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Integrated service and mobility management from an ODP perspective

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Abstract

In the converging fields of intelligent networks, telecommunications management networks and distributed systems, the ODP trader concept is a candidate to implement a service management for the variety of new fixed network services. The increased demand for nomadic, wireless and mobile access to communication services forces the merging of different communication worlds like Public Land Mobile Networks, Packet Mobile Radio and Wireless LANs with wired telecommunication and data communication networks. A key issue is the introduction of mobile data and multimedia services and the development of suitable network and protocol architectures. Thus, mobility and service management cannot be separated and therefore mobility will also be an important issue in distributed systems. This paper investigates ODP trading concepts to develop an integrated service and mobility management in heterogenous nomadic and mobile communication environments. The trader is used to store the user's service profiles and location information. To achieve flexible trader query processing, the control logic is introduced by an additional functional entity. This Service and Mobility Agent is then in charge of all service and mobility aspects on behalf of the mobile or nomadic subscriber.

Keywords

Open Distributed Processing, ODP Trader, mobile communications, nomadic communications, mobility management, service management

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1 INTRODUCTION

Service and mobility management are major tasks in mobile and nomadic networks. Due to the expected large number of subscribers and the heterogenous network structures, recent research and development concentrated on efficient management of the subscriber service and location information, resulting in architectures built upon Intelligent Network (IN) concepts, see Lauer (1994), Rapeli (1995), Apfelbeck (1993), Jabari (1992). The integration of IN, TMN and ODP, see for example Barr (1993) and Dupuy (1995), will be a major part of the integration of telecommunication and data communication services into an integrated network offering a variety of services to fixed, nomadic and mobile users. Hence, mobility will also have an impact on ODP service trading in distributed mobile computing environments. This impact is studied in this paper. An introduction to existing approaches to mobility and services management in mobile and nomadic environments is followed by a discussion of service management aspects in fixed networks. Subsequently we investigate ODP trading concepts to develop an integrated service and mobility management in heterogenous nomadic and mobile communication environments.

2 MOBILITY AND SERVICE MANAGEMENT IN NOMADIC AND MOBILE ENVIRONMENTS

2.1 Nomadic computing

User mobility is a matter of growing interest in fixed networks, where an address, e.g. a telephone number or an Internet address, is usually associated with a fixed location. This is the most convenient approach from the networking point of view, but it does not necessarily reflect user needs. In fact, users, including those using wired networks, frequently change location (e.g. move from one office to another), but want to maintain their reachability for incoming phone calls or electronic mail messages as well as their office environment (e.g. access to file servers, printers). This is referred to as personal mobility and service mobility, respectively, in contrast to terminal mobility as realized in mobile networks.

Personal mobility as provided by Universal Personal Telecommunication (UPT) is based on the use of a Personal Telecommunication Number (PTN), establishing a dynamic association between user and terminal. A user may initiate an association on any network terminal by entering his PTN and a PIN for authentication. The 'In Call Registration' service enables the user to receive incoming calls at this terminal, the 'Outgoing UPT Call' service can be used to make phone calls from any terminal charged to the UPT account. UPT is currently being standardized within ITU-T and is closely related to the emerging technology of Intelligent Networks (IN). The major aspect of INs is the separation between service-control and call-control, supporting for example the address transformations required for implementing UPT services (Lauer, 1994). Similar mechanisms for location handling can be found in all networks supporting mobility.

Today's major global network for data communication is the Internet. Addresses, as e.g. e-mail addresses, identify locations based on a hierarchical structure, typically comprising the user name, an associated machine and the domain where that machine can be found. The normal way to achieve functionality comparable to UPT in the Internet is the forwarding of incoming messages to the new user address. Within the Internet Society, the Mobile IP group investigates protocol enhancements necessary to route IP messages to hosts with varying points of network attachment (Perkins, 1995). The proposed mechanisms are based on location registration and packet redirection. A mobile station changing its location must register with a local facility (e.g. a wireless 802.11 access point), which then handshakes with the station's home agent responsible for the location tracking. Upon successful registration, the mobile station's current address (address of the serving agent) is bound to its home address. This enables the redirection of packets destined to the station's home address to its current location. However, this operational transparency is achieved at the price of less than optimal routing paths, since every message is first routed to the home network of the mobile station.

In OSI networks the X.500 service can be used to establish a (distributed) database for storing dynamically changing associations between users and locations, like it is done by IN for UPT. Addresses of the X.400 Message Handling Service (MHS), for instance, can be directory names, with the X.500 Directory Service (DS) used to retrieve the corresponding O/R (Originator/Recipient) address. If a user moves to another location (i.e. another O/R address) (s)he can use a DS user agent to change the directory entry correspondingly. Thus, a directory query can be compared to the call setup signalling in UPT, and the data transmission to the current O/R address resembles the call switching and call control.

2.2 Mobile networks

Characteristic tasks of a communication system in a mobile environment are radio resource management, mobility management, service management and security management, resulting in architectures different from networks connecting fixed stations only (Spaniol, 1995). In contrast to conventional tele- and data communication systems, a mobile network has to keep track of a subscriber's current position to enable routing of incoming calls and continuous communication. To achieve this, the concept of location areas is introduced. A *location area* is the smallest unit for which the mobile network maintains the current location of a subscriber, i.e., a location area is a group of cells with an associated database storing the identifiers of mobile stations currently registered. As subscribers will enter and leave a location area dynamically, the corresponding entries in the database will have to be updated. Upon a mobile terminated incoming call, the network transmits paging messages only to the cells of the location area where the mobile station is currently registered. When the called mobile station answers this paging message, the network knows the cell where the station is located and a communication link can be established (Fig. 1). Existing schemes for mobility management mainly differ in the process to decide on a location update (Bar-Noy, 1995), and in the techniques used to maintain the location information in the fixed network, see for example Wang (1993), Imielinski (1993), Madhow (1994), van den Broek (1992).

The digital second generation systems according to the Global System for Mobile Communications (GSM) standard, operating in the 900 and 1800 MHz frequency bands, respectively, have been replacing their first generation analog predecessors since 1992. DCS1800 (i.e., GSM at 1800 MHz), in operation since 1993, introduces the concept of a Personal Communication Network (PCN), aiming at higher service flexibility (Potter, 1992). The integration of cordless networks according to the Digital European Cordless

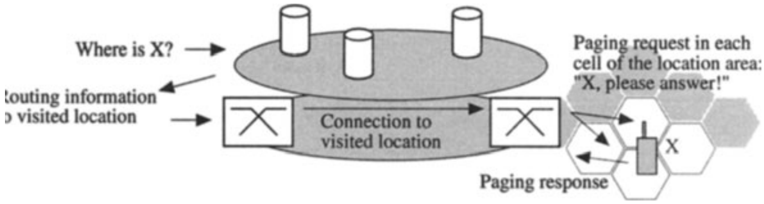

Figure 1 General principle of mobile terminated connection establishment.

Telecommunications (DECT) standard into GSM networks and a satellite component for GSM are under investion for the future evolution of the GSM standard (Mouly, 1995).

The mobility management in GSM is based on a centralized approach (Rahnema, 1993). The Home Location Register (HLR), a central database of a GSM network, maintains for each subscriber a reference to a Visitor Location Register (VLR), which is associated to a Mobile Switching Center (MSC) where the mobile station is currently registered. The location information (i.e., the identifier of the location area) is stored in the VLR. Usually, the VLR is realized as a part of the MSC, even if the standard allows MSC and VLR to be physically separated entities. Upon location update, the entries in the affected VLRs and (eventually) in the HLR are updated (via the Signalling System No. 7, see Kühn (1994)). For each incoming call the HLR is interrogated first. If it accepts the service request, the routing information addressing the visited MSC is returned.

Third generation mobile systems* will have to cope with various telecommunication and data communication services as well as the migration of mobile and fixed networks into one global worldwide universal communication system. A spectrum of 230 MHz around the 2000 MHz frequency band was identified for the system in 1992, and Phase 1 is scheduled to be operational around the year 2000. UMTS enables Universal Personal Communication, i.e. communication anywhere, anytime, mobile or fixed, with a single 'telephone' number (Rapeli, 1995), addressing the subscriber, rather than the device. Services and applications currently investigated, e.g. mobile multimedia (Armbrüster, 1995), will also have impact on the layout of the cellular network: It cannot be expected that multimedia services are offered in the whole network in the medium term, maybe only in in-house subnetworks. Hence, service quality and service offer will change dynamically with handovers and location updates.

The cellular network is based on a hierarchical cell structure, comprising macro (up to 35 km), micro (less than 1 km) and pico cells (less than 100 m). The latter will be found almost exclusively in the in-house sector. Additionally, different kinds of subnetworks (e.g. company wide, building wide or vehicle wide) will be incorporated. Service handling and mobility management will be based on an Intelligent Network (IN), see for example Lauer (1994), Apfelbeck (1993), Jabbari (1992). The expected very large number of subscribers and the area to be covered by a third generation network make a centralized mobility management almost impossible. In addition, the specific communication profiles of subscribers as well as the

* In Europe a Third Generation Mobile System referred to as Universal Mobile Telecommunication System (UMTS) is currently specified by the ETSI, whereas ITU standardizes a similar system called Future Public Land Mobile Telecommunication Systems (FPLMTS).

applications and services they use (e.g. speech, fax, X.400, etc.) require new management schemes, as discussed for example in Spaniol (1995), Fasbender (1995), Wang (1993).

2.3 Service management

In a nomadic or mobile environment the service profile accessible to the user depends on the capabilities of the terminal as well as on the network to which the user's terminal is currently attached. Thus, the network has to maintain service profiles for each subscriber currently registered at the network in addition to localization information. This enables the mapping of the service profile of the user (i.e. the services (s)he has subscribed to), the service profile of the user's terminal (i.e., the terminal's capabilities) and the network's service profile. With the increasing variety of services and their heterogenous QoS requirements the service management becomes a crucial point, especially because of changing environments due to mobility. In the converging fields of intelligent networks, telecommunications management networks and distributed systems, the ODP trader concept becomes an interesting candidate to solve the problems of an integrated mobility and service management upon ODP.

3 SERVICE MANAGEMENT IN DISTRIBUTED SYSTEM ARCHITECTURES

In order to classify management systems several characteristics have been identified, see (Hegering, 1993). One dimension is concerned with the phase of the life-cycle of a resource, that is to be managed from design over introduction, operation, modification until its termination. Resources to be managed establish the second dimension of management systems, subdivided into network, system, service, application and enterprise elements. The third significant dimension determines the functional area the management application deals with. Traditionally these functional areas include accounting, configuration, fault, performance and security management. More recent approaches combine fault and performance into quality-of-service management, whereas security is no more considered as part of management but of the computing infrastructure, see (Sloman, 1990). Whereas the distinction between networks and systems is comparable precise, this does not hold for services and applications. In general, services can be considered as building blocks enabling applications. Therefore, these services are of interest for a wide range of problems, whereas an application has to fullfil specific end-user requirements. Broadly speaking services can be classified for example into 'transport services' enabling various kind of data to be transmitted over communication channels, 'access services' giving access to any kind of (hardware) device, 'information services' allowing storage and retrieval of information with databases or knowledge bases, and general purpose 'management services', see (Hegering, 1993).

One important approach to distributed processing platforms is the Reference Model of Open Distributed Processing (RM ODP). It has been designed in order to extend interconnection of open systems to an open interworking between heterogeneous platforms, see (ISO/IEC DIS 10746-1, 1995). ODP aims at providing distribution transparency to users (application programers), including access, concurrency or failure transparency. It offers concepts for specifying distributed systems from different points of view, see (ISO/IEC DIS 10746-2, 1995). In addition, an architecture for a distributed infrastructure has been developed, see (ISO/IEC

DIS 10746-3, 1995). It comprises several functions implementing certain aspects of distribution transparency. ODP does not offer a service definition as such; services are described through their behaviour at an object's interface. Service offers consist of a service type and a number of service properties. These properties enable a service to be of the same type but offering different properties, e.g. a mailing service can be further described by the kind of media that a meassage might contain. Whereas conventional mail only allows ASCII characters to be transmitted, enhanced mail service may also for instance support voice or video. Service properties can be divided into static or dynamic attributes taking into account its change rate. Properties that change very often are evaluated for every import request, whereas values of static ones are stored along with the service offer. The service type consists of a simple identifier or an interface signature. Interfaces are subdivided into operational interfaces for conventional client-server-oriented interactions and stream interfaces for producer-consumer-oriented data flows. An interface signature consists of a name and a collection of named parameter types. An ODP trader maintains services exported by a server and offers an import operation to clients. Within this import operation, the client determines the required service type and its property values. As a result, it receives several references to matching service offers. An interworking of several autonomous traders is called a federation, see (Meyer, 1996).

Whereas the RM ODP has been developed for general purpose distributed systems, its concepts have been adapted for specifying more special architectures, e.g. for future telecommunication systems. The Telecommunication Information Networking Architecture (TINA) is a logical framework for open telecommunication systems aiming at the separation of network ressources and information services, see Barr (1993), Dupuy (1995). It enables a service provider to introduce and offer services without having to take into account the underlying network characteristics. The TINA consortium has been founded in 1993 and comprises a large number of network providers as well as companies from the telecommunication and computing industry. A TINA service has been defined as a configuration of computational objects, see (Bernd, 95), as defined by the RM ODP.

The overall structure subdivides a TINA service into four parts. The usage part is established by the operations offered to the service user, also called the export interface. In contrast to the normal user interface the management part offers operations for service maintenance and administration that are used by service managers. The substance part is the import interface defining interfaces required for the service's implementation. All parts not relating to one of the three other parts are subsumed under the core of a service. It contains the state information and the control logic (program) of the service. It is independent from the user and management interface, but relies on the operations provided by the substance part. Communication and cooperation between computational objects are provided by an infrastructure called the Distributed Processing Environment (DPE). All characteristics of the local operating and communication systems are hidden behind a common DPE interface, which on the one hand serves as an object storage and management system and on the other hand as an object cooperation facility. It offers a number of generic services like trader or name service on top of the DPE. Therefore the DPE is an adaption of the ODP Architecture as specified in Part 3 of the reference model. With respect to the management of telecommunication systems TINA aims to an adaption to the Telecommunication Management Network (TMN) of the ITU, see (de la Fuente, 1995).

4 AN ODP APPROACH TO SERVICE AND MOBILITY MANAGEMENT

4.1 Global architecture

To use ODP services in an nomadic or mobile environment, where the service invocation depends on the knowledge of the location of the associated communication partner (such as electronic mail or joint editing) the trader has to maintain location information in addition to its service list. Thus, a mobile or nomadic station must register at the trader in which domain it is currently located to enable mobile terminated service requests (e.g. the notification of an arrived email including the forwarding of the email to the domain the user is currently located in), and to map its requested service profile onto the profile offered by the trader. The latter also requires registration and location tracking when the station initiates service requests only in the fixed network (e.g. polling for email instead of a notification). In general, all services implying a notification of a mobile user require mobility management procedures.

The subscriber uses a service profile to indicate which services (s)he intends to use (and pay for). Services are described through their service type and properties with respect to the required quality of service. In general, the user does not need the same service in all domains, the service profile can be specific to one or more domains. The services offered by a domain's trader also can be regarded as a service profile.

In our approach to an integrated Service and Mobility Management (SMM) the domain of a trader corresponds to a location area. A Home Domain (HD) is assigned to a subscriber and the corresponding trader maintains an entry (*SI*, *R*) for the subscriber, consisting of the subscriber identification *SI*, and a reference *R* to locate the user if (s)he is currently not whithin the *HD*. In this case *R* points to the trader where the user can be directly reached or references another trader, thus creating a chain of references to the subscriber. In addition, a trader stores and maintains the services offered within this domain.

Considering the current standard document (ISO/IEC DIS 13235, 1995), SMM logic cannot be achieved by a trader without modifications of the trader itself. Therefore, it is established in a functional entity, the Service and Mobility Agent (SMA). The SMA is installed in the fixed network, associated with one or more trader (i.e., the trader maintain references to the services of the SMA), and is in charge of all service aspects on behalf of the subscriber and provides the connection between mobile station and ODP environment (Fig. 2). To some extent this concept can be mapped onto IN terminology, a trader corresponds to a Service Data Function and the SMA can be interpreted as a specific Service Control Function.

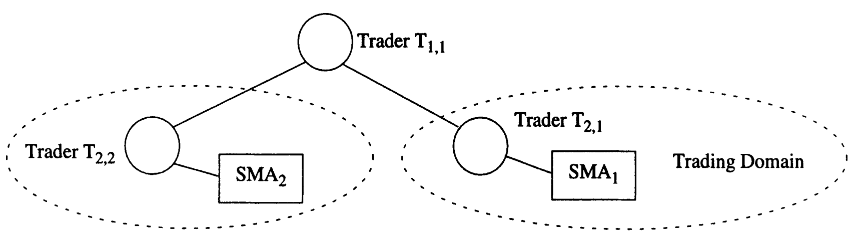

Figure 2 Example scenario.

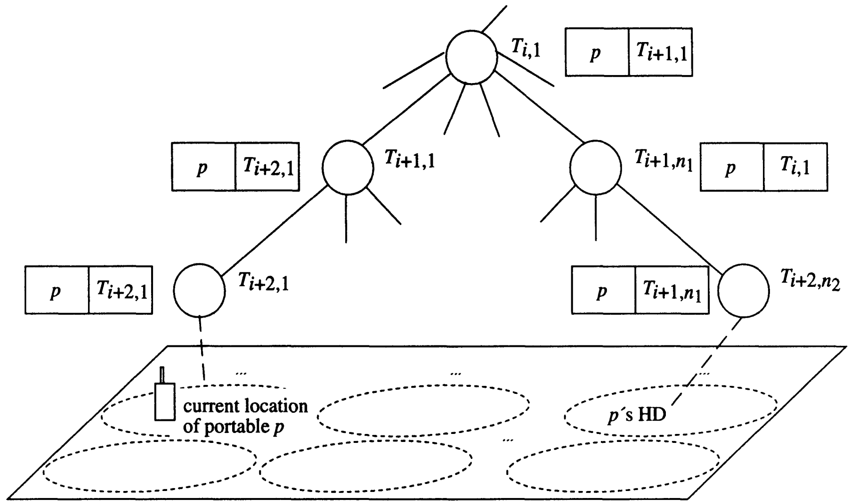

Figure 3 Example of distributed location information.

4.2 Registration and location update

When a mobile enters a new domain D_{new}, the SMA associated to this domain will create a new entry in the trader associated to D_{new}, will initiate an update in the old domain D_{old} and in those traders which maintain references from the *HD* to D_{old} and D_{new}. Algorithms to maintain locations in mobile networks are discussed in Apfelbeck (1993), Bar-Noy (1995), Imielinski (1993), Madhow (1994), van den Broek (1992). In general, the global architecture does not imply a specific location management scheme. Here, we will assume that the traders are hierarchically interconnected forming a tree of traders (as introduced in (Wang, 1993) and extended in (Fasbender, 1995)), with the top layer covering all domains in the system, as pointed out in Fig. 3.

The location update process is performed as follows: The portable registers with the new domain and the location pointers in the distributed trader database are then updated up to the highest layer covering the old and new domain. This holds if the new domain is located within the level *i* subtree spanned by home and old domain. Otherwise, (the portable has moved outside the level *i* subtree) an additional database entry in the next level (*i*-1) is created, and the current level *i* entry is changed to reference its parent node in level *i*-1, as illustrated in Fig. 4.

The operations to update the location information can easily be performed using standardized trader operations:

- importing a service offer of certain type with certain properties;
- exporting a service offer;
- modifying service properties of an existing offer;
- withdrawing a service offer.

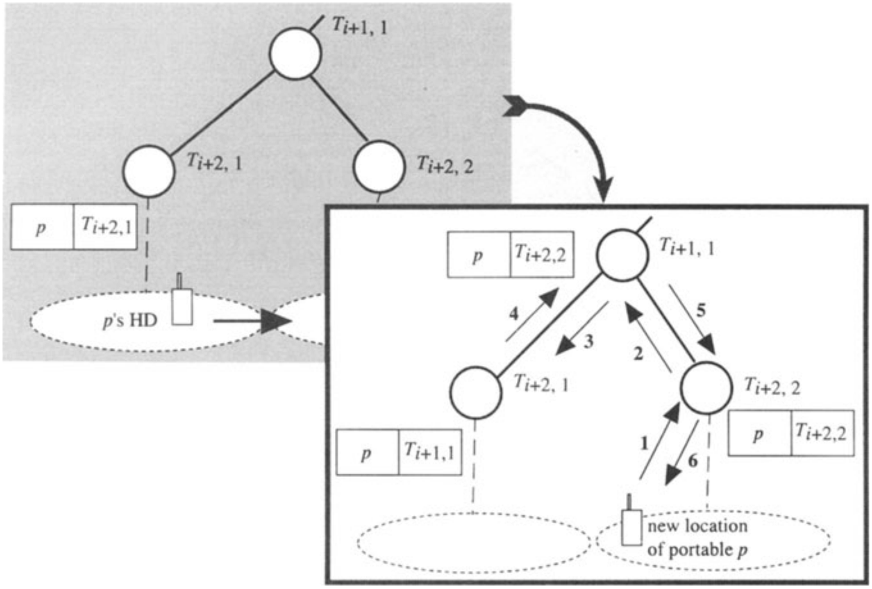

Figure 4 Location update example.

Location information is stored in the trader by a service offer of type `LocationInf` with the following service properties:

- the subscriber identification;
- the location status of that subscriber;
- a reference to the next trader to ask;
- a reference for establishing a binding to the subscriber.

Registering with a domain is done either by exporting a new service offer of type `LocationInfo`, if it does not exist in the current domain, or by modifying the appropriate properties of an existing one. Analogous, deregistering requires properties to be modified. Checking the current status of a subscriber can be done using the import operation looking for a service of type `LocationInfo` using the subscriber identification as a required service property.

4.3 Service management and localization

To ensure that the requested service can be offered with the required QoS, the SMAs invoked on the path to the mobile will only check whether or not the requested service is offered by querieing the associated trader(s). When the process of localization service profile matching reaches a trader where the mobile is registered, the mobile stations' SMA is indicated and if the

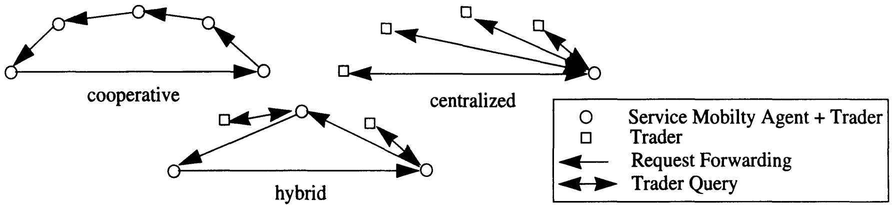

Figure 5 Alternative request control strategies.

service request is accepted by the agent, the chain of service references is returned to the calling SMA which will then initiate the service invocations. The advantage is that all user specific service invocations can be performed under control of the users via their associated SMAs, thus requiring no additional control from the intermediate SMAs.

In order to interact with a possibly mobile subscriber an initiating subscriber needs to specify the identification of the subscriber in question and the required service profile. (S)he forwards these parameters with an SMM request to the local SMA. The SMA first does checks whether the requested service profile is available in its domain. Therefore, it forwards an import request to the local trader for each services contained in the profile. It will abandon search if either one of the required service cannot be found, or none of the services in the profile is available at all, depending on the user's search policy. Information on all servers found in the local domain will be stored and passed as a result parameter of the SMM request. The next task is to check if the receiver can be found in the local domain. Therefore, the SMA forwards an import request to the trader looking for an appropriate service offer (for details see section 4.2). As a result it receives a reference where to contact the subscriber, if (s)he resides in the local domain, or the address of a trader to contact next. After determining the next trader to be checked, the SMA has two possible control strategies, see Fig. 5. The first, which we call the cooperative one, would be to contact the next SMA directly. Alternatively, it can also pass the request back to the initiating SMA, which is then in charge of forwarding the request. We call this the centralized control strategy. The cooperative strategy requires each trader to have an SMA, but realistic scenarios are expected to have one SMA for several traders. In general, one SMA controls more than one trader. Therefore, the local SMA wishing to forward an SMM request to another SMA first has to check if there is a SMA at all. This will be accomplished by an import query to the trader looking for a service offer of type `ServiceManagementAgent`. If no SMA is available the local SMA has to keep control of request processing by itself. This strategy is referred to as hybrid in Fig. 5. Taking the example of a multimedia mail, service

Service Offer
ServiceType MultimediaMail **Subtype Of** ElectronicMail
Service Properties
SupportedMedia **in** {text, voice, JPEG, MPEG}
ServiceOfferProperties
NetworkBandwidth **in** {9,6 kbit/s; 10 Mbit/s, 100 Mbit/s}

Figure 6 Example multimedia mail service description.

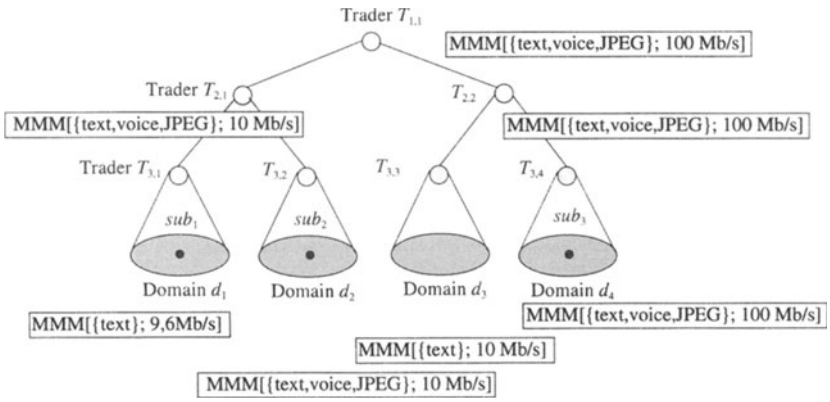

Figure 7 Example scenario for integrated service & mobility management.

offer, see Fig. 6, we will describe the SMM procedure. Fig. 7 shows a sample scenario of four domains controlled by seven trader components. Suppose a subscriber sub_3 located in her home domain d_4 needs to send a multimedia mail to sub_1 who can be contacted in domain d_1, but also has her home in domain d_4. (S)he forwards a SMM request for a multimedia mail service supporting text and JPEG-coded images to her home SMA. For this example we assume this service to be the only one in sub_3's service profile. We further assume a SMA to be available at each trader. The local SMA contacts trader $T_{3,4}$ for an appropriate service, which is in fact available in domain d_4. The location search for subscriber sub_1 results in a reference to trader $T_{2,2}$, which obliges the local SMA to forward the SMM request to the SMA associated with $T_{2,2}$. This process continues until trader $T_{3,1}$ recognizes that the required service cannot be offered to reach sub_1 in domain d_1. A similar request for sub_2 in domain d_2 would be successful.

5 CONCLUSION

Current telecommunication environments supporting mobile and nomadic subscribers handle service and mobility management separately. We do not expect this approach to cope with future traffic requirements, because it causes high overhead on communication links. Therefore, we have proposed an integrated approach to SMM using the ODP trader for storing location and service profile information. In addition we have described a hierarchical structuring of interconnections between traders. Unlike current architectures like GSM or IN we propose to establish SMM on top of a distributed platform similar to the architecture of ODP. We found the ODP trader to be an appropriate tool for realizing SMM. Nevertheless it has become obvious that the ODP trader concepts do not allow dynamic request forwarding, which is essential in the envisaged environment. To overcome this problem we added an object called Service Management Agent to control request forwarding and trader queries within SMM request processing.

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8 BIOGRAPHY

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