Service Continuity and Personalisation in Future Mobile Services

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Abstract-- **With the advent of the Internet and the plurality and variety of fancy applications it brought with it, the demand for more advanced services on cellular phones is getting more and more urgent. Unfortunately, so far the introduction of new enabling technologies did not succeed in boosting new services. The adoption of Internet services has shown to be more difficult due to the difference between the Internet and the mobile telecommunication system. Some of the problems that restrict the introduction of new services can be narrowed down to poor understanding of differences between ordinary Internet based services and mobile services. Thus, the goal of this paper is to investigate the composition and architecture of mobile services, and relating this to two important concepts; namely service continuity and personalisation. Both of these concepts can be more powerful for mobile services than for traditional Internet based services. The current service domains are discussed and a new model of the complete service domain for mobile services is introduced and discussed.**

Index terms—**mobile services, service continuity, service personalisation, mobility, PAN-based service**

I. Introduction

The blooming of mobile data services did not happen as fast as anticipated. Important reasons to this are restrictions in technologies, especially network limitations (limited bandwidth, high latency, low stability and low predictability) and device limitations (low processing speed, small storage space, limited input/output facilities and limited battery capacity).

However, there is a third reason, less known but not less important, namely the lack of knowledge concerning mobile service architecture, service composition and mobility requirements. This paper starts with a discussion of the composition of a generic mobile service and introduces the concept of service continuity as an additional requirement to mobile services. This concept is then further discussed in relation to the expanding domains for mobile services, and in particular for PAN (Personal Area Network) based services. Also, the importance of service continuity for personalised mobile services is addressed. Last, XML Web Services is introduced as a potential technology for the realisation of discussed concepts.

II. Composition and Architecture of Mobile Services

Mobility is the ultimate requirement for mobile services; they should by definition be available at any time, any place using any device with communication capabilities (thus supporting many types of mobility [1]). To be able to address these requirements and further study them, a more formal definition of the composition of a generic mobile service is needed. This section provides a preliminary definition.

Mobile services can be modelled by their *composition* or by their *architecture*. Whereas the compositional model is concerned with the division of a service into discrete components according to their nature and role, the architectural model is concerned with the distribution of components of a service.

Initially, a generic mobile service can be separated into two basic components:

- Service Logic
- Service Data/state

Service logic, or *application logic*, is the code that provides dynamic behaviour to a service. Although usually consisting of several units code, it is in the composition model considered as one.

Service data/state is the data that are used in the execution of the service logic and reflecting the state of it. They are for example variable values, register values, stack values, counting parameters, etc.

In addition to these two components, we propose to introduce two other components, in order to analyse service continuity and personalisation properties of mobile services. These are:

- Service Content
- Service Profile

Service Content are the product of service usage. It can for example be a MS Word document or entries of an address book. This content can also by in the form of a mark-up language like HTML/WML. Service content can either be produced or consumed by the user.

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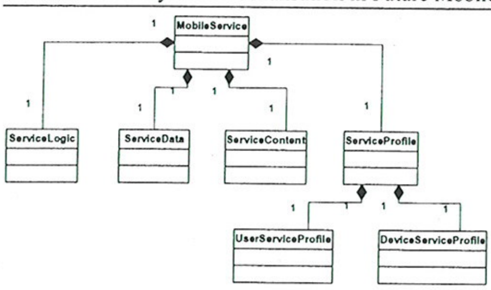

Figure 1: Composition of Generic Mobile Service.

A Service Profile contains settings that are specific to a service and a user/device. It can thus be further divided into a User Service Profile and a Device Service Profile.

The *User Service Profile* contains a user's settings for the particular service. These are typically settings stating how the service should look/behave for that user (e.g. what functions should be available). It can also contain personal information about a user that is used in accordance with another service (e.g. as input).

The *Device Service Profile* contains information about devices that enable the service to adapt according to what type of device is currently used to access the service (e.g. to adapt the presentation of a service to the user).

The User Service Profile is stored or linked to the User Profile of a user, whereas the Device Service Profile is part of a Device Profile.

The User Profile can either be directly modified by the user (explicit) or indirectly through the usage of services (implicit). The former is often used to accommodate personal preferences, whereas the second is used for adapting services (e.g. direct marketing) to fit a particular user. Implicit changes to the profile can be put through using reasoning logic in the network. The profile is then updated according to the continuous usage pattern of a specific user. Information in the Device Profile will usually be added as a user adopts new devices with new properties. This profile should be cross-referenced against a centralised database that contains the actual specifications of the device.

Figure 1 displays the composition of a generic mobile service.

Often when distributed systems are considered, much effort is put into the architecture and distribution of the logic. However, and especially for mobile services as we will argue throughout this paper, the distribution of service content is at least equally important.

With this somewhat formal definition of service composition, we proceed with a study of the relation between service composition and the service domains and service continuity of mobile services.

III. Service Domains and Service Continuity

This section discusses the addition of new service domains and their relevance to the evolution of mobile services. In particular, the challenges of tailoring technologies to exploit these additional service domains are discussed.

Today, technologies addressing mobility of services in both Internet and mobile telecom are mostly focusing on *communication* as the service that should be mobile, i.e., the network layer of the OSI stack (see Figure 2).

Such efforts are visible by contributions to Mobile IPv4 and Mobile IPv6 etc. Also, a commonly accepted definition of mobile services is that they are provided by static, standalone applications running on mobile terminals. To take mobility a step further and to avoid mixing concepts with terminal mobility, *service continuity* is introduced as an additional requirement of mobile services. It is defined as follows:

"Service continuity implies that an end-user service provides sustained access across heterogeneous networks and terminals."

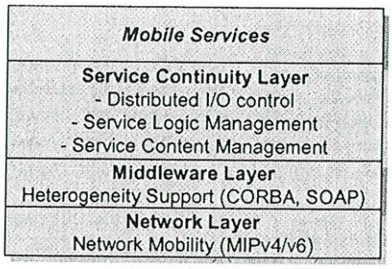

Figure 2: The introduction of a Service Continuity Layer.

The emphasis in this definition is on an end-user service, and not merely on transport mechanisms in the network stack. The requirement of service continuity means that a holistic view of service composition and architecture must be taken; being addressable by an IP address (MIP) is a prerequisite but not enough.

In Figure 2 we introduce a layer below mobile services which is called the Service Continuity Layer. The tasks of this layer are to allow services on top of it to provide service continuity. Some of the elements of this layer are, as depicted in Figure 3:

- A monitor that continuously keeps track of the surrounding networks, domains and hosts
- A handover manager for high-level service handover
- An interoperability evaluator for matching compatible components in dynamic service composition
- A service composition module
- An input/output redirector module

It is important to see the difference between service composition in this context (which is a dynamic *process*), in contrast to the generic *model* presented earlier.

A study of high-level handover for services has been performed in [2].

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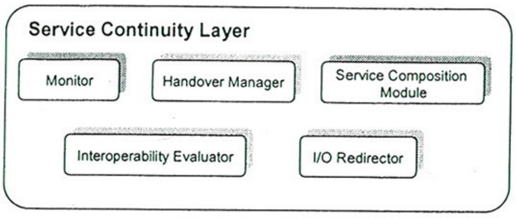

Figure 3: Major elements of the service continuity layer.

It must be said that mobile agents [3] previously have been introduced to perform some of the tasks of the service continuity layer (e.g. transfer of service logic and state from one device to another). However, as the complexity of networks and service architectures grows, and since most mobile services will not be standalone services running on one device with all service content present on the same device, a lot of new challenges must be considered. Also, nothing is settled with regards to this service continuity layer and its distribution and nature. It is only stated as an area that needs re-examination.

A. Location of Service Logic and Content

The first question is where the service logic should be located. In early mobile telecom services (Voice telephony and SMS), the service logic was embedded in the dedicated hardware components of the system (e.g. MSC, SMSC, HLR in GSM [4]). This has been a hindrance for development of flexible services, but more importantly, it means that these services will by default not be accessible from outside an operator domain. Although interoperability has been achieved between operators by roaming features of the mobile telecom systems, the services are still only accessible from specialised terminals, i.e., cellular phones with a particular radio interface (e.g. GSM). Service continuity means that a service also should be accessible by any device. It is thus necessary to decouple the service logic from the system components.

Second, as services for mobile terminals are getting more advanced and productive (to accommodate work and collaboration between workers) they result in more service content (of all three categories mentioned earlier). It is thus not enough that the service logic is accessible from any device, on any network. All service content must be accessible too. This raises the question of where this content should be located, if it should be replicated throughout service domains and networks or if it should be centralised in the home network of a user. Since this content can take on many forms, a simple answer does not exist. Probably the easiest illustration of this challenge is the bookmark list a user keeps in an Internet browser. Today, the browser on each terminal keeps its own bookmark list, instead of providing access to the same content everywhere.

With the advances of network technology the last years, interoperability between heterogeneous networks has become possible. It is now technically possible to choose where in a network the service logic should reside, and where the service content should reside. For example, Internet based content can be accessible from a cellular phone. It is thus important to study the feasibility of such combinations of locations, as well as how to tailor (middleware) technologies to this purpose.

What is certain is that both service logic and content must be carefully distributed throughout networks and terminals, and some of it might be replicated (see Figure 3).

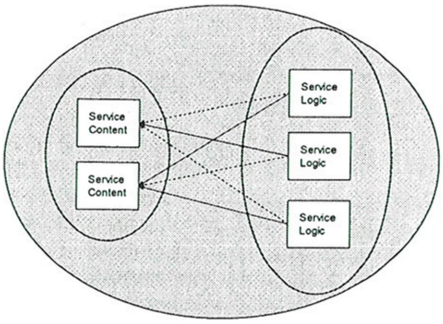

Figure 4: Replication of service logic or content, or both?

B. Service Continuity for Multi-domain Services

As mentioned earlier all services initially provided by mobile telecom operators were located in the telecom network itself, and developed by telecom operators. With SMS and WAP, many services were moved to a third party service provider, outside the operator network domain, providing access through CPA agreements or similar. Also solutions for accessing enterprise network domains and their services have been introduced (for example Microsoft Exchange with Mobile Features).

In general, a *macro*, *micro* and *pico* view should be taken into consideration when discussing service domains. Internet represents the macro view, where heterogeneity is high, distance between devices is long and coupling is low. Local Area Networks can be seen in light of a micro view, where heterogeneity is usually low, distance between devices is low and coupling is a bit higher. Personal Area Networks can be considered as part of a pico view, where, opposed to what is natural to believe, the properties are a combination of the two former views. A PAN can be subject to great heterogeneity in the devices, but distance between devices is small and coupling is initially low.

A complete service should embrace service elements belonging to all the domains as shown in Figure 6. The concept of a Virtual Home Environment proposed by 3GPP for third generation mobile systems allows a user to roam to foreign networks while keeping access to all services that they subscribe to in the home network. Unfortunately, the availability is restricted mostly to mobile telecom services. "Although OSA/Parlay define open APIs that enable data services in the Internet to access and exploit capabilities in mobile telecom networks (e.g. positioning information), these APIs are still restricted both in access by service provider and in what features they can provide. Taking this concept further, the ultimate goal would be to provide ubiquitous access to any data service no matter where the service content and service logic have their origin.

As shown in Figure 6, one important service domain is the Home Network of the user. In fact, more and more people get connection to the Internet at home through a permanent, broadband connection (xDSL, Cable or similar). Some of these have their own LAN at home. As a result, this home network constitutes an important host for personalised services. To offer a more complete service to the consumers, it is important to investigate solutions providing access to services located in the home network.

Ultimately, mobile services will be provided as distributed services where the logics residing in different places will cooperate in delivering the end-user service; i.e. composite services of disjoint service domains.

With this distribution service logic and service content throughout the networks, new challenges arise. In particular, how can service continuity be assured across different domains? Assuming mobility in the network layer is solved, communication sessions can be transferred across different IP subnets. However, this is not enough. For the generic service discussed in II, transfer of a communication session (e.g. real-time stream of video) is not relevant until the appropriate user agent (or service logic) is available on the terminal in question. In addition, service content that is available within a private IP network might not be routable to a terminal outside the private network due to firewall restrictions.

Several parameters will influence the service continuity across devices and networks, and possible classification criteria could be:

1. Synchronous or asynchronous communication model
2. Centralised or distributed architecture
3. Communication-based or data-based service

For each of these categories of services, the goal is the same; the global state of the service must be transferable across networks and devices.

For voice services, service continuity is in large covered by the term *session mobility*. In mobile telecommunication (e.g. GSM), continuity of a voice call is supported by handovers between base stations. It is when it comes to a combination of voice and data services *service continuity* has something more to offer than session mobility.

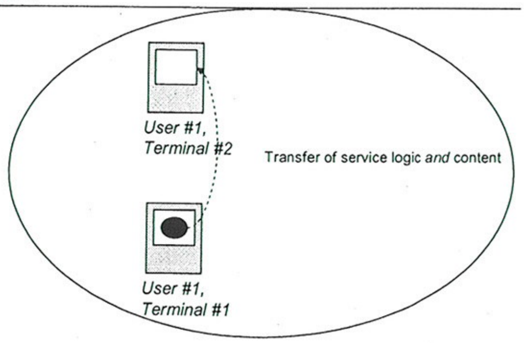

Figure 5: Transfer of a standalone service.

Figure 5 displays a typical scenario. The service is provided by a standalone application running on a handheld terminal. This example service is transferred between two devices part of the same network and service domain. Due to this, the service can possibly be transferred directly between the devices (they can communicate directly). With devices part of different networks and service domains, the complexity increases. This situation is depicted in Figure 6, where a shared intermediary node is used for transfer of the service between the two devices.

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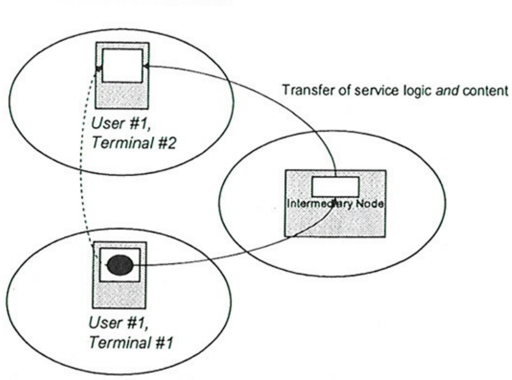

Figure 6: Transfer of standalone service across domains.

With the support of IP based communication technologies (SIP/Voice-over-IP) it has been experimented with transfer of ongoing sessions between various devices [5]. For a data based standalone service, however, there exists no opportunity to move the global state of this service from one cellular phone to another, thus, service continuity is not realised. This could be solved by the service continuity layer introduced in Section III.

A combined communication and data service session could contain information about the peer(s) that should also be transferred when moving the voice call from one device to another. This information could be present in a User Profile on the Internet provided by an XML Web Service [6], but the information about how to access this profile must be transferred together with the voice session.

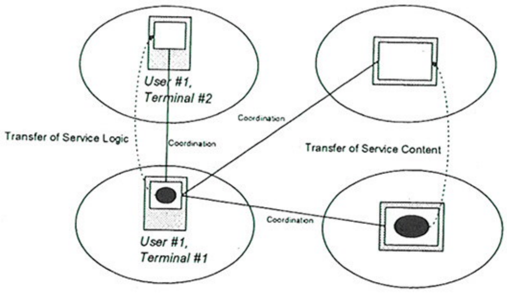

Figure 7: Transfer of a distributed service.

Another scenario is displayed in Figure 7. The service is a data based service rendered by two software components; a client and a server. The global state of this service consists of both the state of the logic and the state of the data. Moving the service from a PDA (with WLAN connection) to a cellular phone means having support for the same service logic on both terminals. In practice, this means that both terminals must have the same application runtime environment (e.g. J2ME CLDC/MIDP) as a least common denominator. In addition, protocols for either accessing the service content remotely, or for transferring completely (replicating) the content down to the cellular phone must exist. In the example, both client and server are transferred between the two domains. Other combinations are possible, for example where only the logic or only the content is transferred. The actual solution depends on several factors, where available runtime environments and access restrictions on devices and in networks are of the most important ones.
As has been displayed, extending the service domains for mobile services poses challenges on the service architectures, and additional middleware layers and service components must be introduced to allow for seamless service continuity.

C. Service Continuity in PAN Based Services

Nowadays, each individual is using several devices like mobile phones, PDAs, digital cameras, GPS, etc. that are autonomous and functioning independently of each other and without any coordination. In fact they are not even aware of the presence of other devices. As the owner the user is required to handle them all and does not always succeed since as a human being he cannot perform many tasks at the same time. With the emergence of wireless short-range technologies like Bluetooth, WLAN and potentially UWB (Ultra Wide Band), Personal Area Networks can be formed to allow communications between devices. The Virtual Device [7] is a novel concept, which considers all the autonomous devices on the user's Personal Area Network as one big "Virtual Device" having multiple input and output units and providing a coherent and surround interface to the user. The Virtual Device concept paves the way for innovative and exciting services. An example is shown in Figure 7.

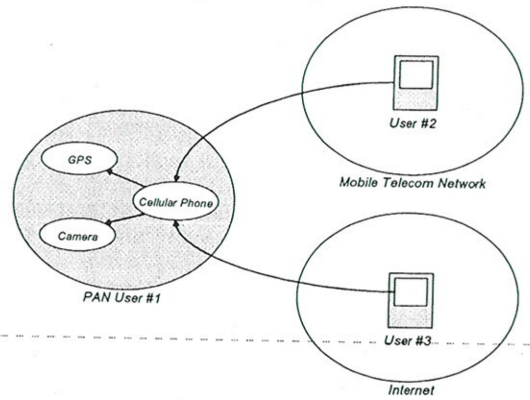

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Figure 8: Providing access to resources in a Personal Area Network.

The User #1's Virtual Device consists of a cellular phone, a digital camera and a GPS receiver. Since it has multiple inputs and outputs multiple services can be executed simultaneously. The first one may supply User #1's location information to User #2 and the second one may show real-time pictures for User #3.
Every PAN becomes a service domain and potential host for service logic and service content as discussed in the previous section.

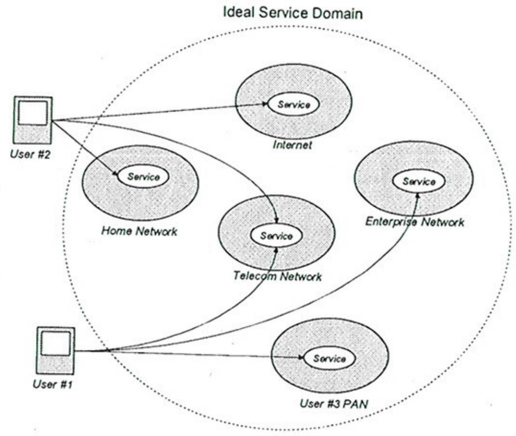

Figure 9: An ideal composite service spanning over several domains.

IV. Service Continuity and Personalisation

It is not trivial to see that service continuity and service personalisation are two related issues. Service personalisation, however, means that all services a user accesses and uses are in one way or the other tailored to his/her use. Without support for service continuity, the personalisation breaks down because other similar services, but without the personalised content, must be taken into use. Consider the use of a bookmark service at home and at work. These are the same services (same type of service logic), but they do usually not support service continuity and thus not personalisation, because the service content differs.

Personalisation has for many years been regarded as an important feature of mobile services. However, a clear picture of what personalisation means, and of exactly what should be subject to personalisation, is lacking. A psychology study [8] defines two categories of motivation for personalisation:

- To facilitate work
- To accommodate social requirements

Until now, most personalisation efforts of mobile services have been to accommodate social requirements, whereas a big potential exists for services of the first category.

Personalisation is not a simple and discrete concept to understand, because it can be performed at several levels:

1. Individual Service Personalisation
2. Personalisation of Service Portfolio
3. Personalised Service Composition

Individual service personalisation is the common way of thinking personalisation. It means changing parameters of a single service to accommodate a specific user's needs. Such parameters can be *passive* (look and feel of the service), *active* (behaviour of the service) or *content related* (user added content, result of service usage). The user-defined values of the personalisation parameters are captured in the user profile that can be distributed or replicated in all the five domains: Telecom Networks, Internet, Enterprise, Home and PAN. Little work has been done on the distribution and organisation of the user profile and they will be subject to future studies.

Personalisation of service portfolio means that a user makes certain services easily available through a portal or menu system. Such personalisation is done on most PCs, where different users have different services/applications available through the desktop environment (or Quick Launch Bar in MS Windows).

Personalised service composition means that users can "create" their own services by picking discrete service components and combining them into a complete service. This, however, is a novel concept that needs further investigation.

Taking the analysis of personalisation concepts further will help us reach specific requirements to the service architectures, middleware and platforms that are needed for the evolution of mobile services.

V. XML Web Services and Service Continuity

Service continuity depends on services to be *reachable*; both service logic and service content. With divergent network technologies, increasingly strong security requirements on enterprise and private networks, as well as restrictions based on political issues within mobile telecom networks, it is not given that everything is ubiquitously reachable, although every network soon is IP based and share the same address space.

XML Web Services [9] is a technology that must be carefully considered with respect to service continuity, because it addresses issues like how to "circumvent" firewalls. From a security perspective this is bad, but for true service continuity in future mobile services to be realised, technology to allow generic services to bypass firewalls, without compromising security, is needed. Another advantage of using XML Web Services for realising service continuity, is that the technology is platform and programming language independent. As pinpointed in subsection III.B, mobile services should ideally span several domains; thus various platforms and components developed in various programming languages must be able to interact. This can be done with XML Web Services.

A couple of scenarios for letting services bypass firewalls are:

1. Employ XML Web Services and use HTTP port (80) for communication, since most firewalls accept such communication.
2. Customise firewalls to be even more stateful than today, i.e., allow inspection of higher-layer packet header information (e.g. CORBA headers).
3. Employ Virtual Private Networking
4. Employ specialised proxies on the inside or outside of the firewall.

The fourth solution can be beneficial to combine with for example XML Web Services. A scenario can exemplify this. Usually, a router forwards packets destined for a specific port to a single computer on the network inside of the router. To allow access to more than one computer on the inside of a router, from the outside, an XML Web Service proxy could be installed on the inside of the router, and this proxy could inspect protocol header information to decide to which computer the corresponding request/response should be sent. To allow personalisation for every individual that has a computer connected to a network behind a firewall, a similar architecture is needed. In Figure 10, the stapled lines display how initially access only to services on one computer is possible (due to port forwarding in the router), while when employing a Web Service Proxy, as well as additional service/user identifiers in the header of the SOAP messages, allows every user to access their personalised service in the enterprise network.

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VI. Conclusion and Future Work

This paper addresses the requirements of future mobile services by taking on a holistic view of the composition and architecture of such services. The building blocks of generic mobile services are described and their distribution throughout network and devices is emphasised, with additional focus on an expanded view of the future service domains for mobile services. In particular, the concepts of service continuity and personalisation are related to the composition of generic services.

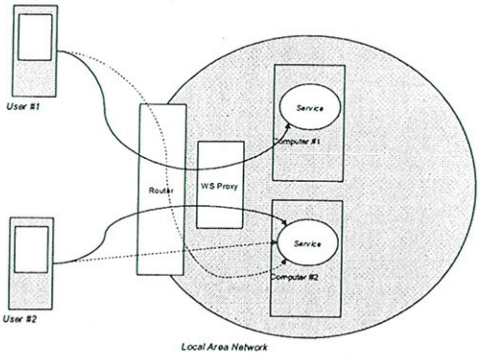

Figure 10: Individual service access with XML Web Services.

A new layer called the Service Continuity Layer is introduced to support mobile services. More specifically what functionalities this layer should provide as well as implementation related decisions are important topics for further studies. XML Web Services, and its properties, is suggested as an enabling technology that can be a catalyst for the development and deployment of future services that provides continuity and personalisation across multiple domains. However, this will not be without the support of other technologies. Therefore, a more detailed study of service composition, multiple-domain services, service continuity and personalisation should be carried out as future work. In particular, an in depth study of what inter-domain services will need in terms of additional middleware and suited technologies must be performed.

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