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# User Profile Identification in Future Mobile Telecommunications Systems

A UMTS user profile denotes in which domains and under which conditions a specific service is available to a user. As the research work on UMTS is still in progress, new requirements for the user profile and its management are likely to be set.

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**T**he so-called second generation mobile telecommunications networks have already been introduced in several European countries. Global System for Mobile Communications (GSM) [1], Digital European Cordless Telecommunications (DECT) and Digital Cellular System (DCS) 1800 [2] enable a pan-European mobile service providing public network access, global coverage and inter-operator roaming.

Nevertheless, researchers are working for the specification of the Universal Mobile Telecommunications System (UMTS), which will be a third-generation system for mobile telecommunications. The UMTS [3] will provide a wide range of telecommunication services to a very large number of Mobile Users (MUs). Services highly comparable to those offered by fixed networks will be available via various Mobile Terminals (MTs). The UMTS will be a multi-operator system and will consist of a range of sub-networks, providing users with access to different environments, according to the entitlement of the subscriptions with which they are associated. As a user moves between sub-networks during a call, handover functions from one environment to another may take place [4]. Each of these environments has different technical and economic constraints and will require different solutions. In addition, the UMTS radio access point must be able to connect to or cooperate with fixed networks and be capable of operating as a stand-alone network for operation in non-B-ISDN environments, although its integration with B-ISDN is an objective for UMTS. Other critical aspects of UMTS are the techniques used to store and manipulate the large amount of information involved, and the intelligence needed in order to control calls and cope with user and terminal mobility.

In order to make use of a service, a UMTS user will be able to register on an MT for this particular service [5]. Since user registrations will be performed on a per service basis, a user may be registered on more than one MT for different services. Moreover, some types of UMTS terminals will support multiple user registrations,<sup>1</sup> but

only one of the registered users will be allowed to make use of the terminal at a time. The UMTS will also support Universal Personal Telecommunications (UPT), which means that UPT users will be able to register onto (one or more) UMTS terminals in order to make and accept calls.

The ability of a user to roam into the various UMTS environments and make use of the resources and services via different terminals will be checked every time this user enters an environment and/or uses resources and services. This means that an information entity must exist for every user so as to be retrieved every time such a checking is required. This user-related information entity is called the UMTS User Profile (UUP). The UUP is stored in the UMTS Distributed Data Base (UMTS DDB) and can be accessed from every point in the network.<sup>2</sup> Management operations on a particular user profile can be performed only by authorized UMTS operators and possibly by the subscriber concerned or by a user authorized by this subscriber. A UUP includes user authentication information, service access information, access domain information, user charging and accounting information, etc.

This article discusses the UMTS user profile identification issues. The authors introduce first the concept of user profile and the UMTS entities related to it. Then, the user profile is described and its management requirements are discussed followed by the description of two scenarios proposed for the user profile identification. Finally, the authors give a comparison of the two scenarios and their concluding remarks. The study of the impact of the proposed scenarios upon UMTS operators, subscribers, users, and mobile terminals is beyond the authors' intent for the scope of this article.

## Entities Related to the UMTS User Profile

**B**efore introducing the UMTS User Profile, we attempt to identify a number of UMTS entities related to this concept.

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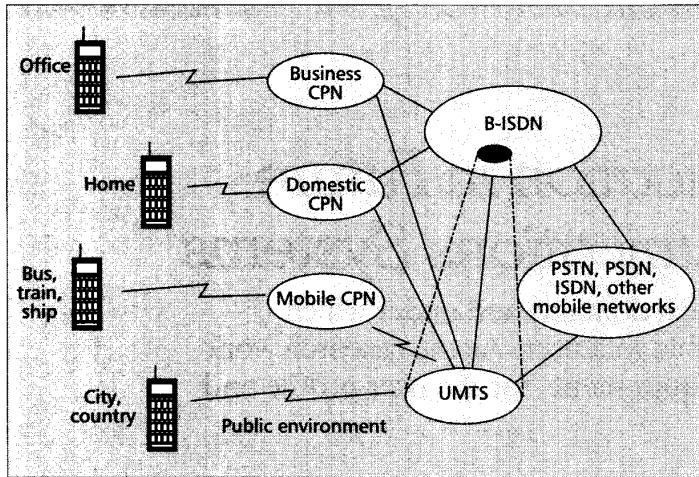
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<sup>1</sup> Whether or not a UMTS terminal supports multiple user registrations will depend on the terminal's infrastructure, the network capabilities and the terminal-network interface.

<sup>2</sup> Names, addresses, and identifiers are unique values, but their most important attribute is that they provide "unambiguous" designation of the information object.



■ Figure 1. The UMTS environment.

### UMTS Subscriber

A UMTS subscriber is a person, or other entity, which has a contractual relationship with a UMTS operator for the provision of a certain range of services with specified features (e.g., QoS) in specified domains on behalf of one or more users. Thus, a subscriber determines the profiles of the users that are associated with its subscription(s). The subscriber is also responsible for paying the network operator for charges assigned to the corresponding users. A UMTS subscription is identified via a unique International Mobile Subscription Identifier (IMSI).

### UMTS User

A UMTS user is a person, or another entity, authorized by a subscriber to use (a part of) the services subscribed to. A user can be associated with more than one UMTS subscription, e.g., with his/her employer's subscription during working hours only and with his/her family/personal subscription all the time. The term UMTS user corresponds to a person or an unattended device. For instance, a user can be represented by an identity device.<sup>3</sup> A UMTS user is uniquely identified via an International Mobile User Identity (IMUI) which is used for out of call procedures (e.g., location updating, user registration). For calling purposes, one or more International Mobile User Numbers (IMUN) are explicitly assigned to the user.<sup>4</sup> Both the IMUI and the IMUN could be viewed as pointers to the DDB.

### Public UMTS Operators

A public UMTS operator<sup>5</sup> is an authority that provides the UMTS network capabilities so as to support a set of UMTS services. Every UMTS network is identified via a unique UMTS Operator Identifier.

We identify two roles for the public UMTS operators as follows.

**Home UMTS Operator** — is the operator with which a subscriber has a subscription for UMTS services. It operates the UMTS network in the subscriber's home area,<sup>6</sup> provides user profile-related information to other UMTS operators, and col-

lects charging information from other operators for its roaming users [6]. A home UMTS operator is "by default" authorized to have management access on the profiles of its users.

**Visited UMTS Operator** — is any operator except the Home UMTS operator in the domain in which the users are allowed to roam and use UMTS services. A user roaming in a visited UMTS network can make use of the available services, if this is permitted by his/her profile. Charging information concerning the use of the resources in the visited operator's domain is transferred to the user's home UMTS operator.

### UMTS Administrative Domains

A UMTS administrative domain is a system area under the supervision of an administrative authority, such as a UMTS operator. UMTS will operate in both public and private domains/environments. A private UMTS domain is also called Customer Premises Network (CPN). Depending on its size and complexity, a CPN may offer none, some or all of the following: bearer control, call handling and mobility management. The following types of UMTS administrative domains are distinguished:

- Public UMTS.
- Business CPN (BCPN).
- Domestic CPN (DCPN).
- Mobile CPN (MCPN).

Figure 1 depicts the matured UMTS environment integrated to B-ISDN.

### UMTS Services

For the time being, it is expected that the following types of services will be available to UMTS subscribers.

**Teleservices** — telephony, voice messaging, telefax, short messaging, video telephony, short message cell broadcast, reservation broadcasting, etc.

**Supplementary services** — calling line identification presentation/restriction, connected line identification presentation/restriction, malicious call identification, call forwarding, call deflection, call waiting, call hold, closed user group, advice of charge, reverse charging, etc.

**Value-added services** — e.g., a map service that provides the user with a map of the desired area on request.

**Management services** — e.g., modification of a UMTS user profile by the corresponding subscriber or by an authorized user.

### Description of the UMTS User Profile

A UUP is an information entity whose main purpose is to identify both the services that can be used by a specific UMTS user and the UMTS domains in which this user can have access to each one of these services. A UUP can be associated with one or more subscriptions. A particular subscription  $j$  is characterized by its subscription profile  $SP_j$ , which can be considered

<sup>3</sup> Such an identity device may be a UMTS user smart card similar to the GSM Subscriber Identity Module (SIM).

<sup>4</sup> Whether it will be possible to assign more than one IMUNs to a user, it will depend on the user profile management strategy that will be followed. This situation will be clarified below.

<sup>5</sup> A UMTS operator may serve as a UMTS service provider as well. In this paper, we assume that a UMTS operator is also a service provider. This assumption does not contradict the existence of other independent UMTS service providers in a UMTS operator's domain.

<sup>6</sup> The home area of a subscriber is the area within which the subscriber's premises lay, e.g. a company premises for business subscriptions, residential premises for family/personal subscriptions, etc.

as the product set of the sets  $D_j$  and  $S_j$ , where  $D_j$  is the set of the accessible UMTS domains according to the entitlement of subscription  $j$  and  $S_j$  is the set of services that can be used within  $D_j$ , when they are available. That is:

$$SP_j = D_j \times S_j$$

Since  $D_j \subseteq D$  and  $S_j \subseteq S$ , where  $D$  is the whole set of UMTS domains and  $S$  is the whole set of UMTS services, it follows that

$$SP_j \subseteq S \times D$$

Also

$$UUP_{ij} \subseteq SP_j$$

where  $UUP_{ij}$  is the part of the user profile of the  $i$ -th user associated with the profile  $SP_j$  of the  $j$ -th subscription.

For the clarification of these relationships, Fig. 2 provides an example of service/domain access combination. In this example the set of accessible domains  $D_j$  of the selected subscription is:

$$D_j = \{ D_1, D_2, D_m \}$$

and the set of services that can be used within  $D_j$  is:

$$S_j = \{ S_1, S_2, S_3 \}$$

The profile of the subscription shown in Fig. 2 is:

$$SP_j = \{ (D_1, S_1), (D_1, S_2), (D_1, S_3), (D_2, S_1), (D_2, S_2), (D_2, S_3), (D_m, S_1), (D_m, S_2) \}$$

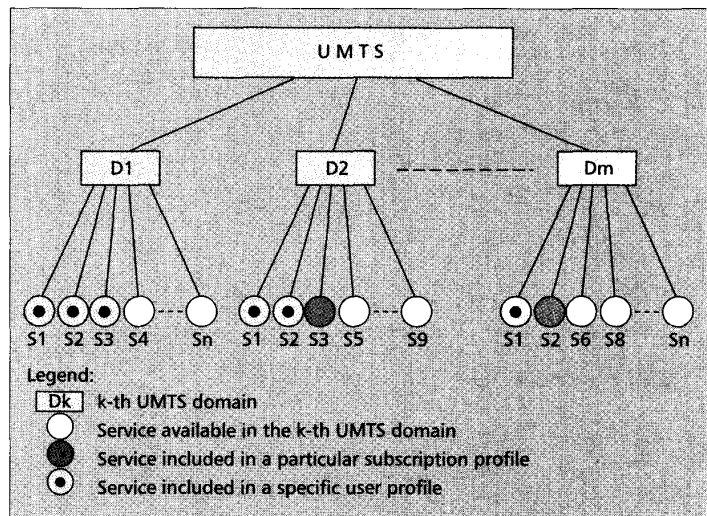
and the profile of the  $i$ -th user associated with  $j$ -th subscription as presented in Fig. 2 is:

$$UUP_{ij} = \{ (D_1, S_1), (D_1, S_2), (D_1, S_3), (D_2, S_1), (D_2, S_2), (D_m, S_1) \}$$

Apart from service/domain access information, a user profile must also provide the network with user and subscription identification information, charging related information, security related information, etc. To accomplish this, the UMTS user profile must contain the following:

- User identification information (e.g., the IMUN of the user).
- Subscription identification information (e.g., the IMSI).
- Service access information (i.e., a list of services the user is permitted to use).
- Access domain information (i.e., a list that defines the UMTS access domains for each one of the services to which the user is subscribed as well as the access priority among overlapping domains).
- Charging and accounting information (e.g., charging options such as reverse charging, split charging between the end users, or charging of a third party).
- Special features (e.g., currency and language for advice of charge).
- User profile utilization related information (e.g., a user profile may hold only under specific conditions such as time and date).
- Security-related information.

The information contained in the user profile appears as a static one to the service control and



■ **Figure 2.** An example of service-domain access combination for a particular subscription of a specific UMTS user.

mobility control layers of UMTS. A user profile is checked in real time from the UMTS DDB whenever this is required by the various call control procedures such as acceptance of incoming calls and initiation of outgoing calls, and mobility control procedures such as change of environment and user registration on a mobile terminal. Also, a part of a user profile can be replicated and transferred to the visited UMTS so as to accelerate the different control procedures, when a user is roaming outside his home UMTS. The modification of a user profile is a management procedure and can be performed only by an authorized UMTS operator, if this is requested by the subscriber. It is likely that a subscriber or a user authorized by the corresponding subscriber will be able to perform a limited set of modifications onto a user profile without the involvement of a UMTS operator.

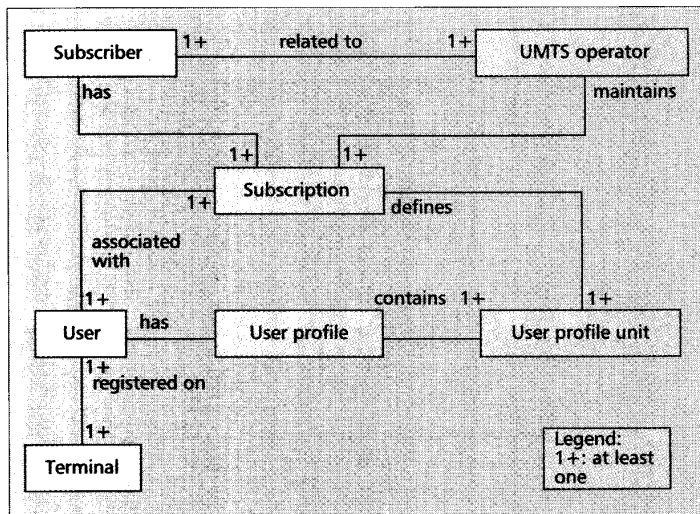
Speaking in terms of object orientation [7], the aforementioned UUP information items will consist of the attributes of a managed object class representing the user profile and each particular user profile will be an instance of this class. Any changes of the values of (at least one of) these attributes will result in a new user profile, thus in a new instance of this managed object class.

## UMTS User Profile Management Requirements

It is expected that the management of UUP will meet a number of requirements set by the UMTS subscribers, users, and network operators.

### Requirements from the Subscriber's Point of View

- It shall be possible for a subscriber to request from an authorized UMTS operator the creation, deletion, or modification of a user profile associated with its subscription.
- Only the subscriber is "by default" authorized to request creation, deletion or modification of a user profile associated with its subscription.
- It shall be possible for a subscriber to authorize



■ Figure 3. Entity-relationship diagram for the "user profile unit" scenario.

users or other subscribers to request creation, deletion, or modification of a user profile associated with a subscription of its own.

- A subscriber may be able to perform a specific set of operations on a user profile without the involvement of a UMTS operator.

#### Requirements from the User's Point of View

- It shall be possible for the user to be associated with more than one subscriptions and have a separate profile for each of them.
- It shall be possible for a user to select one of the subscriptions with which is associated at a time. This selection will result into a specific part of the user's profile.
- A user may be authorized by the corresponding subscriber to request or perform a specific set of operations on its profile.

#### Requirements from the UMTS Operator's Point of View

- A UMTS operator must be able to create, delete, or modify a user profile, if this is requested by the corresponding subscriber.
- The home UMTS operator of a subscriber will be the only UMTS operator which is "by default" authorized to create, delete or modify a user profile.
- It should be possible for UMTS operators to replicate and transfer a part of the corresponding UUP to a visited UMTS operator's domain in case the user roams in that domain.
- Consistency between the original user profile and any copies possibly existing in other domains of UMTS must be guaranteed by the database system.

### Two Possible User Profile Identification Scenarios

<sup>7</sup> A user may select from a subscription list appearing on the display of its mobile terminal.

In this section, we propose two generic scenarios concerning the management of user profiles in UMTS. Especially, we are interested in describing the relations among user profiles and the cor-

responding UMTS entities. The scenarios that will be discussed conform to the basic UMTS concept of distinguishing between users and subscribers, and they meet the requirements which have been introduced.

#### The "User Profile Unit" Scenario

This scenario introduces the concept of the User Profile Unit (UPU). A UPU serves as the profile of a user acting under a specific subscription. Thus, a particular UPU is associated with only one subscription. Provided that a user is always associated with at least one subscription, the overall profile of a user will contain at least one UPU.

Figure 3 presents the entity-relationship diagram for the "user profile unit" scenario and identifies the relationships which occur among those entities. In this figure, the User Profile entity is more or less a virtual entity representing the overall user profile as it is conceived by the user.

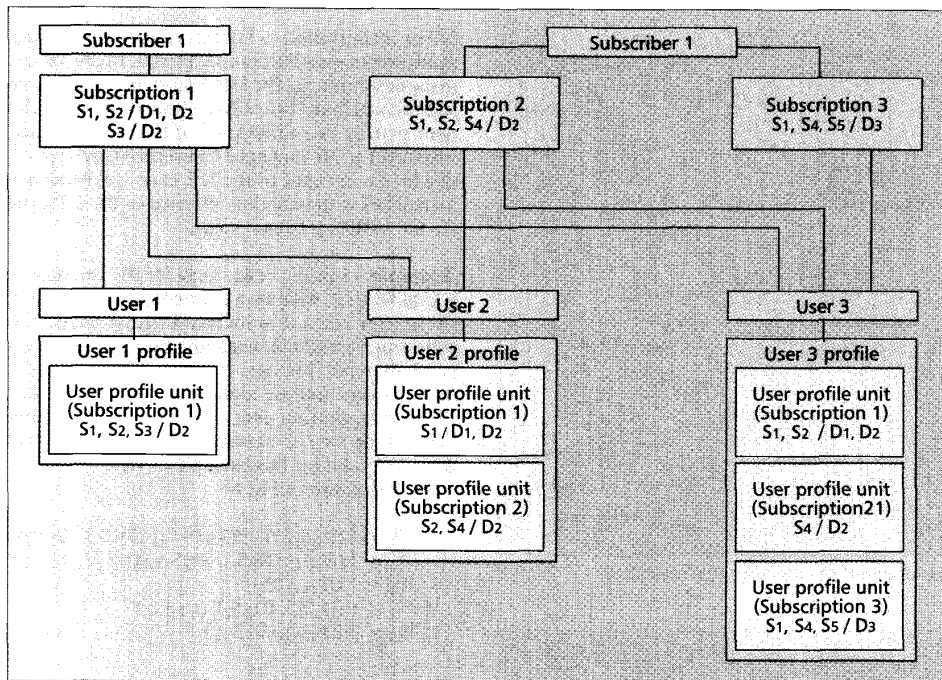
A UPU will be stored in the home UMTS of the corresponding subscriber. If a user is associated with several subscriptions with different home UMTS operators, his or her overall profile will be the union of all his or her UPU's. In this case, the overall profile will be managed by more than one UMTS network operators, each one of them having access to a different UPU.

When a UMTS user registers on a mobile terminal for a specific service, the respective network must access the appropriate profile unit. Since several profile units can belong to the same overall user profile, i.e., they are associated with the same IMUN, it is not possible for the system to retrieve the appropriate profile unit from the DDB using only the IMUN or IMUI as a pointer. The IMSI of the subscription that is used at that time is also needed for access to the DDB. This shall be provided manually<sup>7</sup> by the user during his/her registration on a mobile terminal. Therefore, for the retrieval of the proper UPU in this scenario the following relationship holds:

$$\text{IMUN} + \text{IMSI} \rightarrow \text{UPU}$$

An alternative solution, so as to avoid manual provision of IMSI, is the utilization of an appropriate mechanism that will be based upon a default rule. This rule will state under which conditions an IMSI holds. Such a condition may be based upon the time/date of the registration, e.g., an employee will be associated with his or her company subscription during the working hours of a weekday and associated with his or her personal subscription during all days. In order to avoid conflict among IMSIs with overlapping utilization time periods, an ordered preference list may be included in the default rule denoting which of the conflicting IMSIs is to be utilized. Furthermore, such a time-based rule caters for the avoidance of conflict in case the requested UMTS service/domain combination is covered by more than one UPU's of the user.

This default rule may be stored in the user identification device and also in each one of the user's profile unit (i.e., user profile utilization related information). Moreover, for the needs of a particular call, the user will be able to deviate from the default rule and choose among his or her profile units manually providing a particular IMSI for that call.



■ Figure 4. Example of the "user profile unit" scenario.

**Object orientation** — Each UPU will be an instance of a managed object class named User Profile Unit. An instance of this class will define the profile of a particular user for a specific subscription. The UUP data described previously will serve as the attributes of such an object class. The union of all the UUPs of a particular user constitutes his or her overall profile.

**Example** — An example for this scenario is depicted in Fig. 4. In this example we consider two UMTS subscribers (one of them has two subscriptions), and three UMTS users, each of them associated with these subscriptions in different ways. In this example we have made the following assumptions:

- A subscriber may have more than one subscription.
- Each one of the subscribers has subscribed to a set of services and access domains via a subscription.
- A user can be associated with more than one subscription.
- Each UPU corresponds to the total or to a part of the associated subscription profile.

According to Fig. 4, the following considerations have been made for this example:

$$\begin{aligned}
 SP_1 &= \{ (D_1, S_1), (D_1, S_2), (D_2, S_1), (D_2, S_2), (D_2, S_3) \} \\
 SP_2 &= \{ (D_2, S_1), (D_2, S_2), (D_2, S_4) \} \\
 SP_3 &= \{ (D_3, S_1), (D_3, S_4), (D_3, S_5) \} \\
 UUP_1 &= \{ UPU_{11} \} \\
 UPU_{11} &= \{ (D_2, S_1), (D_2, S_2), (D_2, S_3) \} \\
 UUP_2 &= \{ UPU_{21}, UPU_{22} \} \\
 UPU_{21} &= \{ (D_1, S_1), (D_2, S_1) \} \\
 UPU_{22} &= \{ (D_2, S_2), (D_2, S_4) \} \\
 UUP_3 &= \{ UPU_{31}, UPU_{32}, UPU_{33} \} \\
 UPU_{31} &= \{ (D_1, S_1), (D_1, S_2), (D_2, S_1), (D_2, S_2) \} \\
 UPU_{32} &= \{ (D_2, S_4) \} \\
 UPU_{33} &= \{ (D_3, S_1), (D_3, S_4), (D_3, S_5) \}
 \end{aligned}$$

where:  $SP_j, j=1,2,3$  is the profile of the  $j$ -th subscription,  $UUP_i, i=1,2,3$  is the profile of the  $i$ -th user and  $UPU_{ij}$  is the user profile unit of the  $i$ -th user associated with the  $j$ -th subscription.

#### The "User Role" Scenario

This scenario introduces the concept of the User Role (UR). A UMTS user is associated with a subscription via a user role. A user can have only one role for a particular subscription, but he or she will have as many user roles as are the subscriptions he or she is associated with. Each user role has a particular user profile which is determined by the corresponding subscriber. Moreover, a user is always associated with each of its user roles via an IMUN. Therefore, for the retrieval of the proper user profile in this scenario the following relation holds:

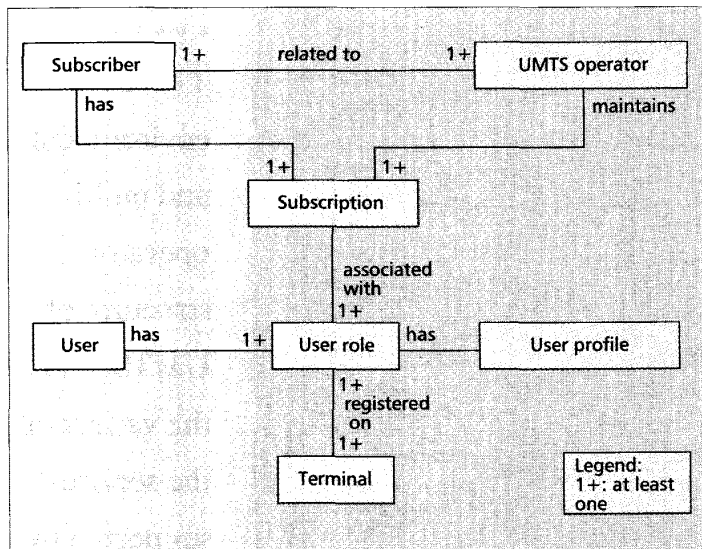
$$IMUN \leftrightarrow UR$$

The entity-relationship diagram for the "user role" scenario is depicted in Fig. 5.

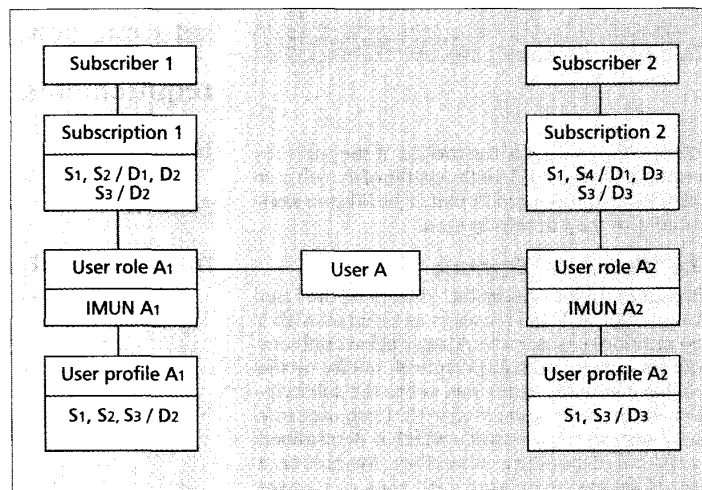
As in the previous scenario, the overall user profile UUP is a virtual entity representing the union of the user profiles determined by the roles of the user. Provided that each one of the roles of a user is associated with a unique IMUN, a UMTS user will be assigned as many IMUNs as his or her roles (i.e., the subscriptions which he or she is related to) are. Each of these user profiles will be stored in the home UMTS of the corresponding subscriber.

Every time a UMTS user inserts his identification card into a terminal, a particular user role of his or hers is registered onto that terminal and the corresponding user profile will be invoked when necessary according to the IMUN stored in the identification card.

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The multi-environment and multi-operator structure of UMTS, and the variety of the services supported by the system, set some new requirements for the user profile management.



■ Figure 5. Entity-relationship diagram for the "user role" scenario.



■ Figure 6. Example of the "user role" scenario.

| User profile unit  | User role   |
|--|---|
| <p>+</p> <ul style="list-style-type: none"> <li>All UPU's are associated with only one IMUN and a single user identification device is enough to allow a user to take full advantage of all subscriptions with which he is associated.</li> <li>There is no need for allocation of additional unique identifiers to distinguish the different profiles.</li> </ul> | <ul style="list-style-type: none"> <li>A user role and consequently the related user profile is uniquely identified by the IMUN only.</li> </ul>  |
| <p>-</p> <ul style="list-style-type: none"> <li>For the determination of a UPU either two identifiers are needed or an additional procedure must be executed based on a default rule.</li> </ul>   | <ul style="list-style-type: none"> <li>A separate IMUN will be assigned to each UMTS user role. Thus, a vast number of IMUNs and identification devices will exist.</li> <li>Only one user role can be registered on a mobile terminal which does not allow multiple user registrations.</li> </ul> |

■ Table 1. "User profile unit" vs. "user role."

**Object orientation** — For this scenario, a UP-managed object class is introduced. The UUP data defined in the description of the UMTS user profile will consist the attribute list of this class. Any particular user profile is an instance of this object class. Moreover, a UR-managed object class may be introduced. An instance of the UR class will be always associated with only one instance of the UP class via the IMUN attribute value.

**Example** — In Fig. 6 we consider the example of a UMTS user with two user roles. Each one of these user roles is associated with a particular subscription and has a specific user profile. For a particular call, the user is associated with one of its roles via a unique identification number (i.e., the corresponding user's IMUN). The assumptions made for the example of the previous scenario are valid for this example as well.

As it is shown in Fig. 6:

$$\begin{aligned}
 SP_1 &= \{ (D_1, S_1), (D_1, S_2), (D_2, S_1), (D_2, S_2), (D_2, S_3) \} \\
 SP_2 &= \{ (D_1, S_1), (D_1, S_4), (D_3, S_1), (D_3, S_3), (D_3, S_4) \} \\
 UUP_1 &= \{ UP_{11}, UP_{12} \} \\
 UP_{11} &= \{ (D_2, S_1), (D_2, S_2), (D_2, S_3) \} \\
 UP_{12} &= \{ (D_3, S_1), (D_3, S_3) \}
 \end{aligned}$$

### "User Profile Unit" vs. "User Role"

#### "User Profile Unit"

In this scenario, all the UPU's of a UMTS user are associated with only one IMUN. Thus, only one single user identification device is enough to allow a UMTS user to take full advantage of the subscriptions with which he or she is associated. On the other hand, an additional identifier, the IMSI, is always needed together with the IMUN in order to define a particular UPU. The IMSI can be provided either manually by the user or automatically by the network on the basis of a default rule.

In all cases there is no need for additional unique identifiers, IMUNs or IMSIs, to be allocated for the distinction of the different profiles of the same user.

#### "User Role"

Only the IMUN of a UMTS user is needed in order to determine which one of the user's roles holds for a particular interaction with the system. Provided that a user role is associated with only one user profile, the IMUN is enough for the identification of the user profile that will be used. However, a user will have as many IMUNs and user identification devices as his or her user roles are. This means that a considerable number of UMTS users will be assigned more than one IMUN. Moreover, in the case that a mobile terminal does not allow multiple user registrations, only one user role of a UMTS user can be registered on this terminal at a time.

Table 1 summarizes the above remarks.

### Conclusions

In this article, we have dealt with the problem of the UMTS user profile. A UMTS user profile denotes in which domains and under which con-

ditions a specific service is available to a user. The multi-environment and multi-operator structure of UMTS, and the variety of the services supported by the system, set some new requirements for the user profile management. These requirements mainly define the management access rights to user profiles for the involved UMTS entities (e.g., operators, subscribers, etc.). Two different generic scenarios for the UMTS user profile identification have been proposed and a comparison between them has been made. Both scenarios are consistent with the various UMTS call handling and mobility management procedures. Nevertheless, a unique user profile management scenario must be adopted. For the selection of the most appropriate solution not only numbering aspects must be considered but also performance issues, interoperability aspects and security requirements must be taken into account.

As the research work on UMTS is still in progress new requirements for the user profile and its management are likely to be set. Consequently, the proposed scenarios may need to be upgraded in the future or serve as a basis for the introduction of other UMTS user profile identification scenarios. Finally, the resulting scenarios must be evaluated via an appropriate simulation tool in order to identify their performance features and test their interoperability with the rest of the UMTS "environment."

#### **Acknowledgements**

This article is partly based on work done in the work-package MF4 of the EU RACE Project R2066 MOBILE NETWORKS (MONET). Nevertheless, the ideas expressed here are not necessarily endorsed by the project. The authors would like to thank their colleagues in MF Core Task (Mobility Functions) who have contributed in MF4 work and helped with their comments.

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#### **Biographies**

GEORGE P. ELEFTHERIADIS received a Dip.-Ing. in Electrical Engineering and Computer Science from the National Technical University of Athens in 1992. He is currently working towards his Ph.D. at the National Technical University of Athens, Department of Electrical Engineering and Computer Science, Division of Computer Science. His research interests are in the fields of mobile communications, performance evaluation of data communication networks, routing, flow control, and IBCN. He has several publications in these areas. He is also participating in RACE 2066 MOBILE NETWORKS (MONET). He is a member of the Technical Chamber of Greece.

MICHAEL E. THEOLOGOU received a degree in electrical engineering from Patras University in 1972 *summa cum laude*, coming first in his class. He received a Ph.D. from the Department of Electrical Engineering and Computer Science of the National Technical University of Athens in 1980. During 1972-1974 he worked in the Research Centre of Greek Army. From 1975 to 1991 he had been working as a Telecommunications Engineer in the Hellenic Telecommunications Organization (OTE). At the Greek Telecom Organization he gained a wide experience in all facets of the Telecom Industry. In parallel he served as an instructor at NTUA teaching Telecom Courses and conducting Telecom System Laboratory. Currently he is an assistant professor at National Technical University of Athens, Department of Electrical Engineering and Computer Science, Division of Computer Science conducting teaching and research in the wider area of Telecommunication Systems. His research interests are in the fields of Integrated Broadband Communications Networks, routing, flow control, quality of service and mobile communications. He has several publications in the above areas. He has also participated in several RACE projects of EU. He is a member of the IEEE and the Technical Chamber of Greece.

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As the  
research  
work on  
UMTS is  
still in  
progress new  
requirements  
for the user  
profile and its  
management  
are likely  
to be set.