A Framework for Mobility in Wireless Personal Communications

Marie-Pierre Gervais
Laboratoire MASI and Université René Descartes

Bijan Jabbari
George Mason University

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ABSTRACT: In Personal Communications, mobility control in the form of terminal mobility, personal mobility and service portability is essential. On the other hand, the concept of Intelligent Network (IN) has been applied to Personal Communications to provide enhanced services as well as personal mobility. In this paper, we analyze the extent to which intelligent network is used in providing mobility through the Universal Personal Telecommunication (UPT) service and extend this capability to incorporate terminal mobility. This study focuses first on the integration of mobile networks with their inherent terminal mobility into the IN for UPT services. Subsequently, we propose a solution for mobility by introducing an IN-based terminal mobility service and chaining it with the personal mobility service provided by UPT. We show the chaining of the two IN-based services through the call model. Throughout, we illustrate the concepts through the service procedures for incoming calls terminated to a UPT subscriber using a mobile terminal.

1. Introduction

Personal Communication Service (PCS) is a term used to describe services and supporting systems that provide users with the ability to communicate anytime, anywhere and in any forms. This definition encompasses the concepts of terminal mobility, personal mobility and service portability [4]. Terminal mobility refers to the ability of a portable terminal to access telecommunication services from any location while in motion, and the capability of the network to locate and identify the mobile terminal as it moves. Personal mobility is the ability of end users to originate and receive calls and access subscribed telecommunication services on any terminal in any location, and the ability of the network to identify end users as they move. It is based on the use of a unique personal identity (a "personal number") associated with a person and his or her service profile instead of with a terminal. Service portability refers to the network capability to provide subscribed services at the terminal/location designated by the user. Service portability is accomplished through maintaining an up to date service profile of the user and querying it as necessary.

In order to reach "full" mobility, these different mobility aspects need to be combined. Intelligent Network (IN) provides a framework that can be suitable to support these combined mobilities in a uniform way. IN is a service-oriented architecture as it separates the transport-related functions and the service control-related functions. In general, mobility in IN is envisioned to be provided through the Universal Personal Telecommunications service (UPT), which is defined by ITU-T as "a telecommunication service that enables access to other telecommunication services while allowing personal mobility. It enables each UPT user to participate in a user-defined set of subscribed services and to initiate and receive calls on the basis of a personal, network-transparent UPT number across multiple networks on any fixed or mobile terminal, irrespective of geographical location, limited only by terminal and network capabilities and restrictions imposed by the network operator" [5]. However the current UPT specifications are more focused on the personal and service mobility aspects than on the terminal one.

We present in this paper how IN can be used to provide "full" mobility, i.e., not only personal mobility and service portability, but also terminal mobility. We investigate two different ways to achieve this goal. In a first step, a short-term solution can be chosen in order that "full" mobility can be reached as soon as the UPT service is available. This solution is based on the terminal mobility in the cellular networks along with IN for personal mobility. In a further step, the terminal mobility is provided by the IN itself in terms of a new IN service (Terminal Mobility - TM). This enables to optimize call routing as the called party address becomes available at the originating side. "Full" mobility is obtained by chaining the two services (UPT and TM) in a single call. We draw the requirements of such a solution especially those related to the call processing aspects.

2. The Mobile Networks and the UPT Service

In the second generation mobile network (e.g., GSM, D-AMPS, PDC), MAP (Mobile Application Part) is used to provide database access procedures between network elements such as HLR (Home Location Register), VLR (Visiting Location Register) and MSC (Mobile Switching Center) for terminal mobility [3]. When the terminal is moving from one location area to another, an updating procedure is performed. According to whether the change of location area involves change of the MSC area on one hand, and a change of VLR on the other hand, only the VLR is updated or VLR and HLR are updated. Mobile outgoing calls follow the same procedure as fixed outgoing calls, except that an authentication of the terminal may be performed. Routing of incoming calls from a fixed network to a mobile terminal involves routing to a Gateway MSC, which initiates the call setup to the appropriate visited MSC by obtaining its address from the HLR. The MSC requests the location area in which the terminal is roaming from the VLR and performs the paging within this location area. After receiving a response, the call setup to the mobile terminal continues. A detailed description of theses procedures can be found in [1].

The UPT service is based on the IN architecture [7]. The functional components which are relevant in our context[1] are the following. The CCF/SSF[2] performs the switching functions and provides the interface with the SCF, which performs the service logic by using information contained in the SDF. In the UPT service context, the network is conceptually divided into three parts. The Originating network is the network from which the call is initiated. The Home network is the network to which the user has subscribed. It stores the service profile of the user in the SDF_h (home SDF). The Terminating network is the network in which the call terminates. In order to use the UPT service, the user has to register first. For that, he dials the UPT service access code, provides his identification and authentication code, and then his registration address, which is the terminal identity where his incoming calls should be presented or from where he will

1 Here, service processing as opposed to service creation
2 For a detailed definition of these IN functional entities, refer to [7]

make outgoing calls. The registration procedure updates the user service profile in the SDF_h. Then the user can initiate or receive calls. To initiate outgoing calls, the UPT user has to provide his identification and authentication code after dialling the UPT access code. Then he dials the called number and the network routes the call to its destination. When there is an incoming call for the UPT user, the network detects it based on the dialled UPT number, and has to translate this UPT number to the terminal identity by consulting the registration address in the SDF_h. The call is then routed to its destination. Detailed information on the UPT service can be found in [6].

3. Terminal Mobility and Personal Mobility

As stated above, a mobile network provides terminal mobility. This refers to the ability of a mobile terminal to access telecommunication services from any location while in motion, and the capability of the network to locate and identify the mobile terminal as it moves. It is associated with wireless access and requires that the user carry a terminal and be in a radio coverage area. So a mobile network deals with a terminal—location area relationship. The location functionality is terminal-oriented, and addresses the question: "at which place is this terminal?". In such a network, the user is always associated with his/her terminal. The mobility aspect is then a terminal location-oriented one, provided through wireless access. However, in realization of this capabillity, often a dedicated network is also developed.

Intelligent Network deals with mobility through the Universal Personal Telecommunication (UPT) service, which provides personal and service mobility through the use of a personal number that can be used to originate and receive calls at any fixed or mobile terminal. The fixed association between user and terminal (in both mobile and fixed networks) is removed and the user is uniquely identified to the network by a personal number known as the UPT number. For that, the user registers each time he wants his calls move from one terminal to another. The registration updates the user location. Although the UPT service definition allows a subscriber to use a mobile terminal, in its current specification, the UPT service is limited only to a user—terminal relationship. The location functionality is user-oriented and addresses the question: "which terminal is the subscriber using?". The mobility aspect is a user location-oriented one. The fact that a UPT user can use a mobile terminal is not taken into account by the current recommendations on UPT.

4. Mobility Through Intelligent Network and Mobile Network

A first solution to provide "full" mobility is to use an underlying mobile network. In this case, IN provides the user—terminal relationship and then is relayed by the mobile network which provides the terminal—location area relationship.

In the following, we study the requirements related to the different processing occurring when a UPT subscriber is using a mobile terminal. Concerning the registration and outgoing call procedures, the UPT user has to dial the UPT access code. So the MSC must have the ability to recognize such an access code as an IN service demand. That means that an SSF entity has to be resident in the MSC and must be able to access an SCF. Then the usual processing of these UPT procedures can be achieved. Concerning an incoming call process, when a call is initiated towards the UPT user in a network, the UPT service is first performed in order to translate the UPT number into a terminal identity (user—terminal relationship). Once the switch gets the registration address, since this corresponds to a mobile terminal, the mobile network is used in order to deliver the call (terminal—location area relationship). Figure 1 illustrates this processing[1]. When the UPT number is detected in the basic call processing, the UPT service logic is invoked in the SCF_o ①. This consults its local SDF_o to get the location of the SDF_h in which the user service profile is stored ②. The SCF_o can then retrieve the current registration address of the user ③ and gives the order to the SSF_o to establish the call to this address ④. The call can be processed as a usual mobile call by using the mobile network. It is routed to the gateway MSC ⑤, which interrogates the HLR to obtain the routing information ⑥. Typically, the HLR obtains this information by interrogating the VLR ⑦. The Gateway MSC now can initiate the call setup to the visiting MSC ⑧. The MSC requests the location area in which the terminal is roaming from the VLR ⑨. Furthermore, the mobile terminal is paged within the location area. When it responds, the call to the mobile terminal is set up.

This solution can be used as soon as the UPT service is available. However, a major drawback of this solution is related to the routing optimization. Even if the calling party and the called party are located in the same area, the call is routed from the SSF_o to the Gateway MSC and from there to the visited MSC. The worst case illustrating this lack of routing optimization is to consider that the caller himself is using a mobile terminal and is moving in the same location area, i.e., his calls are being processed by the same MSC as the visited one.

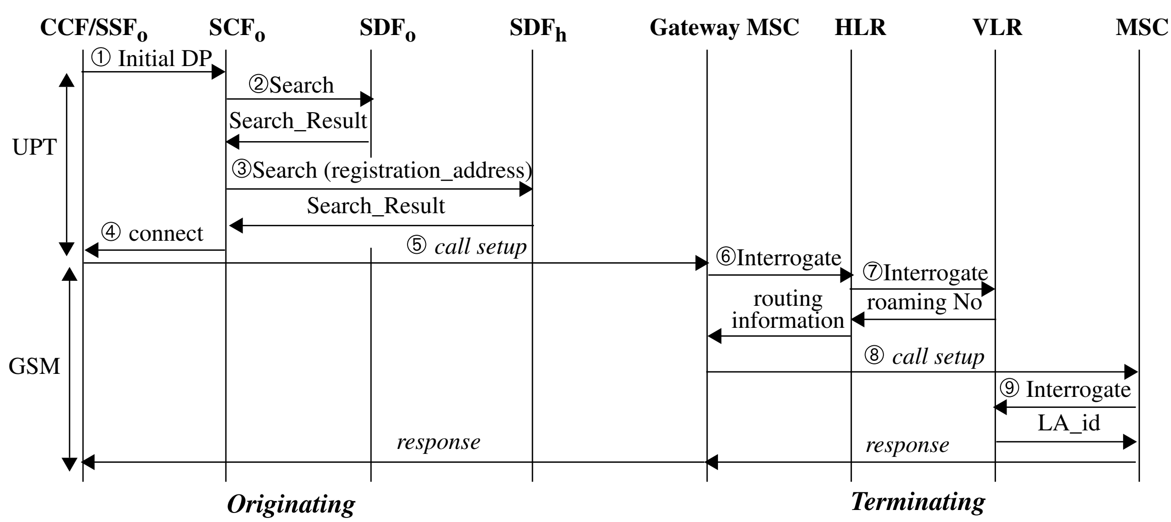

Figure 1: Incoming call to a mobile UPT user

1 In order to simplify the diagram, we omit processing parts that are not directly related to our purpose, such as the user interaction in the UPT service.

5. IN-based Terminal Mobility

In order for IN to provide "full" mobility by itself, a Terminal Mobility (TM) service has to be designed as an IN service. Its service core functionality is to establish the terminal—location area (T—LA) relationship. For that, the SDF_h in the home network is used instead of the HLR. It provides the location of the visiting SDF. This is used instead of the VLR and is able to determine the location area in which the terminal is roaming. It stores the T—LA relationship. We assume that functions that are specific to the mobile part and that are needed between the switch and the terminal (via the base station) are available. On the other hand, the switch has to implement the SSF functionality and then to be able to query an SCF. Here, we focus on the service logic part related to the provision of the T—LA relationship, namely the updating and incoming call procedures.

Updating procedures occur each time the terminal moves from one location area LA_i to a new one LA_j. Depending on the implementation choices, LA_i and LA_j can be managed by the same SDF or not. Figure 2 illustrates the updating procedure in both cases. Once the service logic is invoked in the SCF_j ①, it consults its local SDF_j to get the location of the visiting SDF_i, namely the location of the SDF which stores the T—LA relationship ②. If SDF_j stores it, then the local SDF_j and the visiting SDF_i are in fact the same SDF, and then it sends back its own identity (1). If SDF_j does not store it, it sends back the SCF_h identity (2). Based on this response, the SCF_j performs either set of the following actions. In (1), it can update the location area identity ③. In (2), the processing consists of getting the previous visiting SDF_i location from the SDF_h ④, updating the SDF_h with the location of the new visiting SDF_j ⑤, updating the previous visiting SDF_i by removing the location area identity ⑥ and updating the local SDF_j which becomes the new visiting SDF ⑦.

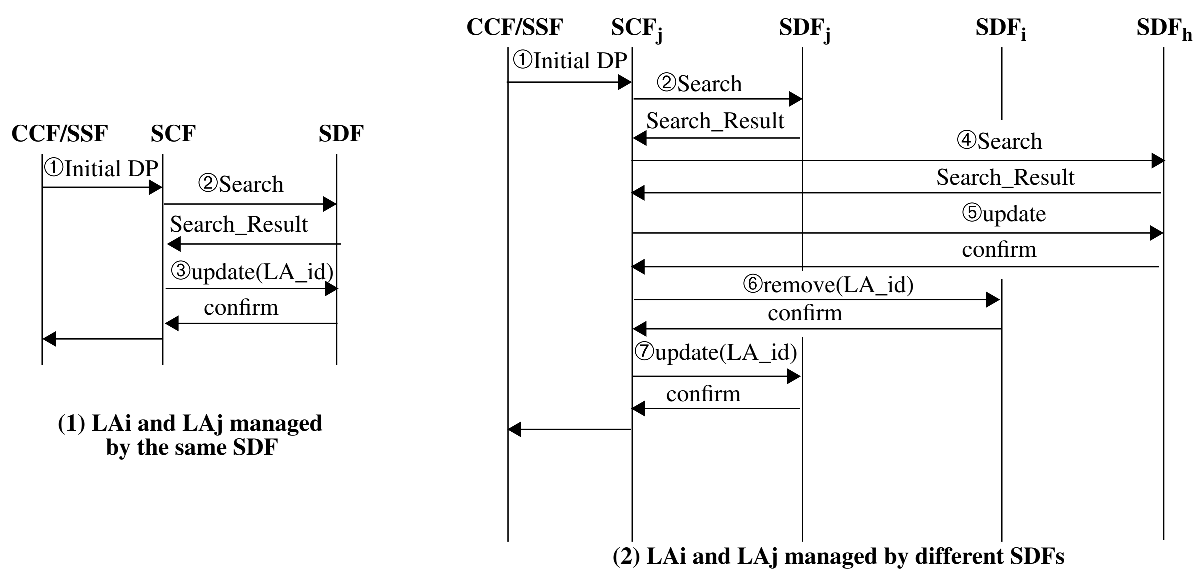

Figure 2: Registration and location updating in the Terminal Mobility service

Figure 3 deals with the incoming call processing. We make a logical distinction between the local network, from which the call is initiated, the home network which contains the SDF_h and the visiting network in which the TM user is located. When a TM number is detected in the basic call processing[1], the TM service logic is invoked in the SCF_l ①. This one consults its local SDF_l by providing the TM number to get the location of the home SDF_h ②. The SCF_l can then retrieve the location of the visiting SDF_v ③ and retrieve the location area identity ④. Then it gives the order to the SSF_l to establish the call to this address ⑤. The mobile terminal is paged within this location area. When it responds, the call to the mobile terminal is set up.

In this case, the translation terminal—location area is performed by the local network, and no more by the visiting one, as it was the case in the mobile network. The advantage is a potential for an optimized routing, since the called party address can be available at the originating side, the call can then be routed directly to its destination.

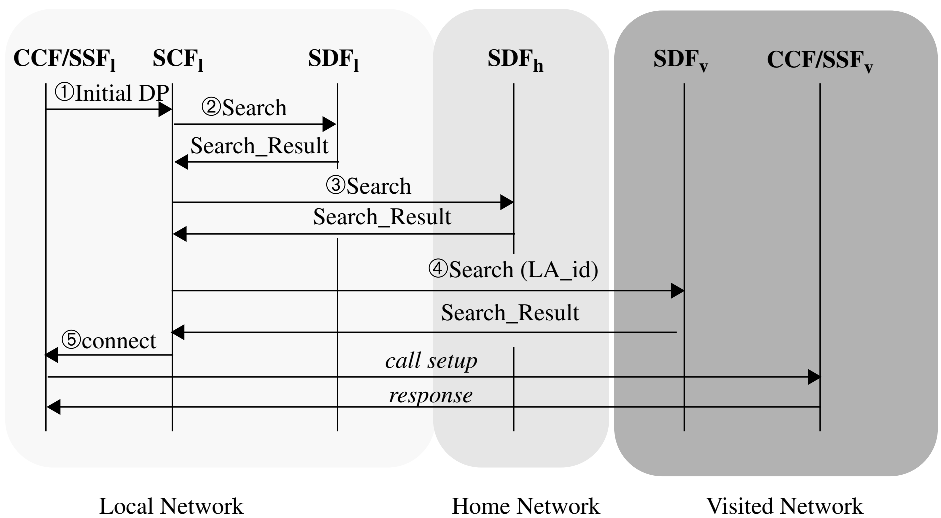

Figure 3: Incoming Call in the Terminal Mobility Service

6. Mobility Through the Intelligent Network

Once a Terminal Mobility service is available, "full" mobility can be provided by the IN itself without using an underlying mobile network. It provides the capability for the UPT user to use a mobile terminal. From an architectural viewpoint, this means that the CCF/SSF entity has a MSC capability, i.e., it is able to provide the mobile functions. From a procedural viewpoint, when the UPT user is using a mobile terminal, registration and outgoing calls are processed in the same way as in a fixed network. Therefore, only incoming calls are considered as they introduce requirements related to the call processing. Actually, when an incoming call is initiated towards a UPT user using a mobile terminal, first the UPT service logic has to be invoked in order to

1 We assume that similar mechanisms as in UPT are available in the basic call in order to detect a TM number (trigger detection point and associated criteria).

translate the UPT number into a terminal identity (user—terminal relationship), then the TM service logic will be invoked in order to locate the terminal (terminal—location area relationship). In order to realize the chaining of these two invocations inside the basic call processing, the step corresponding to the analysis of the dialled number (PIC 3) has to be performed twice in the same call (see Figure 4). So once the UPT number is analyzed and recognized as a number for which a service logic has to be invoked (DP3), the SCF_o having performed the service, it sends back to the SSF_o the command to connect the call to the terminal using the mobile identity (TM number). During this time, the call processing has been suspended, and then it resumes at the PIC 3. An analysis is performed a second time. The number is recognized as being a TM number, so the TM service logic is invoked. Once the service is accomplished, the call processing resumes at the PIC 4 as the normal processing of a mobile call. So the chaining is obtained by the outcome of the UPT service, which is the order from the SCF_o to the SSF_o to resume the call to the PIC 3, by providing the translated number, i.e., the TM number.

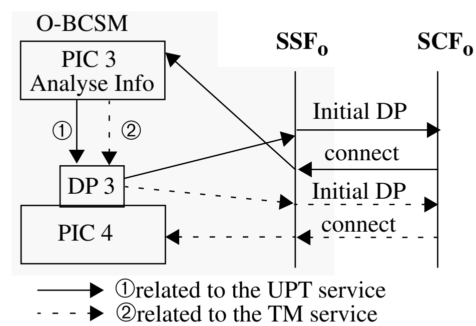

Figure 4: Chaining the UPT and the TM service in the Call Model

7. Conclusion

In order to provide PCS, and then full mobility, IN can be used as the supporting system. IN provides a suitable framework as it is a service-oriented architecture that separates the transport-related functions and the service control-related ones, and as it already deals with mobility through the UPT service. In a short-term approach, IN can use a mobile network as an underlying network providing the terminal mobility. In a further step, IN can provide a TM service. An IN-based solution can provide full mobility by chaining the UPT and the TM services through the call model, .

In both cases, the functional architecture has to be considered. In the first solution, an SSF entity has to be implemented in the MSCs. This solution is rather simple, but its disadvantages are that two distinct networks are involved in the provision of mobility, and routing is not optimized. In the second solution, IN is the single supporting system and implements all aspects of mobility. For that, the transport network part of IN has to be composed of switches able to implement the mobile capabilities as well as the SSF. The service network part of IN provides the service logic and data of the UPT and the TM services. In this solution, an optimized routing can be obtained as the translation of the numbers is performed in the originating network.

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