AGENTS IN PERSONAL MOBILITY

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Personal mobility features, that is the ability of a user to access his or her personalized telecommunication services at any terminal, are of great importance to answer to the challenge of providing computing and communication services anywhere and anytime in the disconnected world. Agent technology is a new and emerging software solution that can improve the design and implementation of systems supporting nomadic users. We present a framework for using mobile and intelligent agents to implement personal mobility features. Our prototype implementation clearly demonstrates advantages of agent-based solutions when compared to IN-based and to DPE-based implementations.

1 Introduction

The spread of mobile computers and the evolution of wireless networks boosted the development of applications for nomadic computing [11]. Business users of today demand–and home users of tomorrow will demand–that they can continue their usual way of using computing and communication services wherever and whenever in an easy way. Computer manufactures have answered to this request with laptop computers more powerful and more comfortable to bring along. Mobile phone manufactures produced cellular phones with PCMCIA cards so that laptops and palmtops can exploit connectivity provided by mobile phones.

The ability to use a personal computer and world-wide connectivity while traveling around the world is called as nomadic computing, The concepts of personal mobility and terminal mobility were introduced to clarify the different needs that should be addressed in order to meet the challenge of nomadic computing. In the same time agent technology has gained attention both among software houses and among research groups. Several agent platforms enabling use of agent technology are now available. Agents have also been a popular topic among now publishers that have published a pile of books on the topic [6].

However, agent technology is not yet mature enough for worldwide exploitation in telecommunication applications. There are still problems in designing software systems that integrate the concepts and functionality of personal mobility, terminal mobility, and agent technology. Moreover, there are no standard design widely accepted but several international forums, including FIPA [5], OMG [12], TINA Consortium [14], are requesting proposal to resolve the issues. The resolution may be available too late since every commercial system will have an architecture of its own that, in turn, makes the interoperability at least cumbersome if not impossible.

In this paper we present a way of using mobile and intelligent agents to implement personal mobility features in an easy way. The proposed way leaves space to custom implementations but gives guidelines so that the main concepts are inherently portable to different usage scenarios.

The rest of the paper is organized as follows. After a brief overview of related work we introduce the basic concepts and definitions in Section 2. In Sections 3 and 4 usage scenarios for telecommunications and kiosk are presented. In Section 5 we concentrate on the issues related to service invitation, that is locating the User's current terminal and notifying the User who (or which service) wants to contact. Finally, in Section 6 we state our conclusions and discuss further refinements.

1.1 Related Work

Basic features of personal mobility are specified by ITU-T in Recommendation F.851 [8]. Some of the features are already provided to customers by telecom operators. These implementations are based on the Intelligent Network (IN) [9] that has several limitations in flexibility of service provisioning and customization. Personal mobility features will also be a crucial part of the 3rd generation mobile system known as IMT-2000 [7].

Alternative approaches to personal mobility have been searched in TINA context [2,3]. The EC/ACTS project DOLMEN enhanced TINA to support both personal and terminal mobility [15,17,4]. Their prototype implementation, which was based on CORBA platforms as a substitute to the TINA DPE, showed merits of DPE-based solutions over IN-based solutions. However, DPE-based solutions have some major limitations in service customization.

Currently, there are several EC/ACTS projects in the CLIMATE [1] cluster that examines feasibility and exploitability of agents in various areas of telecommunications.

The MONTAGE project has done some initial studies to introduce mobile and intelligent agents to handle personal mobility in the TINA framework [10].

2 Basic Concepts and Definitions

2.1 Personal and Terminal Mobility

The distinction between personal and terminal mobility was introduced in the Universal Personal Telecommunication (UPT) [18]. Figure 1 depicts the different concepts.

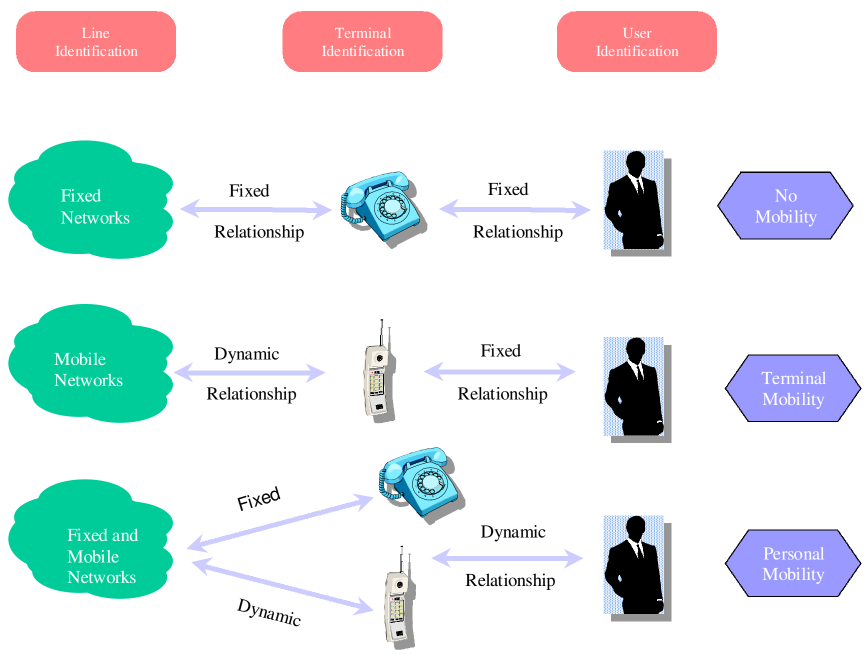

Figure 1: Different degrees of mobility

In fixed telecommunication networks the user is always associated with his own terminal, and the terminal is permanently tied to the network.

Terminal mobility is defined as the possibility to move the terminal while keeping the service active. It allows the users to travel with their terminals. They do not need to terminate the service, then to move and finally to restart the service.

In **Personal Mobility** the users are not tied to their terminals. They can move because either the services are tied to terminals. The users can travel, find suitable terminals wherever they are and start services. Sometimes personal mobility includes also terminal mobility.

We can think to a mobile phone as an application of both the definitions: The user starts a phone call, then she or he can move while continuing the conversation[1]. This is obviously an example of terminal mobility. Now, in GSM [13] systems a terminal, that is a mobile phone, needs a so-called SIM card. When a user signs a subscription to a GSM operator, she or he receives a SIM card. Having a subscription and an SIM card the user can move wherever she or he wants and then insert the personal SIM card to a phone and start a conversation. The user is not tied to a phone, and thus this is an example of personal mobility.

2.2 Basic Elements

Below we present the basic definition that will be used in the following examples. All together they represent the minimum set of elements that compound the proposed architecture[2]. These basic elements are:

The **User** is the one who wants to start a service session.
The **Service Provider** is the stageholder that offers services.
The **Connectivity Provider** is the stageholder that takes care of physical connections between terminals and Service Providers.
The **Terminal** logically connects the User with the Service Provider.

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[1] Of course this mobility is limited by various elements, like radio coverage and the type of subscription with the telephone operator.

[2] Even if some definitions remind to TINA concept, this architecture does not rely on TINA.

Mobile Agents are software objects that act on behalf of the User through the various Service Providers,
User Profile contains all the useful information about the behavior and preferences of the users.

These basic elements are sufficient to build and to support most of the scenario existing in personal mobility. In the next section, through some examples, we will refine and extent these definitions.

3 Telecommunications Scenarios

A User has a subscription for a service in the local Service Provider. The type of the service requires that the User Profile is located near the Service Provider as in Figure 2. This is due to the fact that most of the time the User will use a Terminal logically located (through a local Connectivity Provider) in the Service Provider domain.

When the association with the Service Provider is fixed (due to administrative or economical reasons) the Service Provider is called **Home Service Provider**. In this example the user is connected with the Home Service Provider and can directly use the Services provided by the Home Service Provider.

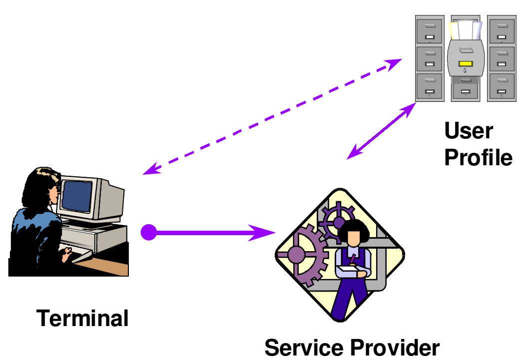

Figure 2 A normal subscription

When the user moves out from the Home Service Provider domain, he or she can use a Terminal connected to another Service Provider that has a **Federation Contract** with

Home Service Provider. A Service Provider different from the Home Service Provider is called a **Visited Service Provider**. A Visited Service Provider does not have the User Profiler, so the service cannot be allowed immediately. Anyway, since there exists a Federation of Service Providers and the User has a subscription with a Federated Service Provider, the User can obtain the service through the Visited Service Provider (see Figure 3).

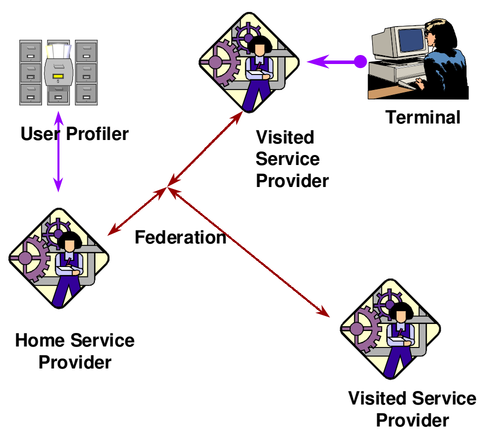

Figure 3: The User roams

In order to do that, a Mobile Agent connects to the Home Service Provider and gets the needed information from the User Profile and comes back to the Visited Service Provider (Figure 4).

After checking the information, the Visited Service Provider allows or denies the Service to the User.

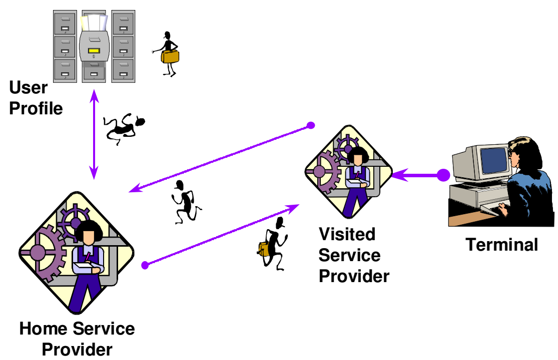

Figure 4: The user obtains the service

3.1 The Roaming in Detail

When the User moves and wants to use the Service outside the Home Service Provider domain he or she must find a Terminal in the Visited Service Provider domain. After that the user registers asking for the Service (Figure 5). This is done using a Mobile Agent.

The Visited Domain receives the request from the Terminal. The request also contains the unique Identifier of the User so that the Service Provider can check the subscription from its Database. The Service Provider finds out that the User has not a subscription here but that the User has roamed. The Service Provider needs to obtain the User's information to decide whether or not to allow the Service. So the Agent goes to the Home Service Provider of the User and gets the information (Figure 4).

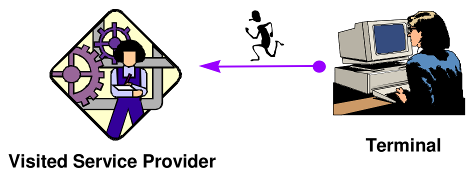

Figure 5: The User registers himself to the Visited Service Provider

The scenario becomes more interesting if the Terminal can connect with more than one Service Provider. In this case the User do not only request a service, but also wants to have the cheapest one (or the best one). In this way the User Agent can add a Quality of Service (QoS) requirement to the Service request.

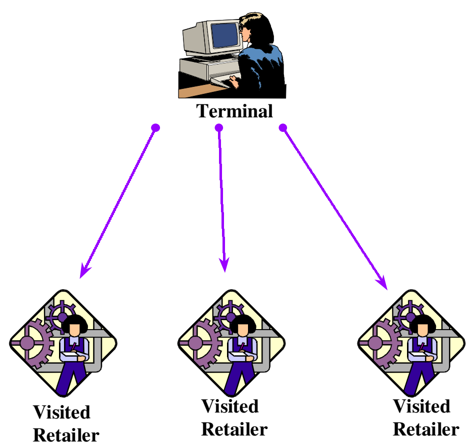

Figure 6: Agents negotiate QoS

The role of the Mobile Agents becomes indispensable. Every Service Provider has a Local Agent whose role is to promote Services of the Service Provider to the visiting Agents. When the User, through the Terminal, requests a Service outside the Home

Service Provider, a Mobile Agent visits all the local Service Providers and collects the information (promotions) given by the local Service Providers (Figure 6).

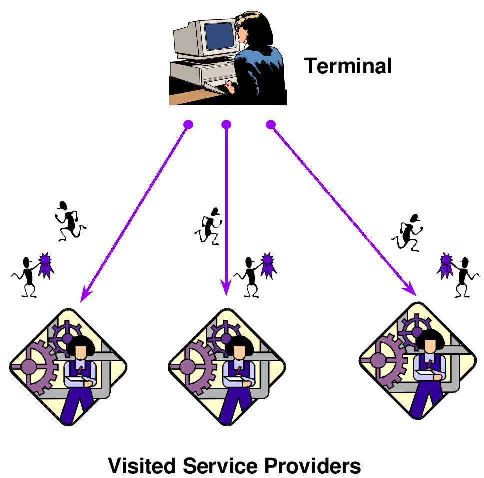

Figure 7: After negotiation the Mobile Agent choose a Service Provider

The Mobile Agent goes also to the Home Service Provider to collect the User Profile and then decides which Service Provider fulfills the User preferences and requirements best. After this phase, the Terminal starts a connection with the chosen Service Provider (Figure 7).

4 Kiosk Scenario

In this example the Services the User wants to obtain are simple. For example, the User wants to send a fax document from a Terminal situated in a shop or wants to find the cheapest way to travel to a foreigner city from a Kiosk located in a Travel Agency. These types of Services are not strictly tied to a particular Provider. Thus the User

Information, provided by the User Profile, is directly owned by the User[3]. Therefore, the role of the Home Service Provider has no meaning. The role of the Terminal is also different: Instead of being in the User domain it logically belongs to the Service Provider domain. The new scenario is depicted in Figure 8.

The User connects to a Terminal giving the Identification Code. Since the User Profile is located in the User domain, the Service Provider immediately gets the information it needs. Then the Service Provider satisfies the User request directly or through another Service Providers.

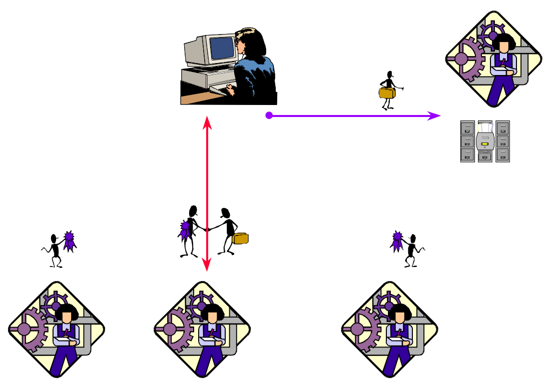

Figure 8: Kiosk Scenario

4.1 In Detail: booking a flight though a Kiosk Provider

The User wants to travel to Paris. He goes to a Kiosk Service Provider in the nearest Travel Agency. He puts a Smart Card to a Kiosk Terminal and digits the Identifier of his own. A Mobile Agent of the User is transferred from the Smart Card to the Terminal. An immediate negotiation between the Mobile Agent and the agents presenting the Kiosk Service Provider takes place. If the Services is allowed, then another Agent, specialized in Travel Services will get the needed information from the User Profile such as preferred Airline, usual flight class, desired departure and arrival time, and move to the well-known Airlines Providers. Special Agents in those Providers will

[3] Smart Cards could be used.

promote the service and, after the usual negotiation phase, the User will receive the list with the different options and he will choose one. Figure 9 depicts the scenario.

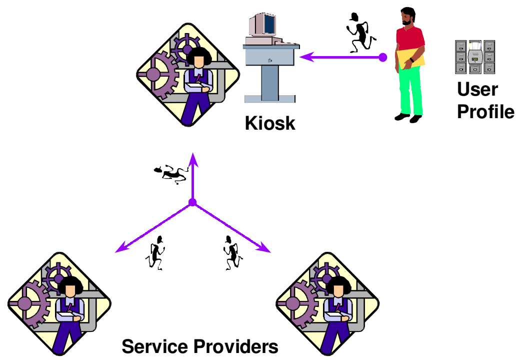

Figure 9: Booking a flight

4.2 In Detail: Sending a Fax

Sending a fax through a Kiosk is managed in the same manner: Again, the User inserts a Smart Card to a Terminal connected to the Provider. Also in this case the Smart Card contains the User Profile. However since the Service is a typical anonymous one where the only needed information is a credit card number or a prepaid card, only this information is given to the Provider. The other phases in this service are similar to those in the previous one: The Provider, using a Mobile Agent, finds the cheapest route to send the fax, and then finishes the job.

5 Service Invitations

Since in personal mobility the User is not strictly connected with the terminal, new cases involving "Service Invitations" may be interesting. In other words, if the user cannot move the terminal (like a telephone or a fax machine), he would like to have the same services from the Visited Service Provider.

As an example, the user would like to receive incoming call to the fax at home redirected (diverted) to a visited fax. The user has already subscribed a service at a Service Provider, and the service is active. Since the Service Provider needs to have the user information, the User Profile is tied to the Service Provider that acts as a Home Service Provider. When the user decides to move to a place with no prior knowledge whether or not the service can be served there, the call cannot "a priori" be diverted to a different number. The User can just announce to the Home Provider his intention to roam. Once arrived at destination and a terminal suitable to receive the service has been found then the User registers in the new site to receive the incoming calls. This is done in the same way of the first case: a Mobile Agent scans all the available Connectivity Providers, negotiates the appropriate Quality of Service and decides the best route to reach the Home Service Provider. After this phase, the Agent moves to the Home Service Provider and delivers the new location of the User and the best route to follow (Figure 10).

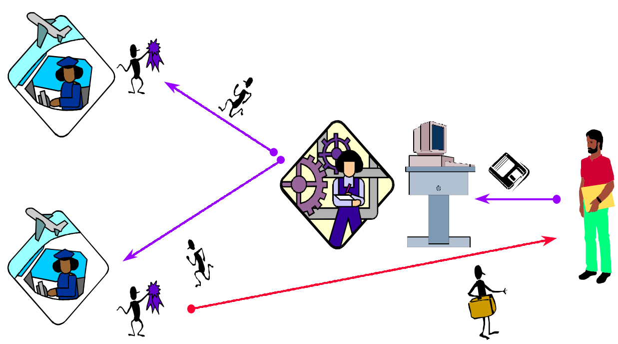

Figure 10: Service Invitations

When an incoming call is received, the Home Provide will divert it to the new location. In this way, if two Users have both roamed to the same Service Provider's domain, different from the Home one, after the first call they will directly talk, without involving the Home Service Provider anymore which minimizes the costs. Another example of the same scenario: A user requests a service that needs long time to be served. In this case the user could want to receive the reply to another terminal.

5.1 Service Invitation Implementation

We have implemented a simple prototype of the service invitation scenario using Voyager ORB [16] agent architecture. The scenario is as follows:

The User subscribes to a News Service to receive the latest news. This service is independent to the user location and the terminal. When a new piece of news becomes available, the service sends it to all the users who have subscribed. The User Agent, through the Agent Platform, takes care of delivering the piece of news to the right Terminal.

In details**,** the User must register to the Service. He or she has to give his Personal Information Code (PIC) and to specify a host address. In the current prototype there is no authentication procedure. The host specified by the User becomes the Home Service Retailer of the User.

At this point the User name is inserted into the User Database in the Home Service Retailer who creates a User Agent for the User.

When the User is willing to receive the News, he or she starts the Service giving the PIC. The User Agent is awaked. When a piece of news arrive, the User Agent take cares to display it at the current location of the User (Figure 11).

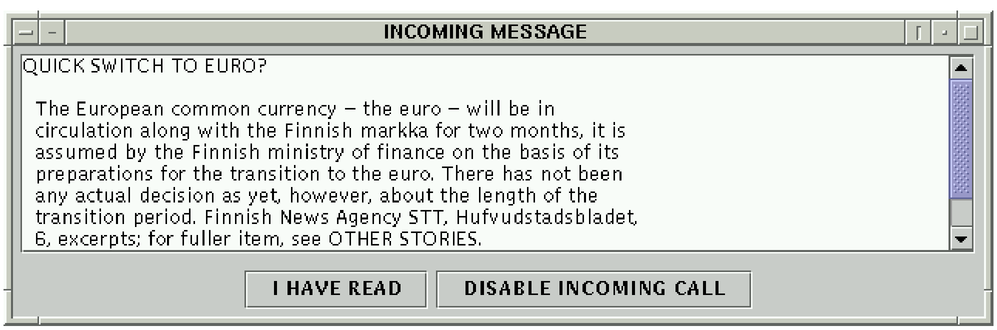

Figure 11: The News Service is active

When the User roams, the User Agent will follow the User to the new location, thus taking care of obtain the forthcoming pieces of news from the Home Service Provider. In Voyager, when an agent migrates, it leaves a “trace” behind so that the platform, which created the agent, can always find the agent. A more sophisticated prototype will be implemented and demonstrated in the EC/ACTS project MONTAGE[19] later this year.

6 Conclusions

We described a typical example of usage of our architecture in telecommunications. We can notice different roles of the basic elements:

- The Terminal is strictly associated with the User. From the architectural point of view the role of the Terminal is to connect the User represented by a Personal Identification Code (PIC) to Service Providers.
- The User Profile is an essential element in allowing or denying the services. Thus, the importance of the Home Service Provider depends only on the presence of the User Profile. Furthermore, the Home Service Provider is static.
- The role of agents is to connect them to and to the other elements and to transfer information. Since they act on behalf of the User and they act autonomously, they fulfill the most common definitions of Agents.

This scenario is related to a typical Telecommunication Service, such as GSM, in which the User signs a subscription for the Service with a Provider that keeps the User Information in its Database. Different Providers agree to exchange information related to services when a User is temporarily roaming. However the User information is always maintained and managed by one Provider. With the architecture described in this paper some improvements to the typical service are easy to obtain. For example, when roaming the User does not need to choose which Provider to use but the Agents will do that on behalf of the User. Furthermore, if the User will move for a long time, the Providers could exchange the whole User Profile. In that case the concept of the Home Service Provider become dynamic and distributed.

6.1 Refinement of the Definitions

As stated above, the User Profile is not static but dynamic or mobile. It is easy to construct new scenarios changing the "position" of the different elements. The main idea is to have a few elements and a general architecture valid for a wide number of different scenarios. By refining the basic elements described in Section 2.2 we obtain:

- The User is the entity that requests the services. It should be notice that a Service can also start another Service as in the Service Invitation scenario. Therefore, from the architectural point of view, the User in not necessary – only the User Profile is essential and an entity representing a paying customer.
- The Terminal is just a means to connect the User and the Service Provider. It can be a real laptop computer, a GSM phone or just a cash dispenser, but the logical function is the same. Sometimes the Terminal is located in the User domain, sometimes in the Service Provider domain.
- The Service Provider is the stageholder that offers Services. The Home Service Provider is a Service Provider that has the User Profile.
- The User Profile is the core of the architecture. It contains all the information needed to a Service. What is needed depends on the scenario: An exhaustive database for a typical telecommunication scenario, a prepaid card for a Kiosk one. The main idea is that the User Profile can be mobile: It is obvious in the fax scenario, since follows the movements of the User. However, the profile, or part of it, could also move in the Telecommunication scenario, especially when the User moves for a long time.
- The Mobile Agents are the communication means between the other components. They can contain information and intelligence that can be used for benefits of agents' principals.

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