Context Sensitive User Profiling for Customised Service Provision in Mobile Environments

Spyros Panagiotakis, Maria Koutsopoulou, Athanassia Alonistioti

National and Kapodistrian University of Athens, Department of Informatics and Telecommunications, Communication Networks Laboratory, 157 84 Athens, Greece
emails: {spanag, mkoutsop, nancy}@di.uoa.gr

Abstract—Present paper focuses on context awareness in service provisioning and proposes a framework that enables efficient management of contextual profiles. Furthermore, a more flexible and innovative model for user profiling is introduced. The innovation is based on the enrichment of common user profiling architectures to include location and other contextual attributes, so that enhanced adaptability and personalization can be achieved. For each context instance an associated User Profile instance is created and hence, service provisioning is adapted to the User Profile instance that better apply to the current context. The generic model, the structure and the content of that Context-sensitive User Profile, along with some related implementation issues, are discussed.

Index Terms—user profile, context, customisation, user preferences, Context Zones

I. INTRODUCTION

In the context of future mobile communications the users will be able to access an abundance of services typically developed by many co-operating entities. Moreover, the diversity of service access environments and the co-existence of different technologies leads to the heterogeneity of the networks and systems that support end-user application provision. This creates the requirement for applications to be optimally delivered and executed over a large diversity of infrastructures and configurations, as well as for dynamic adaptability of services to changing conditions and contexts.

As context we define the combination of information relevant to the nearest environment of a user, such as the user location, the serving network, his terminal device, etc. Since it would not be feasible to develop separate versions for different execution contexts; applications should be to a large extent agnostic of the environment they run on. Intelligent mechanisms should exist for identifying the context and the particular high-level requirements of an application and mapping them to appropriate reconfiguration operations on the underlying hardware and software infrastructure [1].

The contextual information is encoded in various related profiles such as, the user preferences profile and the terminal, ambient, network, and service profiles. The combination of all these profiles constitutes the User Profile [2]. Since profiling information is exchanged among different administrative boundaries, to assure interoperability the XML [3] and the other XML-based languages (e.g., WSDL [4], SMIL [5], OWL [6]) are the best candidates for describing profiles. Moreover, profiles should be laconic so that they are transmitted efficiently. In situated-aware architectures user profiles must be dynamically composed since their constituting segments may be distributed. Contextual profiles influence greatly a service’s deployment and execution, since context-aware services should adapt to context and related updates. Profiling information included in the User Profile can be classified as summarised below.

♦ The Terminal Profile

According to the User Agent Profile (UAProf) specification [7], it includes device attributes specific to i) the hardware platform (e.g., CPU, screen size), ii) the software platform (e.g., java platform and virtual machine version, operating system name, vendor and version), iii) the network characteristics (e.g., current bearer service, supported bearers), iv) the browser user agent (e.g., support for javascript, tables, frames).

♦ The Network Profile

It can include i) identification and general description information for the surrounding networks, like type (e.g., GSM/GPRS, UMTS, WLAN), physical location and network operator data, ii) variations in the QoS provided by the network infrastructure (e.g., the available bandwidth) iii) technical characteristics, like type of bearer, supported bandwidths, topological and coverage information, iv) characteristics of hybrid business/technical nature, such as support of open interfaces (e.g., Parlay/OSA [8][9], JAIN [10]) that enable access to selected network functionality.

♦ The Ambient Profile

It includes information like temperature, presence of other people, whether the user is outdoors/indoors and/or in an urban/suburban/rural area. It also includes date and time information, which has particular significance for certain types of applications and may affect the service functionality as well as management tasks (e.g., billing).

♦ The Service Profile

It is a web document that describes the different multimedia content elements and objects that each service consists of. In case that a multimedia element within a service document is
offered in multiple content alternatives, the full collection of those alternatives is specified inside the document. For example, if an image inside a web document is offered in three different versions according to the screen size of the targeted device, a listing with those three alternatives is given. It can also include all the required information for publishing the service and supporting its provisioning to the end users. For example, it can include all the necessary service identification information, as well as data needed for discovering, accessing and managing the service. XML, WSDL and SMIL have been widely used for publishing such documents.

- **The Charging Profile**

The charging profile collects charging, pricing and billing specific user information. Substantially, it encodes the user willing to pay additional charges in order to ensure a better quality of the provided services. It can include: i) the user subscription information (e.g., user identities, subscription status), ii) the subscribed charging characteristics, iii) the subscribed charging services (e.g., the location-based charging service), iv) the user charging, pricing, and billing preferences.

- **The User Preferences Profile**

The User Preferences profile encodes the user preferences, which express desirable service provision features that are particular to an individual user. User preferences can be categorised into service-independent, which apply to all services that are accessed by the user and service-specific, which pertain to a particular application. The user preferences may include a broad range of attributes related to i) the perceived QoS requirements, like the desired audio/video quality for streaming applications, ii) the languages that the user prefers, iii) the content and media presentation characteristics (e.g., text vs. audio vs. video), iv) font sizes, v) tariffing/billing, vi) privacy and security, vii) favorite geographical zones, viii) user identity, including name, gender, profession, ix) user presence information, x) user history and calendar, etc..

The challenge with mobile, distributed computing is that exploits the user’s dynamic environment with a new category of applications that are aware of the context in which they run. Context-aware services takes into account the current context of users and adapt their behavior to the respective users’ needs including personal preferences and environment’s capabilities [11]. In particular, they present information and services to a user, and automatically execute services and commands, sensing context and its changes. Changes of the contextual environment, are modeled as events, and are communicated to applications for real-time service re-adaptation. For example, the effectiveness of a service-to-terminal/network adaptation depends on the dynamic creation of a generic service presentation description. Therefore, a service should provide multiple different views to users, modifying and transcoding the user interface multimedia components for appropriate presentation based on the user’s terminal and the network capabilities. On the other hand, location sensitive applications retrieve location and presence information and associated events to offer users truly customized and localized communication services through the mobile phone or other mobile devices. In particular, the issue of adapting service provision and providing personalised services based on user preferences is what 3GPP introduced in Virtual Home Environment (VHE) [13]. Primary aim of VHE is to consistently present users the same personalised features, User Interface customisation and services in whatever network and whatever terminal (within the capabilities of the terminal and the network), wherever the user may be located. VHE is enabled by user profiles since they encode parameters that are essential to the user, such as the users’ communication preferences and service presentation on the terminal.

To enable third parties to develop context-aware services, various efforts have been undertaken by standardization work groups and fora towards the introduction of open, network-independent interfaces enabling context retrieval [8][9][10]. These interfaces provide applications with transparent access to network functionality (e.g., call control, location information, messaging, profiles retrieval), thus offering third party application developers the opportunity to create advanced, network-independent and context-full services with standard software engineering tools and general-purpose programming languages.

Present paper focuses on context awareness in service provisioning and proposes a framework that enables efficient management of contextual profiles. Furthermore, a more flexible and innovative model for user profiling that enriches the common user profiling architectures to include location and other contextual attributes is introduced. In more specific, section I introduces to context awareness and profiling and section II presents the 3GPP Generic User Profile (GUP). Sections III and IV detail in the proposed framework for user profile management and present the User Profile Manager (UPM), its interfaces and the context-sensitive model it adopts for user profiling. Section V illustrates some example interactions and finally, section VI concludes the paper.

**II. THE 3GPP GENERIC USER PROFILE (GUP)**

3GPP has specified the service requirements for the Generic User Profile in [14] and the GUP architecture in [2]. The objective is to provide a conceptual description that enables harmonized usage of shared user-related information distributed in different entities (i.e., the User Equipment (UE), the home network (Home PLMN), or the third party Application/Service Providers (ASPs)). 3GPP introduced GUP as a solution to the increasing amount of user-related data. GUP allows intra-network and inter-network usage, which results in its access by different applications in a standardized way. Intra-network usage concerns the exchange of data between applications within the mobile operator’s network, while inter-network usage deals with the communication of profiling information between the mobile operator’s network and the ASPs. Each entity can hold a copy of a component that can be originally located in another entity.

Figure 1 shows the GUP reference architecture. GUP Data Repositories are located in various nodes across networks and are distributed from UE and Home PLMN to 3rd party ASPs. Each GUP Data Repository stores the primary master copy of
one or several Profile Components. The Repository Access Function (RAF) provides standardized access to the GUP Data Repository and hides the implementation details of the data repositories from the GUP infrastructure. The Rg and Rp are standardized interfaces providing harmonized access to GUP Server and GUP Data Repositories respectively.

![Figure 1: GUP reference architecture](image)

The GUP Server is a functional entity providing a single point of access to the GUP data of a particular subscriber: it authenticates and authorizes profile requests from applications; it identifies the Profile Components relevant to the request and localizes them at the various GUP Data Repositories. The GUP Server can support two operation modes: acting either as a proxy or as a redirect server. The GUP reference architecture does not specify or limit the physical location of the GUP Server.

III. THE USER PROFILE MANAGER (UPM)

The architecture we propose for User Profiles management enhances the 3GPP GUP architecture with the concepts of Home Zones and Context Zones. It adopts the distribution and information model of the GUP incorporating in its logic provision for enhanced context sensitivity. The enhanced GUP server proposed here is called User Profile Manager (UPM) and constitutes structural part of an innovative architecture providing context aware service provision [15]. The UPM is responsible for managing the User Profiling information distributed and stored in several User Profile Data Repositories (UPDR) across the network and disseminating the user-specific information to the requesting applications and services. It mediates between application/services and UPDRs, hiding from applications the underlying infrastructure and facilitating the interaction with the profiling sources. The applications that may request access to the User Profile data can vary from applications in the ME or the Home PLMN to third party Application/Service Providers (ASPs). Figure 2 illustrates the environment of the UPM.

To hide the implementation details of the profiling architecture from applications and services and assure service transparency, the interaction between internal modules or services of the profiling architecture, as well as authorised third party applications, and the UPM is implemented through an open Application Programming Interface (API) [8][9] provided by the User Profile Manager to authorized entities. Through this API, the UPM enables authorised applications to insert/delete or modify user profiling data in UPDRs, retrieve user profiling data upon request and receive profiling dependent event notifications, each time a registered event occurs.

Each UPDR stores the primary master copy of one or several profile components. Possible candidates for UPDR are the ME, the HSS/HLR, and various application and management servers in Home PLMN or 3rd party Application/Service Providers. Synchronization between profiling data in UPDRs and UPM is required. Access to UPDRs is accomplished through the associated User Profile Data Repositories Access Functions (UPDRAF). Each UPDRAF can be viewed as the front end to the underlying repository that realizes the harmonized access interface to the associated UPDR. It hides the implementation details of the UPDR from the rest UPM infrastructure. The UPDRAF performs protocol and data transformation where needed.

![Figure 2: The UPM environment](image)

The protocol between the UPDRAF and the UPDR is implementation dependent and not standardized. The UPDRAF can take also part in the authorization of access to UPDR. Through UPDRAFs the UPM can insert/delete/modify the underlying profiling data, read them, and receive synchronization notifications whenever some change on profiling data occurs.

The UPM interacts, also, with the Location and Presence Manager and the context sensors of the proposed framework to retrieve the location, presence and other contextual information needed to compute Context Zones and provide context sensitive User Profiling. The concepts of Home Zones, Context Zones and context sensitive User Profiling are discussed in the section that follows.

IV. CONTEXT SENSITIVE USER PROFILING

A key means to offer to subscribers truly context aware and customised service provisioning is the User Profile. The User Profile can also be context aware. Context awareness of the User Profile is based on the concept of Home Zones. Each Home Zone comprises a geographical area into which a user wishes to experience personalised and customised service provisioning (e.g., the Home, the office, the resort, etc.) [12].
Ideally a Home Zone should be as wide as the user wishes, so that truly customisation can be achieved. For example, a user may wish to experience differentiate service provision in each room of his house or office. In such a case each room of the house or office should be considered as distinct Home Zone for that user. However, limitations in the location measurement accuracy induced currently by various position estimation technologies, forbid location-based services to distinguish among very narrow Home Zones. Due to this fact, certain distance among the defined Home Zones of a user, depending on the accuracy of the location measurements, should exist, so that the position detection system can follow the moves of subscribers from one Home Zone to another.

Taking into account that within a single Home Zone a subscriber can switch from one type of mobile equipment to another (e.g., from a UMTS mobile handset to a PDA or laptop) and access different radio environments (e.g., from GPRS or UMTS networks to WLAN/WiFi or Bluetooth), further classification of user profiles within a Home Zone can be achieved. The current Home Zone, current terminal equipment and current serving Radio Access Technology (RAT) of a subscriber are considered to be the three key context attributes that uniquely identify the current context of a user. Each triplet of type {current Home Zone, current terminal device, current RAT} defines a user specific Context Zone that can be used for identifying the user status and customising service provisioning accordingly. As the user moves to a different location (Home Zone) or switches between mobile devices or access networks, a different Context Zone assigns to him. Since within the geographical area that defines a Home Zone a subscriber can move from one terminal device to another or change the RAT he is attached, obviously the concept of Home Zone is considered to be broader than the Context Zone one. Hence, within a Home Zone multiple Context Zones can coexist, which differ to the terminal device used or the serving RAT. As the user changes terminal device, while remains attached to the same RAT, a different Context Zone assigns to him. The same occurs when the user transits to a different RAT, while using the same mobile equipment.

A user may have defined multiple preferences profiles for a single Home Zone. Differentiating the user preferences according to the three basic axis: the location of the user (e.g., Home, office, resort), the terminal device used, and the serving radio access network and maintaining different User Profiles instances for each Context Zone instance (that is {location, terminal, network}-dependent Profiles, or equally Context Zone-dependent Profiles), better personalization and customisation can be achieved during service provisioning [12]. Profiles can be also further classified and associated with specific presence attributes of subscribers such as the time or period of the day (e.g., at lunch time) or a specific ambient attribute (e.g., temperature, velocity, height, etc.), or even a certain mood of subscriber (e.g., happiness or sadness), broadening thus the concepts of Context Zones and Context Zone-dependent profiles accordingly. The presence information required can be retrieved by either specific presence sensors or the associated Presence Server [16] of the underlying network infrastructure. A presence-aware Context Zone should include the presence attribute additional to the three aforementioned ones, so that each quaternary of type: {current Home Zone, current terminal device, current RAT, current presence status} is defined as Context Zone.

Whenever a user enters a Context Zone where multiple profiles have been defined, the system prompts the user to indicate which profile to activate. Each User Profile instance can be considered as a user preferences customisation set that includes the user Interface preferences, the browser appearance, the preferred memory usage, etc. and the application/service subscription Profiles, with the preferred settings for the subscribed applications/services. The services provisioned to a user depend on the current Context Zone and hence, the associated active profile.

Figure 3 illustrates the concept of context sensitive User Profiling. The rounded rectangles in blue represent the triplet of the current context zone of the subscriber (Home Zone 3, Mobile Equipment 2, Radio Access 2) and the associated active user preferences customisation set (User Preferences customisation set 2). From that point of view each context sensitive User Profile can be considered as a tree with the subscriber’s identity (e.g., IMSI, e-mail or SIP identity) at the root, the three Context Zone attributes as nodes and the user preferences customisation sets as leaves. Storing locally such a tree-like User Profile for each subscriber, finding his current Context Zone and crossing that tree from top to down, the UPM can retrieve the most up-to-date user profiling data each.
time it is required. For example, as a subscriber moves from one Home Zone to another, the change of its current Context Zone leads also to a different user preferences customisation set. Such a change of the active User Profile instance triggers the UPM to generate and propagate an associated alert event, so that the components registered for receiving such notifications are properly informed.

V. EXAMPLE INTERACTIONS

In this section an example interaction of the UPM that demonstrates its enhanced context-sensitive nature is presented. In more specific, Figure 4 illustrates the interactions between various components of the profiling architecture when an application accesses the UPM to retrieve the current user preferences of a subscriber.

Interactions include:
1. An authorised application requests some User Profile components of a specific subscriber. The application does not include the Context Zone parameter in the request.
2. The UPM authenticates the application and checks its authorization to receive the requested data.
3. Since Context Zone is not provided, the UPM presumes that the profile data requested are those associated with the current Context Zone of the targeting user. Hence, the UPM contacts the Location Manager of the architecture to retrieve the current Home Zone of the user.
4. The UPM retrieves the type of the Mobile Equipment from the appropriate context sensor.
5. The UPM retrieves the type of the RAT serving the user from the appropriate context sensor.
6. The UPM identifies the current Context Zone of the user and crosses the Context Zone-dependent structure of the User Profile to identify the location of the requested profiling components.
7. The UPM accesses the API of the identified UPDR to request the specified data, including Context Zone and data reference in the request.
8. The UPDRAF retrieves the requested data and responds to the UPM.
9. The UPM responds to the application with the requested profiling data. Since the data requested by the application may be stored in several UPDRs, it is likely the UPM to have to interact with all involved repositories to request the data. In that case, the UPM should properly combine the returned data before responding to the application.

VI. CONCLUSION

Present paper focused on context awareness in service provisioning and proposed a framework that enables efficient management of contextual profiles. Furthermore, a more flexible and innovative model for user profiling was introduced. The generic model, the structure and the content of that Context-sensitive User Profile, along with some implementation issues, were also discussed.

ACKNOWLEDGMENT

Work presented in this paper has been performed in the framework of the project LIASION (IST-511766, web site http://liaison.newapplication.it/), which is partly funded by the European Community. The Authors would like to acknowledge the contributions of their colleagues. The content of this paper expresses solely the opinion of the authors.

REFERENCES

[9] 3rd Generation Partnership Project (3GPP) TS 29.198: “Open Service Access (OSA); Application Programming Interface (API); Part 1-12”, version 5.0.0, 2002-06.