Preference-based Session Management for Personalized Services

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Abstract

The increasing variety of mobile multimedia services raise the need for mechanisms to select those services that best match individual user requirements and allow for service customization. In this paper we describe an advanced concept for service personalization in next-generation IP-based mobile systems. Our approach extends conventional service management by introducing a preference order on the available service features according to the specific demands of a user. Furthermore, we exploit the fact that in current IP-based mobile communication systems application layer signaling messages traverse several network functional entities between client and server application. Our architectural solution based thereon comprises a stepwise refinement of profiles and preferences including an early matchmaking to service capabilities.

1 Introduction

Personalization is regarded to be one of the most compelling features of future mobile communication systems. User-centered services and personalization promise to support customers in selecting their favorite services from the rapidly increasing diversity of mobile multimedia services and adjusting their personal services to their individual needs. We consider personalization as the matchmaking of a user's preferences and demands to the available services under the constraints of a given situation or environment. To select and tailor services to the actual demands, we need to take into account (Eurescom P1203, 2003):

- knowledge about users and their context,
- the features of available services,
- and the capabilities and constraints of the network employed.

Given the diversity and highly dynamic nature of mobile communication systems – e.g., concerning heterogeneous networks and terminals – personalization is not only important for the discovery and selection of services (Balke & Wagner, 2003), but also for establishing and managing service sessions on behalf of an individual user. In traditional multimedia communication systems the network signaling system only supports the end-to-end transport of basic service capabilities and user preferences, typically expressed as simple parameter or feature sets. The negotiation process itself is performed by the applications. Moreover, service selection is performed off-line and the result is bound to a network address of a specific server, e.g., by picking up a servers IP-address from a search machine. Systems for service discovery such as Jini (SUN, 2003) or the Service Location Protocol (Guttman, 1999) give support to an automatic, profile based service selection. However, these solutions only scale for limited network areas not addressing increasing globalization. Moreover, the trend to globalization and the increasing need for context aware applications (Naghshineh, 2002) that go beyond location-based applications, cause that the parameter sets to be processed will soon become very complex. To cope with this complexity advanced user support and application support is needed from within the communication network.

In this paper we propose an advanced approach to a preference-based management of service sessions for IP-based systems. According to existing approaches for user preference and capability descriptions, such as (Rosenberg & Schulzrinne, 2002), we model service parameters as feature predicates in first-order predicate logic. In addition, we allow users to express their personal wishes and dislikes in terms of a preference order on these feature predicates. Presenting a sample video streaming scenario, we show how to leverage the personalized session management by user preferences that are already pre-processed in the network. Our overall approach aims at supporting:

- Preference-based service selection
- Preference-based capability negotiation to adapt and customize the selected service

- Efficient propagation of profile information through the network
- Effective selection of a session signaling path for the selected service respecting given preferences and constraints

In this paper, we focus on the efficient propagation of user preferences as part of the user profile information and on the capability negotiation. Furthermore, we describe the application of the findings in an advanced signaling architecture for IP-based communication networks.

Concepts for preference-based service discovery and service selection are already described in (Balke & Wagner, WWW 2003) and (Balke & Wagner, ICWS 2003). These papers describe a two level mechanism for a system-assisted personalized selection of user-centered services using an onthology-based model of the service offerings, individual user preferences and typical usage patterns. In particular, web services were addressed as an example to illustrate the increasing service diversity and need for advanced support for personalization.

Our approach described in the following refers to an IP-based mobile system architecture as mentioned above. IP-based multimedia service architectures have already been specified in detail for the third generation mobile communication systems. In this respect, the most important example for IP-based mobile networks is the IP-based Multimedia Subsystem (IMS) standardized by the 3GPP for IMT2000 (3GPP, 2002). 3GPP has adopted the Session Initiation Protocol (SIP) of the Internet Engineering Task Force (Rosenberg, 2002) to serve as the application layer signaling protocol in the IMS. Since SIP allows the exchange of capabilities only in the traditional way, we propose several improvements by introducing preference-based session management mechanisms.

The remainder of this paper is structured as follows. First we describe how the negotiation of service and endpoint capabilities is enhanced by an advanced preference model. In Section 3 and 4, we discuss how profiles and preferences are efficiently propagated and resolved in such IP-based mobile system environment. Architectural solutions for preference-based session management are described in Section 5 along with a detailed example scenario. Section 6 gives an outlook on preference-based routing before we conclude our paper with a summary.

2 Preference-based negotiation

In addition to RFC 3261 specifying the Session Initiation Protocol (Rosenberg, 2002), the IETF SIP working group has - among other proposals - drafted an extension to SIP to support so-called caller and callee preferences for profile-based service request routing and for capability matching when a request reaches an application server (Rosenberg & Schulzrinne, 2002). However, preferences are still expressed in a rather simple fashion.

Figure 1 gives as simple example of SIP callee capabilities: the ‘codec’ predicate determines that a video stream can be encoded in the formats ‘mpeg’, ‘dvx’ or ‘avi’. The ‘res’ predicate states that videos are available either at ‘high’ or ‘low’ resolution, and the ‘audio’ predicate establishes that the audio stream of a video session can be transmitted as ‘full’ audio – in combinations of the languages ‘EN’ (English), ‘GER’ (German) or ‘JP’ (Japanese) – or be reduced to a text-based ‘caption’ version.

```
codec(mpeg)
codec(dvx)
codec(avi)
res(high)
res(low)
audio(EN,GER,JP;full)
audio(EN;full)
audio(GER;full)
audio(EN;caption)
```

Figure 1: Sample feature predicates

Similar to callee capabilities, SIP caller preferences are expressed as feature predicates in first-order logic (as shown with the capability list in Figure 1) that can be further combined through logical connectives, e.g., conjunction (logical and) or disjunction (logical or). In (Rosenberg & Schulzrinne, 2002) negotiation between caller and callee is then performed as the matching of feature predicate set and results in a possibly large sets of potential service features that have to be singled out by the end user.

We advocate that personalized session negotiation can benefit from an advanced preference model and therefore propose to express user preferences as a (partial) ordering of feature predicate as shown in Figure 2. In this example, e.g., a ‘codec’ in ‘mpeg’ is preferable to ‘dvx’ or ‘avi’. During service selection this user preference is treated as a soft constraint, i.e. ‘mpeg’ is selected if available, otherwise ‘dvx’ and ‘avi’ are treated unbiased. Analogously, ‘audio’ in ‘EN, GER, JP; full’ is considered to be superior to ‘EN; full’ and ‘GER; full’ with both of these audio characteristics preferable to ‘EN; caption’. Very naturally, ‘high’ video resolution is preferred over a ‘low’ one.

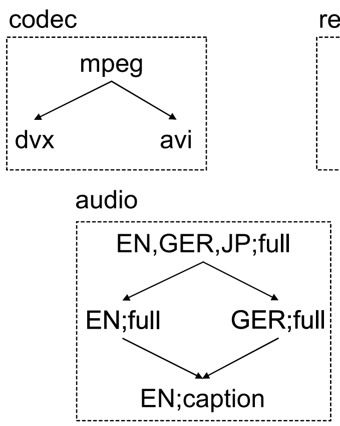

Figure 2: Individual user preferences

Preference/capability matching can now be performed along the lines of the given preference order, e.g. matching the preferences from Figure 2 onto the capabilities in Figure 1 can result in a video session encoded in 'mpeg', with full 'audio' capabilities at 'high' resolution as a best possible match.

3 Preference propagation

The efficiency of a preference-based capabilities negotiation can be further improved when we employ pre-filtering to the profiles and preferences that are propagated through the network. Sometimes one or more of the preferred capabilities cannot be granted, either if there is no network service supporting this feature available, or if the session signaling path within the network does not allow the transmission of the feature (e.g., due to a limited available data rate).

In these cases the feature predicate sets will be relaxed along the given preference order. An example for such a preference filtering is given in Figure 3. In this case 'GER,EN,JP;full' is dropped from the 'audio' preference set leaving an unbiased choice between 'EN;full' and 'GER;full' (both preferred to 'EN;caption'). While 'codec' remains untouched the preference set for the video resolution is reduced to 'res(low)' due to limited network data rate.

For an efficient preference propagation and filtering we consider the following mechanism. In passing profile information through the network all preferences that become irrelevant due to network conditions can be removed and replaced by appropriate constraints.

To further leverage the preferences that are propagated through the last hop of the network, we propose that not necessarily all preferences need to be stored on every user device. Instead, users can be allowed to store common profile information on central network entities and provide minimal (request dependent) overwrites for specialized devices.

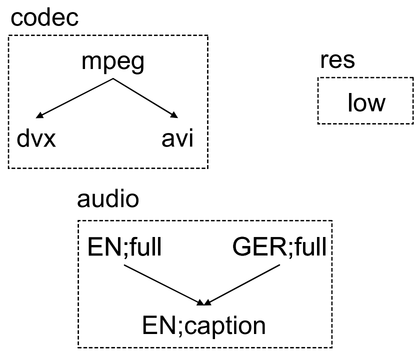

Figure 3: Reduced preference set

To additionally facilitate preference management, default preferences can be provided by central network entities and services. These default preferences could be used in the case when only minimal or none preferences are given in a request. In the case of conventional service requests, e.g., in the style of (Rosenberg & Schulzrinne, 2002) these would be without a specified order on feature predicates.

4 Preference resolution

To manage caller and callee preferences as partial orders of feature predicates a powerful and flexible modelling technique is needed. Claiming to closely match people's intuition, (Kießling, 2002) proposes a strict partial order semantics for preferences that can be adapted for preference-based session management.

A broad variety of qualitative preferences and of quantitative preferences using ranked scores are the key to preference-based modelling in (Kießling, 2002). Complex preferences are inductively constructed from a set of suitable base preferences by means of basic preference constructors and complex preference combination. To be self-contained we will briefly discuss two basic combination operators, namely Pareto accumulation and preference priorization, as possible means of preference resolution in multimedia session signalling systems such as SIP.

4.1 Pareto accumulation

The Pareto-optimality principle has been applied and studied intensively for decades for multi-attribute decision problems in the social and economic sciences. In our case it can be used to handle equally important session preferences. Let us consider the case where the preference set depicted in Figure 1 denotes sample caller preferences that are matched against sample callee preferences as shown in Figure 3. Various matches are possible that can be expressed as triples of ('codec', 'audio', 'res') yielding a matchmaking partial order. Under Pareto-accumulation, for a matching triple t_1 to be considered better than a second triple t_2 it is not tolerable that t_1 is worse than t_2 in any component. Thus, in our example matches of highest priority are ('mpeg', 'EN;full', 'low') and ('mpeg', 'GER;full', 'low') – both representing best matches in all three components – followed by ('dvx', 'EN;full', 'low'), ('mpeg', 'EN;caption', 'low') and other triples of low matching priority.

4.2 Preference priorization

On the other hand, in the matchmaking of service request and capabilities some preferences might be more important to the user, e.g. the resolution of a video may outrank the codec. This can be modeled by stating relaxation orders for user preferences – often referred to as preference priorization. In our example it is conceivable that a user ranks video resolution over codec and in turn codec over audio. This implies a different order on the matching feature triples with those preferred that are considered best matches in 'res' and 'codec', respectively. Thus, in our example ('mpeg', 'EN;full', 'low'), ('mpeg', 'GER;full', 'low') and ('mpeg', 'EN;caption', 'low') are considered better matches than ('dvx', 'EN;full', 'low'), ('dvx', 'GER;full', 'low'), ('dvx', 'EN;caption', 'low') and so on.

5 Preference-based session management

So far we have described several preference handling solutions using a preference order on the available features in addition to existing first order logic descriptions, which allows to express user wishes and other rather soft constraints. In this section, we focus on architectural issues and show the application of the findings in an IP-based mobile multimedia signaling architecture. Moreover, we illustrate the role of the network entities in an efficient preference-based session management.

5.1 Scenario

Taking the example of a business traveller, in (Wagner et al, 2002) we have presented a case study of personalization issues in future mobile communication systems. Here, it is shown how advanced personalized communication support the diverse tasks a business traveler has to perform. Steps include getting an automatically configured rental car at the airport, adapting the route to the meeting place to personal needs, e.g., get local currency from an ATM, automatic rescheduling of meeting start time, and finally discovering communication devices at the meeting room that are automatically configured with the users preferences to be used for access to streaming content featuring business products.

We envision preference-based session management as an essential technical enabler of such a scenario. For the implementation, we address an architecture that consists of a (mobile) client running the user application and a multimedia server in or attached to the network hosting the desired application or content, e.g., a dedicated video server or even the multimedia-enabled end device of another user. We consider an IP-based mobile multimedia communication system for the interconnection of the devices.

5.2 IP-based multimedia service architecture

In a typical mobile communication network signaling messages, which possibly include the above described preferences, traverse several functional entities in the communication path between client application and server application such as a proxy in a visited network or the home network session manager. Each of these entities maintain different information that could be used to process a preference-based service request more efficiently (cf. Figure 4). Examples include:

- **User device**: stores part of user profile and preferences, incl. device capabilities
- **Access node**: transport capabilities, user context (e.g., access on the go)
- **Visited network (VN) proxy server**: local information, here a decision could be taken to select local services or home network based services (without knowing the detailed user profile)
- **Home network (HN) gateway**: network based user profile, user authorization
- **Home network session manager**: service profiles, here decision is to be taken to select the server/called party serving the requested service

These entities map to mobile multimedia communication architectures such as the IMS described above. Here the use of SIP provides several capabilities that we use for preference processing. SIP uses overlay addresses that are different from the IP-network addresses, i.e., the server address is decoupled from the network address. This allows to adapt the request route while the request is traversing several network entities such as the above.

Furthermore, SIP allows to modify the request content in traversed network entities acting as SIP proxy servers. This includes preferences according to (Rosenberg & Schulzrinne, 2002) that are part of the request message syntax or the session description that is carried as additional payload independently of the SIP request. In this way, preferences can be updated or modified in the network entities such as proxy servers.

5.3 Proxy-based signaling

The underlying principle of a proxy-based next generation application layer signaling architecture is de-

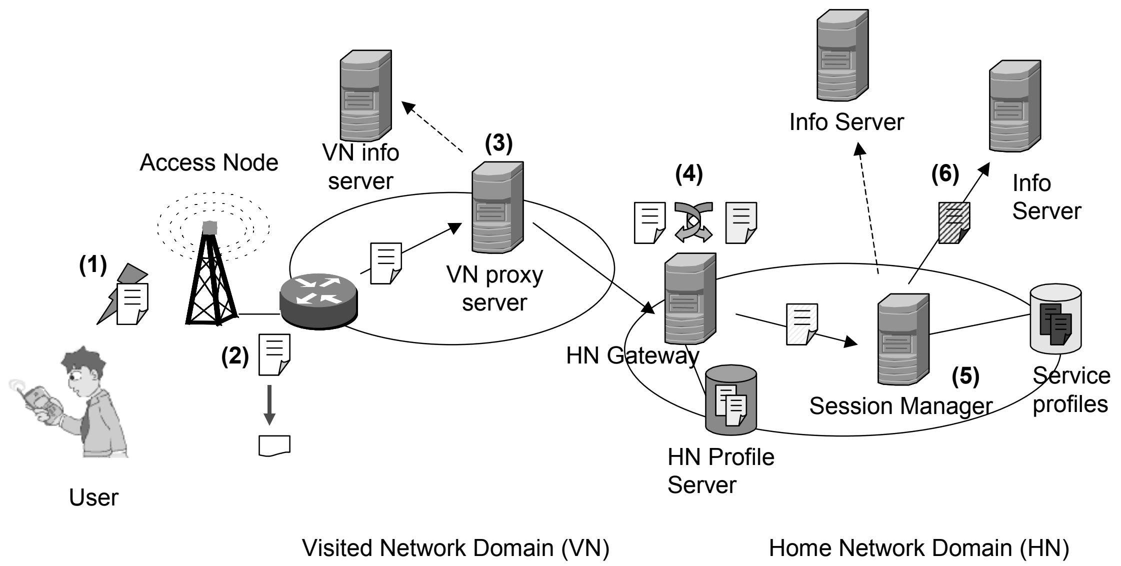

Figure 3: Proxy-based preference propagation and management

scribed in more detail in (Kellerer & Berndt, 2002) and (Kellerer, 2002) focusing on a SIP-based transaction protocol for signaling for session management. There, network servers such as access session controller, service session controller and communication session controller are realized as SIP proxy servers or SIP redirect servers that are traversed by session signaling messages. This architecture is easily transferred to the IP-based architecture that we take as a basis for the considerations described here.

In the architecture of (Kellerer, 2002), two features are described that we use in the following: The selection of the respective servers and redirecting the signaling flow accordingly, and the stepwise refinement of the session description (e.g., adding service profile) when it is processed by the proxy servers. In this architecture, the end-to-end concept of IP-based signaling is kept and at the same time one makes use of the information or control intelligence that is available in the network. In (Kellerer, 2002) user profiles have been considered as part of the session description, but their effect on session management has not been investigated yet.

5.4 Preference-based session management

With the scenario from Section 5.1 in mind, we take a multimedia streaming session to illustrate our findings on preference-based modeling and capability matching. The advanced profiling issues from above are considered together with the different functionalities of the involved network components (cf. Figure 3).

The business traveller might want to retrieve video information about several business products via his laptop over a wireless link. He sets his preferences including 'codec', resolution and 'audio' as shown in Figure 2. These preferences are then transmitted with the service session request (1). On passing a proxy in the access network, some preferences can be singled out, e.g., given that limited wireless capabilities do not allow for transmitting high resolution videos, and respective constraints are added (2) as also shown in Figure 3.

Since local information servers of the visited network domain (3) cannot provide the requested content, the request is routed to his home network domain. There his request is matched with preferences and capabilities stored on the home network profile server (4), which also might add some typical preferences that have not explicitly been specified by the user. Mapping the user's remaining preferences and the constraints added by the network nodes with the capabilities of available service, the home network session manager selects a suitable server providing the requested information (5).

Fortunately for our sample user, a mpeg-capable server providing the requested information could be found. The remaining preferences and constraints are now transmitted to the server to customize the service (6). Here, also further capabilities like the language can be selected without necessary involvement of the user in the negotiation process.

6 Preference-based routing

As we have seen in the example, preference-based personalization of services may not only address the servers on a certain signaling path but may also affect the routing of the service request itself (see step (3) of the example). This means, the routing decisions in the traversed servers can depend on the exploitation of the service request including the contained user preferences.

Multiple proxy paths might exist for a requested service session. In this case, an efficient selection of a path already meeting all user-requested capabilities can be done based on profile information at an earlier point. This allows early decision making and avoids that all requests have to be routed to home domain where the service is known to exist. For an optimal selection without preference preprocessing in the network multiple possible paths have to be explored first to find a suitable match.

(Rosenberg & Schulzrinne, 2002) discusses optional fields to be included in a SIP request to express request handling preferences at an intermediary server such as a SIP proxy server. The specified preference information is used by the server to select among alternative registered contacts of one callee. As already described above, preferences are described in a first-order logic, without expressing soft constraints. When we consider applications servers with a certain replication rate, such as a streaming server, to be the end point for a request, preference-based routing promises to be more powerful, as we are able to decide during routing about possible alternatives that may be closer to the requestor ("Is there a contact registered that is featuring the requested stream?").

7 Conclusion

In this paper we have sketched a novel solution for network assisted service personalization based on a preference ordering of feature predicates and their stepwise refinement in network entities along the session signaling path. Network support of personalization not only promises to foster the operator-customer relationship, but also leverages the personalization efforts of third party service providers and encourages them to enter the compelling market of personal services. Existing solutions for preference handling in application layer signaling, like (Rosenberg & Schulzrinne, 2002), could be improved to express user wishes and other soft constraints to allow better personalization and to reduce the preference complexity by the described processing mechanisms.

Using a practical example in video streaming, we have exemplified how preference matchmaking and service personalization can be achieved in accordance with advanced networking standards. Our approach can be embedded in IP-based mobile communication systems and leverages several profiling features, such as the centralized provisioning of default service preferences. In addition, by early processing the preferences in network nodes, we can reduce the complexity of profile matchmaking.

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