Towards adaptability in 3G service provision

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ABSTRACT

The evolution of mobile networks and systems to 3rd generation and beyond is expected to create a telecommunication service provision model that differs considerably from existing paradigms. A new environment is envisioned, where a plethora of advanced, customisable applications, developed by multiple co-operating entities, will be ubiquitously accessible via diverse terminals and networks. In this context, where service management and provision will become substantially more complex, the need is emerging for intelligent service deployment and management platforms that are able to undertake the necessary inter-domain co-ordination and mediation. Moreover, the requirement for service provision adaptability becomes critical, since applications should be seamlessly delivered and executed in a large variety of environments. In this paper we provide a brief overview of a proposed 3G service provision platform and describe the mechanisms it uses to achieve a high level of adaptability and flexibility.

I. INTRODUCTION

The advent of 3rd generation mobile communication networks (3G) is considered as a milestone event that will irreversibly change the structure of the telecommunications industry and lead, ideally, to a world where an abundance of personalisable value-added services, typically developed by third-party service providers, will be offered to end-users, regardless of their current terminal, location and access network [1]. It is commonly recognized that the plethora of business combinations and technical implementations in the emerging 3G era will substantially raise the bar on the respective service management frameworks. A viable solution for fulfilling these increasing demands can be found in the form of distributed service provision platforms [2] that will accomplish service-level management actions through intelligent mediation between multiple domains. Moreover, the volatility and diversity of the wireless environment that will be accommodated by 3G systems and beyond, calls for dynamic adaptability of service provision. In this paper, we present the intelligent adaptation functions of a distributed software platform for 3G service management, and their utilisation for achieving the goal of service provision adaptability and flexibility.

The rest of this document is organized as follows: We first describe the architecture and functionality of a proposed distributed software framework, which aims to address the provision and management of value-added services in 3G networks and beyond. Next, we discuss in detail various issues related to the incorporation of adaptability functionality to the above platform and present the relevant critical design decisions. We then proceed to describe the implementation of the adaptation functions in the above platform, as well as a scenario that demonstrates the interactions that are required for the accomplishment of the adaptation functionality. The last section of this paper is dedicated to summary and conclusions.

II. A FRAMEWORK FOR FLEXIBLE VALUE-ADDED SERVICE PROVISION IN 3G NETWORKS

In the present section we present an overview of the architecture and functionality of a distributed software platform for service provision and management in 3G networks and beyond. The presented framework is similar to the one designed and implemented in the frame of the IST MOBIVAS project [3].

The platform aims to address major issues regarding the deployment and management of services offered to users of next generation mobile networks. These applications are typically provided by third-party software vendors, commonly termed Value-Added Service Providers. The proposed framework may be administered by a mobile operator, or by an independent entity like an ISP. The platform's functionality comprises automated procedures for service deployment that include appropriate reconfiguration of the underlying network for optimal service delivery. In addition to that, an intelligent context-aware mobile portal is offered to the end-user, where procedures like service discovery, selection and downloading are fully tailored to terminal capabilities, user preferences and network characteristics, in line with the VHE vision of the creation of a consistent, personalized user experience for service access anywhere, from any terminal and over any network [4]. The accomplishment of the above-mentioned tasks is supported by intelligent, generic adaptation mechanisms that enable dynamic customisation of service provision.

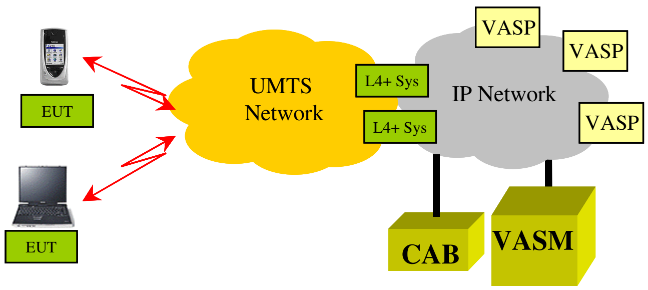

Figure 1: Architecture for flexible service provision in 3G networks.

The architecture of the platform is depicted in Figure 1. The main components of this architecture are the following:

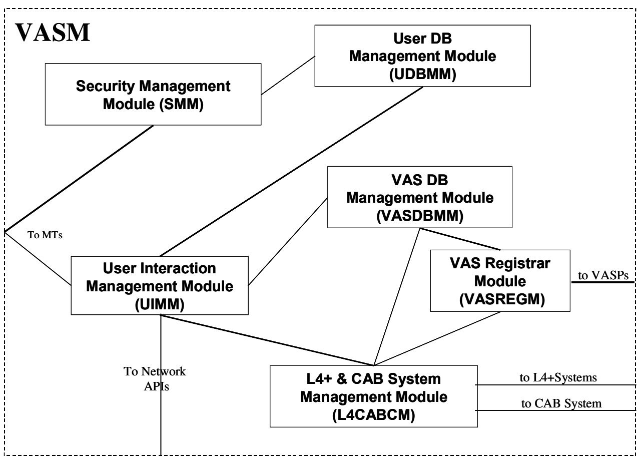

Figure 2: Internal architecture of the Value-Added Service Manager.

The *Value-Added Service Manager (VASM)* is the central platform component in that it co-ordinates the entire service provision and management process. It includes modules (Figure 2) that undertake on-line service deployment by VASPs (VASREGM), network and platform reconfiguration (L4CABCM), maintenance of service- and user-related data in suitable databases (VASDBMM, UDBMM), security (SMM), as well as customized service discovery, downloading and adaptation. The latter functions and in general all interactions with the user including the mobile portal functions and the control of the adaptation procedures (e.g., issuing requests to the adaptation module) are handled by an internal module of the VASM, called User Interaction Management Module (UIMM). The adaptation logic is also part of the VASM. In particular it is integrated in the UIMM.

The *Layer 4+ systems (L4+Sys)* [5] are enhanced IP routers, capable of DiffServ-based QoS provisioning, as well as network traffic monitoring and generation of metering records that are necessary for billing. The above functions are selectively applied to specific traffic flows that correspond to VAS consumption. The L4+ systems are dynamically reconfigured by the VASM. Configuration parameters that are subject to change are the traffic flows that are processed, as well as flow-specific policies (e.g., QoS provisioned to each flow).

The *Charging, Accounting and Billing (CAB)* [6] [7] system is responsible for producing a single user bill for service access and apportioning the resulting revenue between the involved business players. This is accomplished by collecting metering data from standard 3G core network elements as well as Layer 4+ systems.

The *End User Terminal Platform (EUT)* includes functionality such as secure service downloading management, GUI clients for service discovery and selection, as well as service execution management. The EUT is able to identify and communicate to the VASM information useful to the adaptation mechanism, like terminal capabilities and user location.

III. ADAPTABILITY FEATURES IN THE MOBIVAS PLATFORM

The current section elaborates on the problem of incorporation of adaptability features in the MOBIVAS platform. Adaptation in the context of the MOBIVAS framework mainly comprises the intelligent matching of application requirements/features to user, terminal and network profiles. This enables customisation of the application (e.g., intelligent selection of the application's client software that is downloaded by the user) or service provision functions, like application discovery.

In the next section we discuss certain important issues pertaining to implementing adaptability and present the relevant design decisions. Subsequently, we describe in detail the integration of adaptation functions into the system, which are also illustrated by an adaptation scenario, demonstrating the corresponding interactions between platform components.

A. *Issues in adaptability functionality design*

Data format and exchange mechanisms

A major supporting function for adaptation is the collection of data describing the current context (e.g., user, terminal, network). Important issues related to this function are the format of the required data, as well as the way of communicating this data to the module that performs the actual adaptation processing.

At any given time, the service provision environment can be described in terms of the profiles of the entities that comprise it, like terminals, services, users and networks. The format of these profiles should be capable of expressing arbitrarily complex data structures, as well as be suitable for efficient processing. In the case that profile data is communicated across administrative boundaries, compliance to universal, widely-adopted standards is vital, so that interoperability is supported. Moreover, when data is transported over limited-bandwidth radio links, compactness of representation is highly desirable.

In the implementation of the proposed system, the profile data is converted to a Java object before it is provided as input to the adaptation processing function. In particular, for profile description, we use a java representation of a hierarchical, tree structure, which is able to represent profiles of any complexity. In the proposed platform, mappings to the employed Java object format have been developed from relational database records, other forms of Java objects (e.g., retrieved from an API) as well as from RDF/XML documents. The latter case is of particular interest, since XML, a W3C recommendation [8], is able to express arbitrarily complex data structures and it is an easy to use, open, widely adopted standard. A limitation of XML is its inability to unambiguously express the semantics of data. By using RDF, a framework specified by W3C [10], these limitations could be overcome to some extent [9]. In our scheme, we use RDF for the encoding of the typically complex and semantically rich terminal capabilities. More specifically, we followed the W3C Composite Capability/Preference Profile (CC/PP) specification [11], which describes a way of producing profile schemas in RDF[1]. XML is used for encoding the RDF terminal capability descriptors, as well as for representing user and application profiles.

A related issue of considerable significance is profile data exchange. The accomplishment of this function becomes particularly challenging when profile data is exchanged between entities that belong to different administrative domains as well as when it is transferred over limited capacity, unreliable wireless links. In the MOBIVAS platform such a situation has been encountered in designing the mechanism for the announcement of terminal capabilities to the VASM, an operation, which is carried out over the radio interface. Interoperability and efficiency are major concerns in this case. Thus, we chose to adopt again the CC/PP recommendation that specifies a way of encapsulating profiles in HTTP/1.1 headers. The HTTP header includes terminal profile information encoded in RDF. However, the hardware part of the terminal profile, which typically remains unchanged over time is not contained itself in the request; instead, a URL reference to its network location is provided, thus significantly reducing message size and facilitating transmission over wireless interfaces.

Identification of adaptation algorithms

The information as well as the decision criteria taken into consideration in performing intelligent matching as part of adaptation functionality in 3G service provision, are expected to considerably vary, due to the rapidly changing context of mobile communications (introduction of new devices, network architectures, protocols, services, etc.). For example, the adaptation function should account for certain characteristics of a device that was not available at the time of the function's implementation. Moreover, not only are the matching algorithms subject to change over time, but they can also be specific to a particular service provision context. Thus, the integration of matching criteria and algorithms to standardized protocols and mechanisms presents an alternative that does not provide the desired scalability for the case of 3G services.

In our implementation we followed the approach of encapsulating matching algorithms into the Java objects that are used for the representation of profile information. Each profile Java object contains a method called match(), which is responsible for determining whether the current object is compatible ("matches") with another object of the same type, which is provided as a function parameter. With this approach, the adaptation module becomes independent of the profile contents as well as of the matching algorithms that need to be employed in a particular environment. The only requirement is that the adaptation logic is able to load the profile Java objects from local file systems or remote network addresses.

Location of adaptation function

A crucial design decision regarding an adaptation system concerns the placement of the adaptation logic, especially in environments following the dominant client/server paradigm. Two apparent alternatives are placing this function on the server or the client, respectively. An approach similar to the transparent negotiation [12], proposed for dynamic adaptation of web content, could be considered, where delegating part of the negotiation logic to client avoids the transport overhead of including client capabilities with every request.

As far as service provision adaptation in mobile networks is concerned, we have preferred a scheme, which is server-based. The client should be able to communicate to the server its capabilities and probably also certain characteristics of the underlying network, but the actual task of adaptation is performed at the server-side. This choice was made since the information required for this task can be more efficiently collected and retrieved by a fixed network server and namely the service provision platform[2]. It would be highly costly in terms of network traffic to transfer all the necessary data (e.g., application, user, network profiles) to the terminal over the wireless link. Moreover, adaptation processing requires resources that are usually not available in limited capabilities terminals. The proposed, server-based approach has the overhead of having the terminal capability information conveyed to the server over the air, which is nevertheless not very high, since, as shown previously in this paper, the parts of the terminal profile that are not subject to change over time (e.g., hardware characteristics of a specific terminal device) are replaced by small-sized network addresses (e.g., URL) from where the corresponding information can be retrieved. Moreover, since user session state information is maintained by the UIMM for the entire

[1] The schema used is based on the WAP User Agent Profile (UAProf) specification.

[2] It is worth noting that server-side in our case refers to the service provision platform and not the stationary part of the application, located at the enterprise server of the VASP.

session lifetime, typically terminal capabilities are sent only once per session over the wireless interface.

B. *Implementation of adaptability features in MOBIVAS*

Overview

Figure 3 depicts the incorporation of the adaptation function inside the MOBIVAS platform. The adaptation module is part of the UIMM. Logic that resides in the rest of the UIMM is responsible for gathering information useful for adaptation, including:

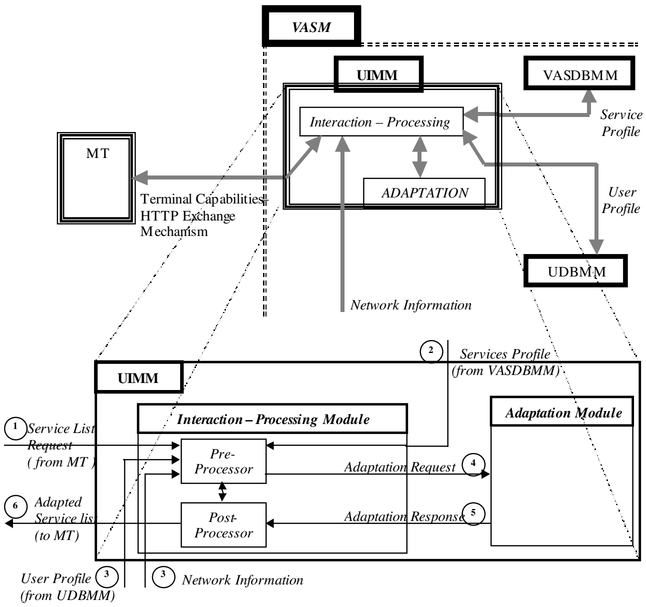

Figure 3: Overview of the adaptation function integration into the MOBIVAS architecture.

- Terminal capabilities and user location. This information is included in HTTP requests sent to the VASM by the EUT, according to the CC/PP Exchange Protocol (interaction 1 in Figure 4).
- Network characteristics that can be retrieved (3) through network open APIs (e.g., extensions to the OSA/Parlay APIs). Further discussion of such APIs is beyond the scope of the present paper.
- User profile data (3) (e.g. preferences, language, favourite services).
- Data concerning the services (2), such as their variants (services may come in multiple versions), as well as their profiles (e.g., requirements from terminal/network, supported languages, etc.).

All the above information is converted by the pre-processor to the Java object profile representation that can be provided as input to the adaptation function. Multiple mappings have been implemented, as described previously in this document. A case of particular interest is the mapping of RDF/XML. For this mapping the pre-processor makes use of DELI and JENA APIs to parse the request from the terminal and to create an object representation of the terminal profile. Deli is an open-source library developed at HP Labs [13]. Deli undertakes the very important task of constructing the entire RDF profile data from CC/PP information (the latter mostly includes URL references instead of actual profile data). To accomplish that, Deli makes use of the Jena [14] semantic web toolkit.
The terminal profile, together with the profile of the service, the user and the network are sent to the adaptation module (4). The latter performs the appropriate matching using the rules included in every profile Java object (5). The results are sent back to the UIMM, which returns to the terminal an adapted service listing encapsulated in an HTTP response (6).

A case of intelligent adaptation in the proposed platform

In this section we demonstrate a case of intelligent adaptation in the context of the operation of the proposed service provision framework. This is illustrated in Figure 4[3], where a sequence diagram is presented, including all the interactions between the user terminal and the service provision platform, required for the procedure of service discovery. The latter is customized according to the preferences of the user (stored in the user profile), the capabilities of the terminal currently employed for service access as well as the characteristics of the underlying network.

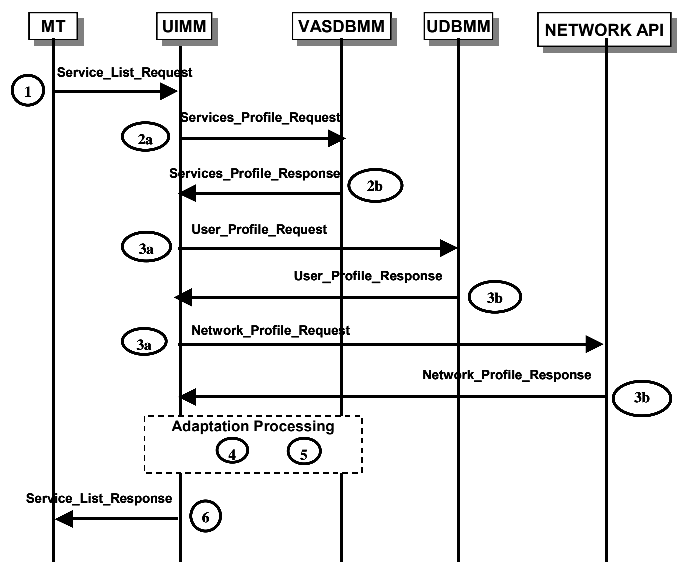

Figure 4: Interaction sequence for adaptable service discovery.

The aforementioned functions are performed through the steps described in the following list. We assume that user login with the platform has already been successfully completed, including the appropriate authentication mechanisms.

1. The user issues a request for a service listing, with criteria like service category and keywords. Terminal capabilities and possibly also network characteristics

[3] The circled numbers in Figure 4 refer to the corresponding interfaces in Figure 3.

(e.g., wireless link capacity) are sent to the UIMM as parameters of the request. These parameters are included in a user session state data structure that is maintained and constantly updated by the UIMM during the entire session of the user with the platform (an end-user session begins with the login and terminates either with an explicit logoff or after a predefined time interval of inactivity).

2. The UIMM retrieves from the service database a list of the profiles of all applications that match the user query. The profile of each application contains, among other information, any requirements/limitations that the application has related to the terminal (e.g., JVM required) and network (minimum link bandwidth), on which it is executed as well as the preferences (e.g., languages supported by the user interface) of the end-user who consumes it.
3. The UIMM collects data that pertains to the user and the underlying network and that is necessary for the adaptation function. User preferences are retrieved from the user profile database (UDBMM), while network properties can be obtained from APIs that provide open third-party access to network information and functionality. The above data is also cached in the user session state of the UIMM, so that if it is subsequently required, further remote retrieval queries are not repeated.
4. The adaptation function performs the required matching, after it is fed with the necessary input parameters, which include the service listing, as retrieved from the database (before customization), as well as terminal, user and network information.
5. The customized service listing is returned to the terminal and presented to the user, who can afterwards select the application he/she wishes to download and execute.

IV. CONCLUSIONS

The introduction of 3G mobile communication systems has been heralded as a major shift of telecommunication service provision away from the paradigm of 2G systems that, despite their admirable reliability and high performance, were also characterized by their rigidity and lack of flexibility. The new era is expected to offer end-users personalized, any-terminal and any-network access to a multitude of applications that will be developed and delivered by many co-operating business entities. In this context, the need for intelligent mediators in the form of distributed service provision and management frameworks has been clearly identified. The adaptability of these frameworks and the services they provide to rapidly changing environments, emerges as a major requirement for ubiquitous, next generation mobile communications. In the present paper we demonstrated how a distributed 3G service provision platform can exploit a generic reusable adaptation function for achieving adaptability to constantly changing user-, terminal- and network-related parameters. The functionality of the platform, including the above-mentioned adaptability features, has been prototypically implemented and tested in the context of a distributed software platform for 3G service provision and management.

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