heads straight for the airport's rental car center where he picks up his reserved car just by identification and authorization via his mobile phone. His phone transparently and automatically initiates a discovery of available services. The in-car equipment synchronizes with the phone and automatically adjusts mirrors, seat and heating to Michael's personal preferences. In addition to his convenience-driving settings, his phone discovers the car's built-in navigation system. The address of the meeting is immediately transferred and the appropriate maps are loaded by the navigation system. Using a local traffic information service, the navigation system chooses a route and is able to predict the arrival time. Since the in-car system signals that there is enough time before the meeting starts, Michael decides to get some cash in the local currency. He accesses an ATM locator service, which shows him the way to the ATM closest to his current location that is able to charge his credit card at the lowest costs. Once Michael has selected an ATM the navigation service has to adjust the route and collaborates with another service to find a nearby parking space.

Finally, Michael is guided to the meeting. Through his situation-aware communication environment, his preference of only being disturbed during meetings in the case of emergencies is activated. At the meeting room, the settings of Michael's communication devices are thus automatically adapted as the session starts. There is no need to explicitly switch to another device profile anymore. Even if there is no internal device profile available that meets the situation requirements, parameters from an external profile are transferred temporarily while carefully respecting emergency settings. During the meeting, Michael is able to transfer his video streaming session from his laptop to the built-in screen and conference system in the meeting room. In addition, other services like a nearby printer and a video transcoder are discovered which support project work. All these devices are initialized with Michael's settings derived from his personal profile. Since an important partner in the meeting is called away to an emergency, the meeting has to be re-scheduled on that day taking the schedules of all meeting parties into account. Meanwhile, Michael might be interested to meet with other researchers from the company. A scheduler service, available through the corporate WLAN, allows for short-term arrangements. It displays the availability of staff and administrative information such as room number or telephone, which are derived from the users' online profiles.

3 Enablers of mobile personality

Various system and implementation aspects have to be considered in engineering future service provisioning platforms that support the above scenario. The scenario already reveals a number of requirements that are essential for the realization of personalized service provisioning towards a Mobile Personality. In particular we consider the following requirements to be most important:

- Modeling the user through advanced profiling;
- Perception and modeling of the environment (context awareness);
- Supporting a user-centered service discovery and service selection process based on the modeled information;
- Processing the modeled information and supporting their effect on the service execution including service adaptation;
- Flexible service support middleware that allows profile propagation and service transfer as well as personalization-driven service composition.

In the following we will discuss the main building blocks for mobile personality.

3.1 Advanced personalization concepts

In our scenario, the "personality" of a user is reflected by the set of personal profiles associated with him and passed to other users, network nodes and service providers. User modeling and profiling beyond device independence – covering user preferences and wishes – are essential for supporting such a virtual mobile personality. Recently profiling standards have been established for describing service delivery context: the Composite Capabilities / Preferences Profile (CC/PP) created by the W3C [25], the User Agent Profile (UAProf) created by the Open Mobile Alliance [18] (formerly WAP Forum) as well as the Generic User Profile (GUP) put forward by the 3GPP [1]. They specify an XML – and (in the case of CC/PP and UAProf) an RDF [16] based framework – to address common needs for device independent service access. Although they provide an interoperable basis for meta data descriptions of profile information, current profiling languages are not yet adequately suited for advanced profiling needs.

As shown in the scenario, semantic-based and cooperative service discovery and selection are integral parts of proactive services; i.e. user needs and wishes will be identified as complex tasks, which are typically further divided into simpler sub-goals and heavily relate to the user's context and environment. For user profiling languages there is a lot to learn from Knowledge Engineering and the database world where the taxonomy or organization of profile elements is often referred to as schema or ontology. We advocate that the design of future profiling languages for personalization can particularly benefit from the current approaches of the so-called Semantic Web [6] where the layering of content descriptions has a similar quality: on top of XML, RDF provides a simple yet coherent structure for the expression of basic semantics and a foundation for different Web Ontology languages with a varying level of expressiveness [19]. For services to be proactive, the sub-goals of a user's tasks have to be further explored and subsequently matched to adequate services. Matchmaking can be achieved with the help of advanced discovery and selection mechanisms [3][4] and autonomous intelligent agents [24] that search the user's service environment according to his personal preferences.

3.2 Context-aware computing

Context awareness is an attribute of a service that is capable of accessing, interpreting and manipulating knowledge of its environment and to adapt the service behavior accordingly [15]. For the provisioning of intelligent services, having their own personality, we are developing a context spaces agent service architecture that allows acquiring, managing and processing context information based on agent technology [24]. Here, a significant attribute of an intelligent agents environment is the existence of other intelligent agents with the possibility for social communication between agents [17]. Thus, allowing agents to exchange context information and experience reports of service usage as well as to adapt to services to user profile/preference information and vice versa.

Introspection capabilities are a key requirement within context-aware computing and specifically in the context spaces architecture. The construction of a context space provides the capability of accessing knowledge of the environment for logic reasoning purposes. To enable introspection in the architecture, accessible data attributes of the environment are modeled and constructed as a context tree structure. Agent services using logic, such as dependency rules or logic expressions, can use the context space as data source for personalization input. Since the resulting context tree structure is an overlay data model designed to remain independent of the original storage model, it can be used for both transient and persistent data originating from data storage repositories or broadcast sensor data.

3.3 Flexible and evolvable service support middleware

Service support middleware has to be capable of efficient session management including profile management and service mobility. The service session control as core part of the service support middleware has to provide advanced service provisioning functions including those described above. We regard application-layer signaling to act as a coordination facility supporting information exchange between the acting entities. To support advanced personalization concepts, we advocate a proxy-based service signaling approach [13]. Here profile management, service session management and resource control are realized in separate interacting proxy servers that are on the end-to-end service signaling path. This concept is substantially enhanced to enable a preference-based session management [12]. Preference-based session management makes use of profile information already in the proxy servers (e.g. network edge nodes) that are traversed by the service signaling messages and not only in the target application.

In addition, regarding user requirements and emergent services, future systems have to be most flexible. To date, nearly all service architectures center on required functionality within a strictly layered system structure. In [21] we describe an architecture that supports adaptation and evolution in systems B3G in general and on a middleware level in particular. Such an adaptable environment allows making personalization effective for service execution by a flexible introduction and exchange of functional components, such as context manager or service selector. Programmable platforms on all system layers form the basis for the component management.

Adaptation and programmability of services should not be limited to content adaptation as it is in most of today's systems. Instead it will involve modifications to behavior (service logic) [9], service interaction and signaling as well. How dynamic service adaptation can benefit from dynamic programming environments such as [8] is further explained in [10].

4 Preference-based service discovery on mobile devices

Using Web-based services has already become an integral part of our everyday life. Semantic Web technology and the advent of universal and mobile access to Internet services will only add to the broad range of existing services on the Web and provide addi-

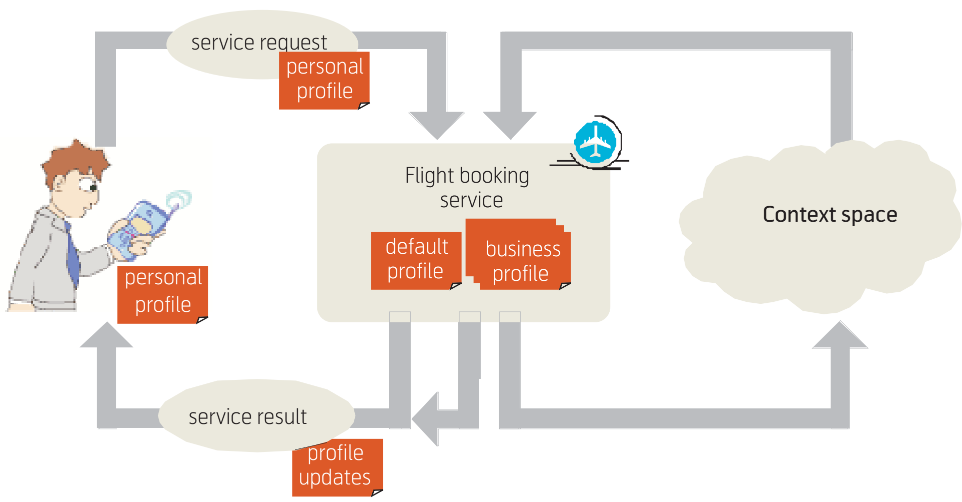

Figure 2 Cooperative service execution and context spaces

tional features like knowledge-based, location- or context-aware information. On the other hand, so far little work has been done to explicitly account for aspects of mobile computing in semantic service frameworks. Whereas much of the work in Semantic Web services discovery and composition concentrated on the functionalities of the services, contextual information, personal preferences and more generally personalization are more pressing challenges in the mobile computing arena. In order to manage an increasing amount of mobile services, it is essential that Semantic Web services standards explicitly support the needs of developers and users, such as the discovery and selection of services they personally need in a given situation or context.

In an early case study we have implemented MobiOnt and MobiXpl as a semantic toolbox to explore mobile user-centered services on the Semantic Web [6]. Our vision is to take full advantage of future complex service offerings on limited client devices and to handle the need for personalized service discovery in mobile environments. At this point MobiOnt and MobiXpl are early prototypes that are realized and can be demonstrated as plug-ins to the Protégé knowledge workbench [22]. MobiXpl emulates different commercially available handsets, whereas MobiOnt encapsulates central preference-based matchmaking mechanisms. Implementations of MobiOnt as a central network component and MobiXpl as a Java-based client running on an actual phone are currently implemented.

4.1 A Concrete usage scenario

We study an extension of the usage scenario published in [28] that addresses a future mobile Internet radio scenario. Internet radio has become increasingly popular in recent years with boosting numbers in Web radio stations and subscribers [20][23]. In this context, personalized access to content is particularly important to accommodate varying technical as well as personal user needs and preferences. In our testbed we have modeled Internet radio stations as Web services with varying service characteristics. Radios channels are described using an Internet radio ontology (a fragment of the ontology is shown in Figure 4) that consists of concepts that describe and classify Web radio services in terms of program format, origin, audio format characteristics and a time-based classification of streamed audio content. This service ontology is then used for preference-based service discovery. Note that our Internet radio use case is only one of many possible applications for the MobiOnt.

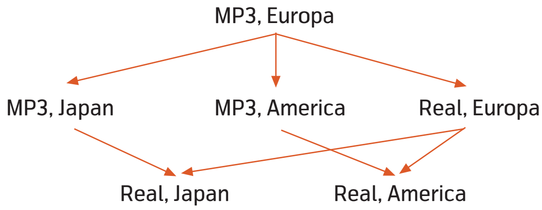

Figure 3 A user-defined preference ordering

4.2 User preferences

While browsing the service ontology, service concepts with key relevance to the user can be selected and combined to preferences. In our preference framework [14], these (partially) ordered feature sets are directly handled without the use of any explicit quality or ranking values: user preferences are introduced as a special relation with the semantics of considering some object (or class) A superior to another object (or class) B ("I like Music channels better than News stations"). Preferences indicate constraints that a service should fulfill to best meet its requirements. On the other hand, even if none of the indicated preferences are met, a match can still be possible. To manage multiple user preferences complex preferences can be inductively constructed from a set of base preferences by means of preference constructors [14][28].

Figure 3 shows an example of a combined preference from the radio scenario. Here a user has indicated that she generally prefers radio programs from Europe to those from Japan or America. Still, the two latter choices are her preferred choices over any other available program. Due to the technical capabilities of her player, she also prefers MP3 encoding to Real. Further, she has specified that both base preferences are equally important to her.

4.3 Cooperative service discovery

User preferences constructed during preference building define a service request that ultimately needs to be mapped to the underlying service ontology. MobiOnt therefore implements a flexible discovery algorithm that can be extended through different strategies. The goal of service discovery is to retrieve those service instances from the ontology that represent the best matches to given preferences.

The implemented preference-based service matching is performed along the lines of the determined preference order to implement cooperative behavior: if the search for a perfectly matching radio station fails, the initial query is gradually relaxed along the path of the (complex) preferences until a next-best match can be found. Thus, if in our example from above during service discovery no match could be found in European

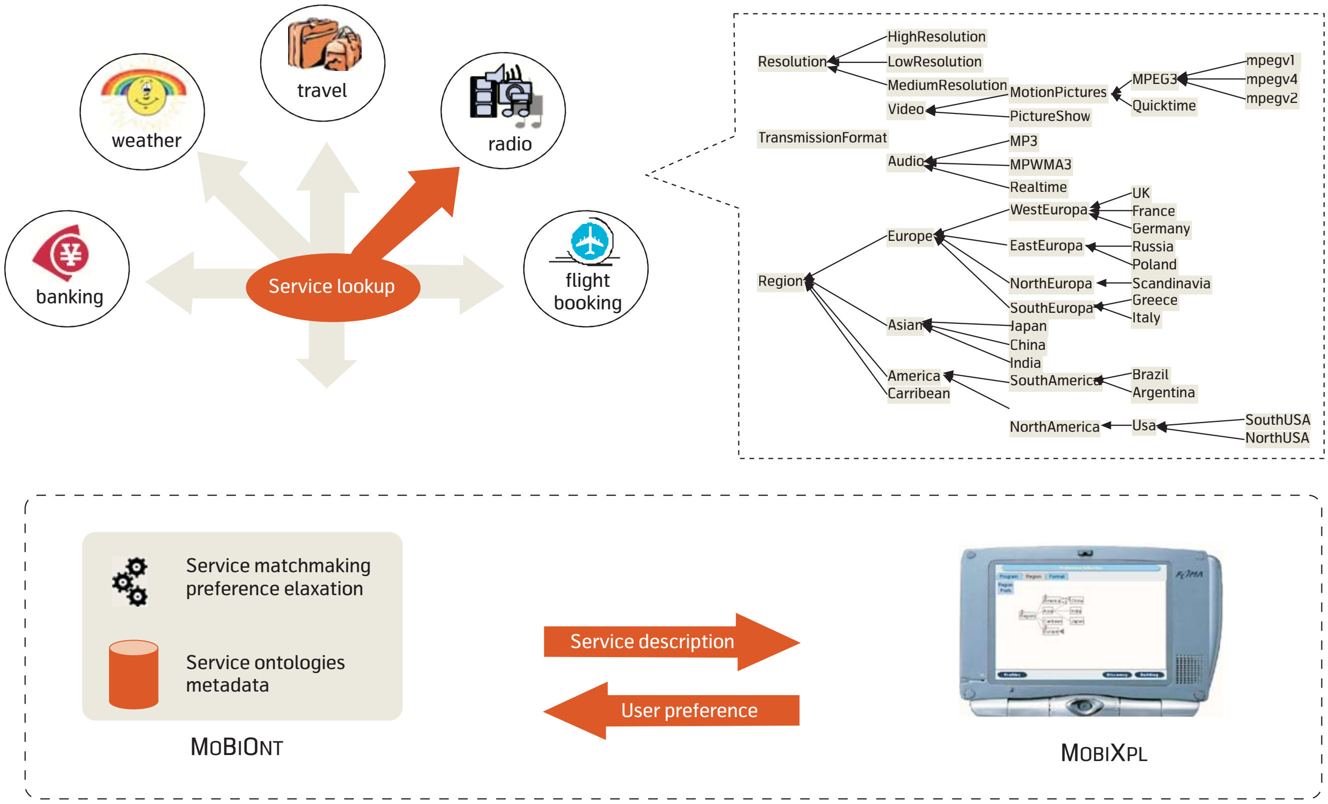

Figure 4 MobiOnt / MobiXpl – A testbed for mobile semantic-based services

programs in MP3 encoding, the next discovery step consists of trying to match radio stations that broadcast Japanese or American programs in MP3 or European programs in Real. If neither of these two second-best choices are available, any other program is matched. Further implementation and application aspects as well as selective ontology browsing and preference building and mapping are further explored in [4][5].

4.4 mobiXpl – a user interface for preference-based discovery

Parts of the Internet radio ontology are carefully exposed to the user through MobiXpl, the graphical frontend to our framework (cf. Figure 5). MobiXpl emulates different mobile terminals and consists of a mobile ontology browser with support for individual user views as well as an intuitive interface to user preferences. The idea is to only display selected concepts and sub-ontologies depending on the user's

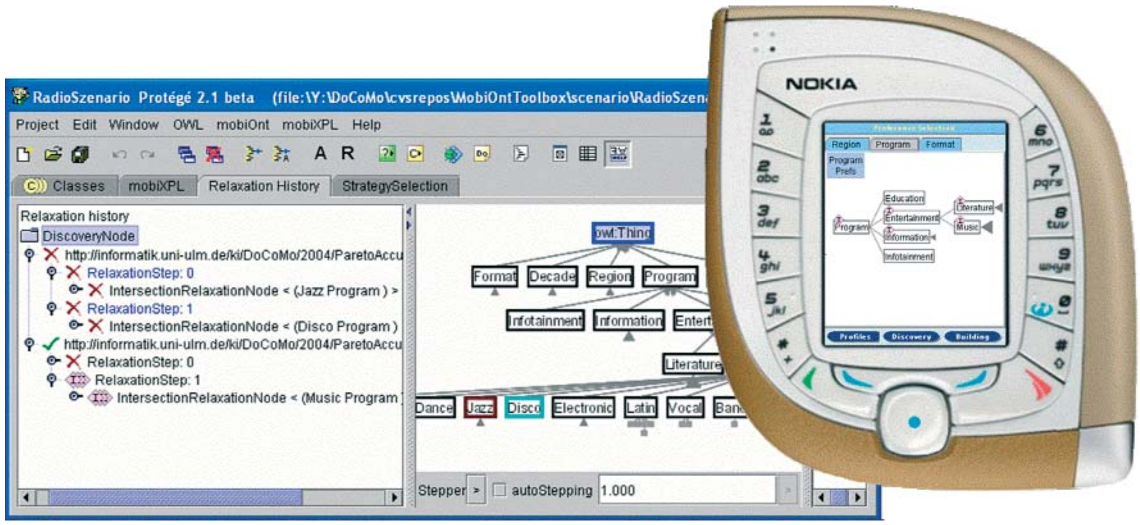

Figure 5 MobiXpl – exploring ontology-based service catalogs on the mobile device

experience level and usage profile. While browsing the service ontology, concepts that circumscribe services with key relevance to the user can be selected and combined to user preferences. Subsequently, these preferences are used during the service discovery to implement cooperative behavior: if the search for a perfectly matching radio station fails, the initial query is gradually relaxed along the lines of the determined preferences until a next-best match can be found. Both application aspects, selective ontology browsing and preference building and mapping are fully explored in [28].

5 Towards a mobile personality

Expressing user preferences, wishes and dislikes in an intuitive way is crucial for the flexible provisioning of mobile services. With the vision of Mobile Personality in mind, we have developed essential concepts and solutions for the flexible matchmaking of evolving user preferences and services; namely,

- an algorithm for preference-based negotiation and interaction with services [3];
- a mechanism for the use of semantically rich services descriptions together with service usage patterns in aggregated service catalogs for cooperative service discovery [4][5];
- early prototypes that leverage preference-based matchmaking in semantically rich service catalogs for the mobile user.

In cases where the perfect match of the user's preferences to the available services is not possible in the given context the next nearest match has to be provided in a cooperative fashion. The outlined approach assumes that user preferences are modeled in terms of hard and soft constraints. Hard constraints model user preferences that definitely need to be matched during service discovery and selection, whereas soft constraints represent parts of a user profile or a user request that can be relaxed during the matchmaking to the available services. Our profiling concepts comprise a notion of usage patterns to express preferences of user groups and typical service invocation patterns. For example, a general preference from the travel domain could be that "everyone prefers a short traveling time" (i.e. a departure date with maximum proximity to the arrival date is preferred). The iterative adaptation of these patterns to evolving user needs plays a key role in the concept of Mobile Personality. As indicated in Figure 2, user preferences are passed to the service provider for service matchmaking and execution. If no match between the personal profile and the default execution profile of the service is available two basic conflict resolution strategies (and combinations thereof) are applicable: on the one hand, the cooperative service execution might decide to relax user's preferences until a match can be made. On the other hand, the user might be associated with a typical group pattern, e.g. "Business User", resulting in the enrichment of his request with additional preference data from the pattern.

Beyond the one-time usage the lifecycle of profile data is crucial in the Mobile Personality paradigm. For instance, when an intelligent agent reserves a rental car at Boston airport on behalf of our sample user Michael for the first time, he will do this based on some base preferences. However, on a revisit to Boston, Michael's user profile will already contain a usage history of services together with an experience report. Again, the left-hand side of Figure 2 illustrates this through the cycle of profile usage and profile update. Based on the user's profile and/or usage history – and maybe additional usage histories, e.g. from Michael's colleagues or users with similar preferences and interest, a more informed decision can be made. In the case of Michael it is conceivable that the choice of car rental agency, formerly price-based, will change based on experiences with the agency in case of a car breakdown or due to unanticipated technical problems with adapting his mobile terminal to the in-car navigation system.

Referring to Figure 2, we show a more detailed prospective of adaptive service interaction and the use of a context space for introspection and interaction by intelligent service agents: in the diagram, Michael initiates the flight booking service using a service request containing meta-data representing his personal profile. Upon receiving the service request, the flight booking service processes the service request and promptly returns the service result and the profile update. In addition to sending the service result to Michael, the flight booking service annotates the context space by writing the updated profile to the context space. Service agents with a similar interest in Michael, using the introspection capabilities of the context space, observe the annotation of the space and use logic to determine if the updates in the profile can be used for personalization. Through agent social interaction, service agents such as a group of car rental agents reason that additional profile update should be made available to Michael. The profile updates are annotated into the context space and the flight booking service is notified for asynchronous delivery to Michael.

6 Summary

The evolution towards systems and services B3G bears the risk of increasingly confronting the customer with technology features instead of service aspects. We claim that similar problems in using and accessing new services have already led to slow service adoption in the past. As a consequence, users might not be able to fully understand novel services and to benefit from future applications. In this paper – with customer acceptance and ease-of-use as the most important success factor for forthcoming telecommunication systems in mind – we have presented our vision and first steps towards supporting advanced personalization concepts under the umbrella of a "Mobile Personality".

The Mobile Personality paradigm is characterized through personal services, user preference and service profiles that evolve over time according to changes in the user's environment, context or the service offerings themselves. The main building blocks of this personalization concept are: advanced personalization concepts, context-aware computing, as well as highly flexible and evolvable system architectures. Our ongoing work has emphasized generic approaches to context management as well as service discovery and selection that feature extendable semantic descriptions of services, users and devices.

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