CONCEPTUAL SERVICE ARCHITECTURE FOR ADAPTIVE MOBILE LOCATION SERVICES ON THE NEXT GENERATION WIRELESS NETWORK

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ABSTRACT

This paper presents a conceptual service architecture for adaptive mobile location services, which is designed to be used in the open service environment of the next generation wireless network. The designed service architecture consists of a set of concepts, principles, rules and guidelines for constructing, deploying, and operating the mobile location services. The service architecture identifies the components required to build the mobile location services and describes how these components are combined and how they should interact. As a means of exploring and validating the designed architecture, a scenario representing a novel mobile location service utilizing the architecture has been developed, and an illustrative case study of this service has been carried out to demonstrate the interactions between different components in the architecture and to demonstrate the applicability of the architecture

Keywords: Service architecture, Mobile location services, Context-awareness.

1 INTRODUCTION

Mobile location services refer to mobile services that provide information based on the geographical location of people or objects. Mobile location services exploit location technologies for determining where the user is geographically located, thus making the provision of different services based on a given location possible. Since 2000, countless mobile location services have been launched on 2G and 3G networks in different parts of the world. The areas with the greatest attention to providing mobile location services are Asia, Western Europe and North America, each with very different technologies, different business models and different outcomes. Mobile location services have been taken up more enthusiastically by mobile users in Asia, especially in Japan and South Korea, compared to other parts of the world. However, the overall usage of mobile location services is still not very high compared to other entertainment and messaging services. One of the main inhibitors to the adoption of the existing mobile location services, besides the lack of location methods that can provide high accuracy location information in closed environments (e.g. inside buildings and undergrounds) and urban areas, is the lack of adaptability and offerings tailored to different users' requirements in particular contexts of use [1][2].

The existing mobile location services are typically available locally within the network of specific operators or available on different networks of different operators in the same country. Universal access is not supported by the existing mobile location service. The sharing of network resources and information resources (i.e. location information and user profile) between different stakeholders is very limited or not possible. The way mobile location services are offered today is not compatible with the open service environment of the next generation wireless network.

The next generation wireless network is based on functional integration and convergence of heterogeneous wireless access networks [3][4]. The next generation wireless network includes not only cellular networks but also emerging wireless access networks such as WMAN, WLAN, WPAN, high speed portable internet, digital broadcasting networks and other forthcoming wireless technologies [5][6]. These wireless access networks will coexist to provide a variety of multimedia services via a common IPv6-based network (i.e. all-IPv6 network) [4][5][6]. The service environment of the next generation network will be open, and the users will be able to access a mobile service regardless of geographical location, terminal model, access network, network operator and service provider [1] [3][4]. Service providers and content

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[1] A service provider offers different kinds of mobile location applications and services (based on the location information obtained by a mobile location technology) via a mobile network to a user requesting the content (e.g. traffic information, weather information, restaurant list, etc.) provided by the content provider.

providers will be able to provide their services and content independently from the operators. Location and charging information can be transferred among networks and applications [4]. Both seamless roaming and universal access is expected to be achieved in the next generation wireless network. Mobile terminals and networks will be multi-mode, operating at different frequencies and using a variety of wireless access technologies.

This paper proposes a conceptual service architecture for adaptive mobile location services, which is designed to be used in the open service environment of the next generation wireless network. The architecture supports a provision of new-concept mobile location services that are not possible with the existing service architecture on the current mobile networks. The provision of mobile location services that allow users to access a service and content based on the location information of other users on the all-IPv6 network will be possible with the service architecture proposed in this paper. For example, the location-based information service may be provided based on the location of other users at the global-level instead of based on the current location of the user himself like the services available today.

The proposed service architecture fits in a multi-supplier/provider/operator environment and which allows the coexistence of a number of stakeholders performing various roles. The service architecture supports universal service access and the end-users are allowed to access a service independently of the physical location, type of access network and type of terminal being used by the users. One of the important features of the designed architecture is adaptability. Based on the analyses made in [1][2], the lack of adaptability is one of the inhibitors of the mobile location services' take-up. Adding adaptability to the designed architecture, the service's behavior and content can be adapted to best fit with the user's expectations, requirements and/or preferences in a particular context of use. This is the way to improve the quality of a mobile user experience and also improve the possibility of being successful for mobile location services.

The importance of user experience to the successful of mobile location services and the influences of context of use (i.e. environment where the service is used) to the user experience formation is presented in section 2. Section 3 presents adaptation possibilities for mobile location services. Section 4 presents user profile and service and content profile which are required in the process of service adaptation. The platform for context-based service adaptation is presented in section 5 and the conceptual service architecture for adaptive mobile location services is then proposed in section 6. The case study of a novel mobile location service utilizing the designed service architecture is made in section 7 as a means of exploring the developed service architecture as well as demonstrating its applicability. Concluding remarks are given in section 8.

2 THE INFLUENCE OF USER EXPERIENCE AND CONTEXT OF USE

The term "user experience" is used more and more in discussions and articles instead of the term "usability", as it is believed that context, emotions, expectations, and overall service processes are becoming more important than ever with regards to mobile services [7][8]. The user experience is the experience that the user gets when using a service in particular contexts of use [8]. Good user experience is one of the important factors in providing successful mobile services, as the users' willingness to continue paying for a service depends on whether or not they get a good experience from using it [8][9]. The users' expectation is the fundamental concept behind the user experience formation, and how good an experience the users get varies depending on how well the service matches their expectations, requirements and/or preferences in particular contexts of use [8][10]. If the service fails to live up to the user expectations and does not meet the user's requirements, the trust towards the service is violated, which can lead to different emotions such as disappointment, anger and annoyance, and this will form a negative user experience [10][11]. In order to provide a mobile service with a positive user experience, the service must be adaptable to match the user expectations, requirements and/or preferences in particular contexts of use.

In the case of a mobile location service, different users use a service at different places and times and in different situations. They access the service through different mobile networks using different location technologies, which provide different levels of data rate and different levels of accuracy. They want to accomplish different tasks using different terminals with different user interfaces. They use the service in different roles and with different social aspects. Using the same service in different contexts of use can result in significantly different levels of user experience [7][12]. For example the service may appear funny or annoying depending on how busy the user is. The quality of the user experience is likely to be improved and the service has a high possibility of being a success if the content of the service can be filtered based on a particular context of use and if the service behaviors can be adapted to match the current context of use.

Figure 1 illustrates the relationship of the five perspectives of the context of use (users, tasks, technologies, physical environments and social environments), where the physical environment plays an important role in the context model of mobile location services.
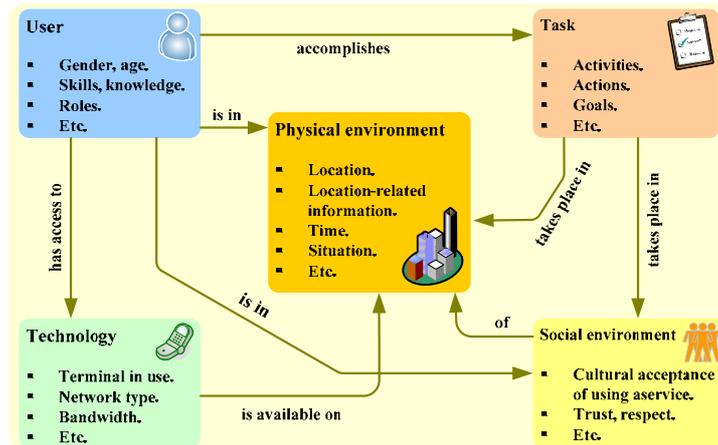
Figure 1: Generic context model of mobile location services. User-service interactions take place in a particular physical environment (location) with particular social and culture patterns (social environment), which may influence the user's behaviors, expectations, preferences and requirements. The interactions between the user and the service are made through the technology context, e.g. mobile terminal and network, available at the user's current location.

The five perspectives of the context of use presented in figure 1 are described in the following.

Users: User refers to people or groups of people who interact with the service [13]. The purpose of designing the service is to fulfill the users' needs and help them finish their tasks and reach their goals. It is therefore very important, when designing a mobile location service, to know who the target users are, what they want, how they want it, where and in which situation they want it.

Tasks: Tasks are the activities undertaken to achieve a goal [13]. To achieve the goal, the user might need to accomplish several tasks. Knowing the current tasks of the target users gives the service designer the opportunity to predict the next task and the fundamental goals of the users. This opens many opportunities to design a successful service; coming up with new tempting tasks, reducing the number of annoying tasks, or making the completion of a task easier can make the service become a success [8].

Technology: Technology context means the technologies involved in providing mobile location services. The technological context is one of the most important parts with regards to how the service will be experienced. Knowing the technology context gives an opportunity to a service developer to know how the service should be designed and how the available technology can be used to improve the quality of the user experience in particular contexts of use.

Physical environment: The physical environment is the obvious factor which directly affects how the user will experience a mobile location service. For mobile location services, the ability to pinpoint the location of the user varies depending on the physical environment. High accuracy location information might not be available

when the user is deep inside buildings or the accuracy might be degraded when the user is in rural areas. Designing a mobile location service should take these context attributes into account and the service should provide alternative ways for the users to complete their task when the quality of the service is degraded because of the physical environments (e.g. an option of determining the user's location manually).

Social environment: Social acceptance, the way people think about other people, has a profound effect on the ways people behave and think [8]. Social environment has a significant influence on the service adoption of the user [14]. The social acceptance of technology and its applications and services determine how and when it is used. Therefore, it is essential to know how certain technologies and services are perceived in the culture where they are supposed to be used, and what social rules apply in connection to the service usage.

3 ADAPTATION POSSIBILITIES FOR MOBILE LOCATION SERVICES

The context-based service adaptation can take place at five different levels: Technology level, service behavior level, user interface level, presentation level and content level [15]. The five different levels of service adaptation are described in the following.

Technology level: In this level, the service is adapted to the technology context. For example, information is encoded for specific mobile terminals with different characteristics (e.g. display size and resolution, memory, CPU power, etc.) or to the transmission media (e.g. network bandwidth).

Service behavior level: The service behavior is adapted to the user's tasks and physical environment.

For example, the parents define in their profiles (task related information) that the location notification of their child should be sent to them every hour on the weekday and location notification should not be delivered in the weekend. The service behavior will be adapted based on this information and the parents do not need to interact with the service every hour in order to check their child's whereabouts. An example of service behavior adaptation based on the physical environment context is the zone alert feature of a tracking service, where the alert message is sent to specific persons when the user leaves a pre-defined zone.

User interface level: The user interface is adapted to the user's tasks, the system in use (e.g. terminal and network), and the user's physical conditions. For example, the user interface is changed from graphic user interface to voice interface when a blind user is accessing the service or when a user is driving. The user interface may also be adapted to a child-friendly version when the child is accessing the service. The service adaptation in the user interface level requires that the terminal can support different kinds of user interfaces; otherwise adaptation in the user interface level is limited or not possible.

Presentation level: The visualization of the service is adapted to user, tasks, system in use (e.g. terminal and network), social aspect, and physical condition of the user. For example, the visualization of the service is changed based on social aspects (e.g. mature look for European users and colorful version for Asian users), or text information is presented with "large text" when elderly people are accessing the service [16].

Content level: In this level the content of the service is adapted to the current location, situation and user (e.g. age groups, gender). For example, the system detects that the user is a child, and the service then adapts the content to an "easy to understand and child-friendly" version.
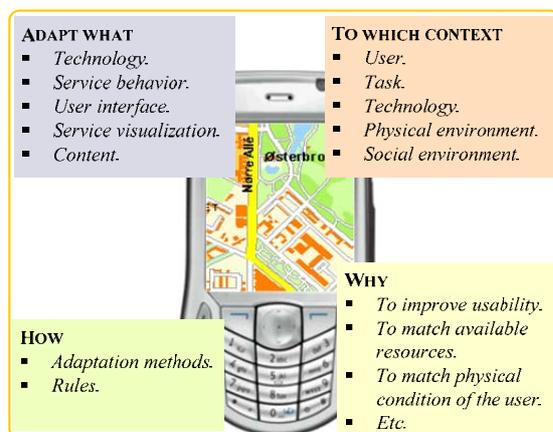
Figure 2: Perspective of the context-based service adaptation for mobile location services.

Figure 2 gives an overview of service adaptation illustrating why the service should be adapted, how and to which context.

The service adaptation can be activated when the context is changed. The change of context can be the change of one or more perspectives of use contexts (e.g. change of user, terminal, location, etc.). The context-based service adaptation platform proposed in section 5 will minimize the need of interactions between the user and the service without taking the overall control of the system from the user. To support the context-based service adaptation, the user profile and service and content profile are required.

4 USER PROFILE AND SERVICE AND CONTENT PROFILE

The user profile is merely a conceptual entity representing a unique lifestyle and current context surrounding and situation of a user. Any user profile will contain details of the user and his personal requirements in a form that can be used by the system to deliver the required behaviors [16]. In some proposals, e.g. in the MAGNET project [17], the user related information (i.e. user profile in the MAGNET project) is maintained separately from the context information. This allows the service adaptation to be based on the user related information alone which will result in an adaptive personalization service. If the context information is also applied for the adaptation, the result will be a personalization and context-awareness service. In other proposals the user profile contains information related to both the user and context attributes, e.g. the user profile management specified by European Telecommunications Standards Institute [16], the user profile proposed in ePerSpace project [18] and the user profile specified in the TINA service architecture [19]. The user profile in this paper is compatible with the user profile proposed in ETSI, ePerSpace and TINA, where the user profile contains the user's related information, user's personal requirements, and attributes of the current context of use.

The information maintained in the user profile should be real-time and up to date information. The user profile can be viewed and modified by the user and/or an agent of the user upon the user's permission. The information maintained in the user profile and used by the context-based service adaptation platform proposed in section 5 is the information related to the user, task, terminal, physical environment and social environment. These five groups of information are the fundamental part of the user profile, as they are unique for each individual user. The groups are related to the current context of use where the user is a part of the context as presented in section 2. The users create some part of the user profile (e.g. user related information and

task related information). The terminal related information is provided by the terminal itself, and the location related information is analyzed from the location information which is delivered from the location server upon request or upon the user's privacy rules regarding the usage and sharing of location information.

The service and content profile is a set of information related to a service and the content provided by the service. This profile is established and managed by the service and content providers. The service and content profile is maintained in the application and content server. It contains information about what the service can and cannot provide to the user including the information of adaptation possibilities.

5   CONTEXT-BASED SERVICE ADAPTATION PLATFORM

An adaptive mobile location service, in this paper, is a service that is able to adapt itself according to the changes of use contexts (or context of use). Not all services can be adapted or are able to adapt themselves, and adaptive mobile location service refers to the fact that adaptation is in principle possible. In some cases, service adaptation requires that the mobile terminals have capabilities for supporting the service adaptation (e.g. supports different kinds of user interface and different input and output channels).

Two adaptation processes can be applied for the real-time context-based service adaptation for mobile location services: Self-adaptation and user-controlled self-adaptation [20]. In the self-adaptation process, the service adaptation is driven by a computer based on the information collected by the system (e.g. user's behaviors, preferences and roles). Since the self-adaptation process is made without the user's control, the outcome of the adaptation cannot be guaranteed to match the user expectations and requirements in a particular context of use. Another obvious problem of the self-adaptation approach is the lack of data protection or privacy, as the information related to the user is collected by the system without the user's control. For the user-controlled self-adaptation process, the adaptation conditions (e.g. how the service should be adapted, when, where and in which condition) are defined by the user.

From the user experience point of view, the user should always have control over the behaviors of the service. As the self-adaptation process is controlled by the system without definitions of the user, it is not an appropriate approach for the service focusing on the user experience.

The service adaptation proposed in this paper relies on the user-controlled self-adaptation, where the service adapts itself based on the conditions defined by the user only. The service based on user-controlled self-adaptation only works if it is easy to understand and if the user knows how to define and control the service adaptation [21].

Mobile location services can be adapted to the use contexts in five different levels as presented in section 3. This section describes the process of context-based service adaptation based on the context attributes stored in the user profile together with the service and content profile. The context-based service adaptation for mobile location services proposed in this paper is based on three principles:

1. The user should always have full control of the service adaptation (the user can decide whether he wants adaptation at all or at certain levels).
2. The service adaptation has to be transparent meaning that the user should know that adaptation is taking place and it should be in the form of suggestions whenever possible. For example, if the service is going to adapt the user interface from text to voice in order to fit with the current context (e.g. when the user is in a driving car), the user should know that the adaptation is going to take place. The adaptation notification may be sent to the user in the form of interaction message and the user can choose whether he would like the adaptation to be performed at all. The user might turn out to be a passenger who is sitting in a taxi rather than driving the car.
3. The user should always be able to manually adapt the service behaviors. The manual adaptation should be allowed at the same levels as the adaptive behavior of the system.

Figure 3 shows the conceptual platform for service adaptation based on the context of use. This platform is placed at the application and content server, which is owned by the service provider. The components included in this platform are a change measurement unit, a trigger and an adapter, and the information required for the adaptation process is in the user profile and in the service and content profile. The change measurement unit detects changes in the attributes of the current context of use stored in the user profile, the trigger triggers the service adaptation and the service adaptation unit adapts the service to best fit with the current context of use.
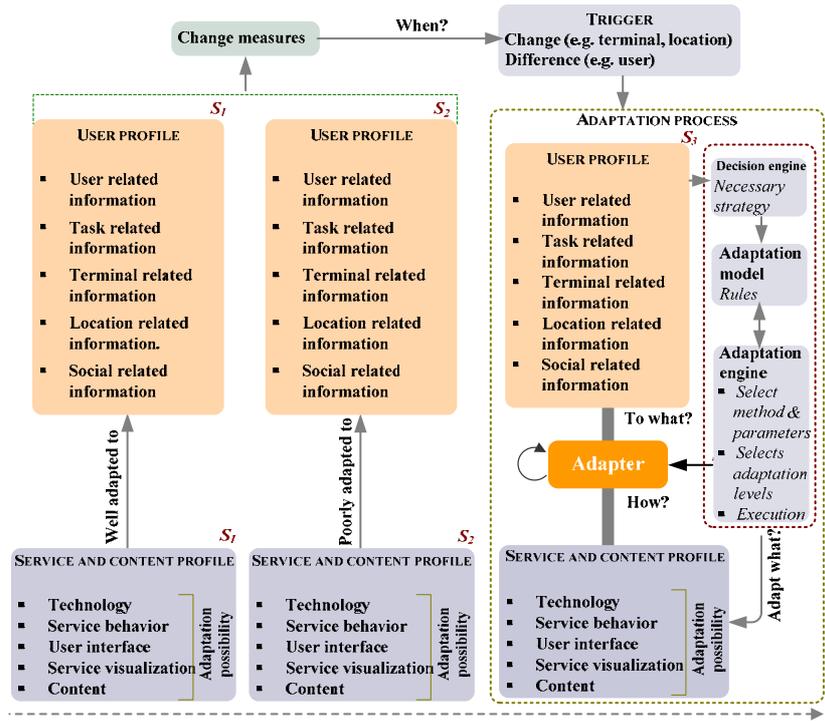
Figure 3: Context-based service adaptation platform for mobile location services inspired by [22].

The service adaptation is triggered by any change or difference of context attributes (stored in the user profile) between stage S_1 and S_2, exceeding a specific threshold level. The threshold value (e.g. pre-defined location, pre-defined time, etc.) may be found empirically or set by the user beforehand. These threshold values indicate states where one or all of the technology, service behavior, user interface, presentation (or service visualization) and content levels do not fit well to the user's requirements or preferences in his current context of use. An adaptation could also be triggered manually by the user while he is using a service. Differences of the context attributes stored in the user profile between stage S_1 and S_2 could, e.g., occur when the attributes of the current context of use surrounding the same user is changed (e.g. change of location or change of social environment, etc.).

When an adaptation is triggered, the context parameters are sent to the decision engine. The decision engine checks whether the adaptation is necessary. If an adaptation is necessary, the decision engine selects an appropriate adaptation strategy. Then the rules for service adaptation are selected from the adaptation model, and the adaptation engine selects the appropriate methods and parameters. Furthermore, the adaptation engine chooses the adaptation levels of the service (i.e. technology, task, user interface, presentation, or content levels) that will be adapted. The last step builds the adaptation execution, i.e. activates the adapter. This adapter adapts the mobile location service by applying the chosen methods, parameter values and rules.

The context-based service adaptation platform presented in this section is an important part of the service architecture for adaptive mobile location services proposed in the next section. The main task of the conceptual platform for context-based service adaptation is to adapt a mobile location service to best fit with the user's expectations, requirements and/or preferences in a particular context of use, which is the way to improve the quality of a mobile user experience and thereby increasing the possibilities of making a mobile location service successful.

6 SERVICE ARCHITECTURE

This section presents the conceptual service architecture for adaptive mobile location services which is designed to be used in the open service environment of the next generation wireless network. An adaptive mobile location service refers to a mobile location service that is able to adapt itself according to the changes of context of use. The architecture supports a wide range of services and allows the provision of new-concept mobile location services that have not been possible on the current network. The architecture supports the universal service access and the end-users are able to access services independently of the physical location, type of access network and the types of terminal being used.
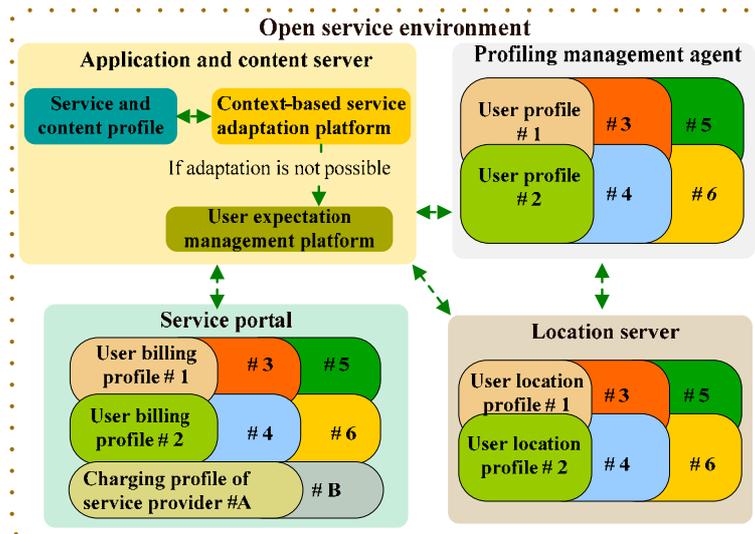
Figure 4: New conceptual service architecture for adaptive mobile location services on the next generation wireless network.

Figure 4 illustrates the components that form the service architecture, and the descriptions and roles of the individual components are given in the following.

The service portal handles session management, requests handling, authentication of subscribers and manages the billing system. The service portal contains the "user billing profile" and "service provider charging profile". When the user accesses the service, the service usage will be recorded and the billing and charging reports will be updated in the user billing profile and service provider charging profile, respectively. The user and service provider can access and check their profiles at anytime regardless of geographical location, access network, terminal model and network operator. However, editing and deleting of the profiles is not allowed. The user billing profile contains the actual information of the user, which is required for billing management such as the real name, real address, telephone number, credit card number and a list of subscribed services. The service portal allows users (or subscribers) of different network operators to access the services of different service providers from anywhere on the all-IPv6 network with the feasibility of managing the billing for the users and revenue sharing between different stakeholders. The service portal is placed in every domain and it is owned and managed by the network operator who administrates the domain. The service portal makes it easy for the user and service providers, as the user can use different services without having to pay different bills for different service providers and the service providers do not have to handle the billing management of different users but instead let the network operator handle this task.

The application and content server handles different tasks from providing the service and content to the user and adapting the service

behaviors and content to best fit with the user's requirements in a specific context of use to manage the user experience towards the service. This server is owned and managed by the service provider. The context-based service adaptation platform plays an important role in adapting the service to best fit with the current context of use as previously presented in section 5. Adapting the service to best fit with the current context of use is the approach to manage the user experience in the usage stage of the service, as the context plays an important role in defining how the user will experience the service [8]. The service adaptation is made based on the current context of use and the adaptation conditions defined by the user and maintained in the user profile, and the service and content profile created by the service and content providers, as previously presented in section 4 and 5

Another task of the application and content server is to manage the user expectation, and this task is handled by the user expectation management platform. The main task of this platform is to inform the user about the service (e.g. if the service is temporarily unavailable, new features, new service update, etc.) and to inform the user of the reason and further suggestions in the case that the service adaptation requested by the user cannot be made (e.g. 3D navigation is not possible because the user's terminal does not support 3D display). This is the platform that controls the user experience by providing an understanding of what the user can and cannot expect from the service. This approach prevents the user from generating unrealistic expectations that the service cannot live up to.

The profiling management agent has been added to the developed conceptual service architecture to support the idea of one network many services, where different service providers provide their services on a common IPv6 network (i.e. all-IPv6

network) [2]. The profiling management agent allows users to access different services from anywhere on the all-IPv6 network and still being recognized by the service providers. The profiling management agent can be placed anywhere on the all-IPv6 network and it is owned by a new stakeholder, which in this paper is called the "profiling broker". The role of the profiling management agent is to maintain, manage and update the user profile of registered users as well as to handle authentication and authorization. This agent acts as a broker handling the usage and sharing of the information in the user profile according to privacy rules defined by the users. Based on the open service environment concept of the next generation wireless network, the users should be able to access, edit or delete their user profiles anywhere and any time they desire [3].

The location server maintains the location information of all registered users on the local domain (the local domain is a collection of networks that are aggregated together based on factors such as geographic proximity or administrative control), and to manage authentication and privacy control. This server is owned and managed by the network operator. There should be at least one location server in every domain. In the location server, the location of individual users is stored in a profile called the user location profile. This profile maintains the actual location of the user and the privacy rules of using and sharing this information is defined by the users. As the mobile user may travel into different domains administrated by different network operators, it should be possible to exchange the user location profile between different network operators according to the user mobility. For example, if the user moves from domain A to domain B, the transfer of user location profile from domain A to B should be possible. This requires new mechanisms for handling the user location profile transfer process and the agreements between network operators.

The ways the components in the service architecture, presented in figure 4, interact with each other vary depending on the types of service, adaptation conditions, privacy rules, and context. However, the typical service requests and responses are as follow. The user accesses the service via the service portal. The service portal authenticates the service request, records the service usage and updates the user billing profile and provider charging profile. The service request is forwarded to the application and content server. The application and content server asks for the user profile from the profiling management agent. The location server may send the most up to date location information of the user to the profiling management agent depending upon the roles of using and sharing of location information defined in the user location profile. In the case that the service (e.g. navigation service) requires real-time location information, the application and content server may request the real-time location information directly from the location server. The application and content server then delivers the requested service back to the user.

7   AN ILLUSTRATIVE CASE STUDY OF A NOVEL MOBILE LOCATION SERVICE

The demonstrations of the services based on the service architecture proposed in this paper are made through the "come along with me" scenario presented below. The scenario represents new possibilities of utilizing mobile location services, possibilities that are not possible with the existing service architecture on the current service environment and current network.

With the new-concept mobile location service presented in the "come along with me" scenario, the user will experience a new way of communication. Instead of saying where I am, the user may share her real-time location information on the map (2D or 3D) or even invite other users to travel with her virtually. This will open up new ways of experiencing mobile location services for the future mobile users, as presented in the following scenario.

Scenario: Come along with me
"Claus has an online friend in Thailand who he normally chats with everyday - Mai. Sunday morning, Mai is ready to go shopping at Chatuchak weekend market[2] and she wants to bring Claus along. She wants Claus to get a good impression of the largest weekend market in the world. She will rather bring Claus along in the virtual world instead of explaining how the market is and how she is going to get there. She also wants Claus to get a clear picture of how people spend their weekend in Thailand - the country where all the shops are open everyday from early morning to late at night. She shares her location information with Claus and guides him on the way. Claus can see all the places where Mai has passed by. Claus can look at the real-time route map based on Mai's location and he can choose either a 2D or 3D map. When Mai passes important places, the information box explaining the places pops up on Claus' terminal so that he can get more information about the place and he can, at the same time, chat with Mai about the places he finds interesting and plans to visit together with Mai when he goes to Thailand next summer. Claus can also choose to disable the pop up box and only let Mai guide him on the way".

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[2] Chatuchak market (Bangkok, Thailand) is one of the largest markets in the world. The market is only open at the weekends, Saturday and Sunday from 7 a.m. until late. It covers over 35 acres (142,000 m²) and contains upwards of 15,000 stalls. It is estimated that the market receives between 200,000 and 300,000 visitors each day. This amazing market has nearly everything you could ever wish to buy and many things that you would never want to.

Mai finally arrives at the Chatuchak market by skytrain and now Claus is ready to virtually discover the weekend market together with Mai. Mai and Claus get the feeling of traveling together in the virtual world and they have common experiences to talk about. Claus gets a good user experience from traveling virtually with Mai at the weekend market and he cannot wait visiting Thailand until next summer. He decides to book the ticket and fly to Thailand next weekend and one of his destinations is Chatuchak.

Utilizing the conceptual service architecture for adaptive mobile location services on the next generation wireless network, the mobile location service presented in the "come along with me" scenario can be realized based on the following assumptions.

- The network is an all-IPv6 based network, meaning that all elements on the network can carry IPv6 addresses.
- The conceptual IPv6-based location method developed in [23] is adopted as a location method on the unified IPv6 network. The existing location methods that can provide high accuracy location information such as GPS-based location methods may also be used especially in outdoor environments.
- The service environment is open allowing the users to access the services regardless of location, access technology, terminal model,

network provider and service provider.
- The business agreements of using and sharing user profiles and locations of the users are made between different stakeholders involved in realizing the service.
- The new business model of how to share revenue between different stakeholders has been developed by these stakeholders.
- The billing management is handled by the network operator who owns the network domain where the user is accessing the service.
- The users have already registered for the service presented in the scenario.
- The users have registered for adaptive functionality provided by the service.
- Adaptation conditions have already been defined by the users in advance.
- The user profiles have been generated beforehand through the mobile or web browser.
- The privacy rules have been defined beforehand by the users. The user may also adopt the privacy rules defined by the service provider.
- The user profiles of Clause and Mai are maintained in different profiling management agents located in different domains in different countries.

Based on the scenario and the assumptions described above, the interactions between the elements in the conceptual service architecture are demonstrated in figure 5
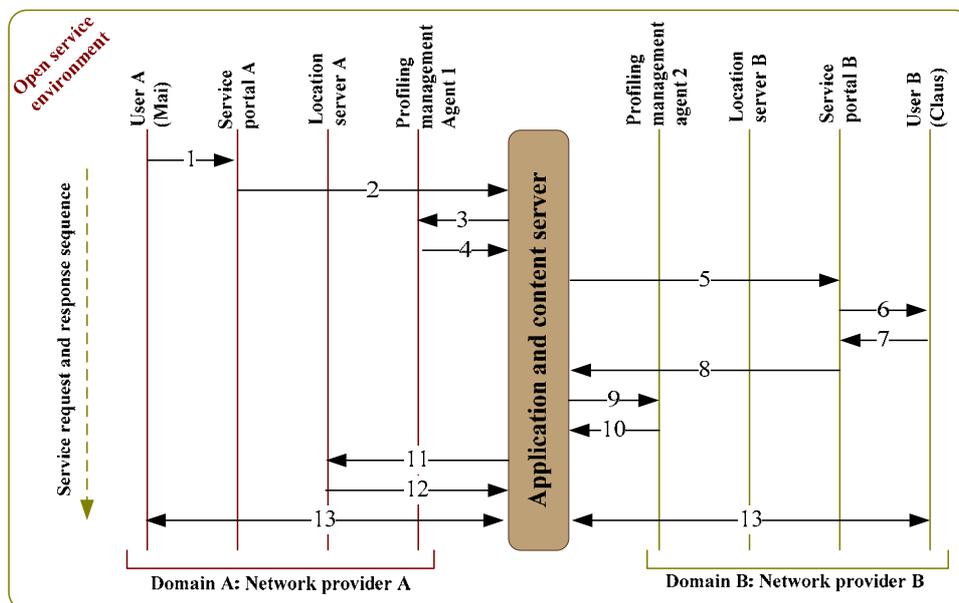
Figure 5: Service request and response sequences based on the "come along with me" scenario. The users are in different domains and different countries. The actual location and the user profiles of the users are maintained in different location servers and different profiling management agents. The exchange of the required information stored in different places owned by different stakeholders is assumed to be made through open standards in the open service environment based on the business agreements made between these stakeholders.

In figure 5, the service requests and response sequences of the "come along with me" scenario start from the point where Mai invites Claus to come along with her in the virtual world.

1. Mai sends a request to the service portal on her current domain via the wireless access network available at her current location.

2. The service portal authenticates Mai's request, records the use of the service for billing management, and forwards the service request to the application and content server.

3. The application and content server requests Mai's user profile from the profiling management agent 1.

4. The profiling management agent 1 provides the information that is necessary for the requested service to the application and content server. This information will be used for adapting the service behaviors based on the adaptation condition set by Mai.

5. The application and content server forward Mai's request to the service portal of the domain where Claus is currently located.

6. The service portal sends the acknowledgement to Claus to ask whether he will accept the invitation to come along with Mai in the virtual world.

7. Claus accepts the invitation, and the acknowledgement is sent back to the service portal. The service portal records the use of the service, which may be used for billing management depending on the business model.

8. The service portal forwards the acknowledgement to the application and content server.

9. The application and content server requests Claus's user profile from profiling management agent 2.

10. The profiling management agent checks the privacy rules set by Claus and forwards the required information in Claus user's profile to the application and content server. This information will be used to adapt the content and service behaviors based on the adaptation conditions set by Claus.

11. The application and content server asks for the actual location of Mai maintained in the user's location profile located in the location server. The use of Mai's actual location is subject to the privacy rules defined in Mai's user location profile.

12. The real-time location information of Mai is sent to the application and content server.

13. The content based on Mai's location is delivered from the application and content server to Claus. This content may be adapted based on Claus's requirements and preferences pre-defined in his user's profile, as Claus is the one who receives information utilizing the location information of Mai. While Claus is enjoying the content based on Mai's current location, Mai has a possibility of controlling the service. She may give Claus permission for receiving information based on her location for one or two hours and this can be disabled anytime by Mai.

Norman has stated in the book "Emotional design" [11] that the service that almost always guarantees success is the service that provides social interaction and emotional connection between people. With the new concept of mobile location services, the mobile users can travel virtually to anywhere in the world utilizing the location of friends or family members. The service based on "come along with me" is not only an information service, but it is a kind of service that provides social interaction and emotional connection between users. The users can get the felling of being together and have a common topic to talk about. This kind of service has a high potential of being a success if it functions as it is presented in the scenario.

"Come along with me" is the new concept of a service utilizing real-time location information of other users on the all-IPv6 network. The service based on the "come along with me" scenario cannot be made available with the current technologies and service environment, due to the lack of open standards and open service environments, and the fact that the mechanism for sharing network resource, information resource (e.g. location information, user profiles) and revenues between the different involved parties have not been developed.

8 CONCLUSION

This paper presents a conceptual service architecture for adaptive mobile location services to be used in the open service environment of the next generation wireless network. In the designed service architecture, the service portal and profiling management agents play important roles in realizing the concept of one network many services. The context-based service adaptation platform, user profile and service and content profile play important roles in adapting the service to best fit with the user requirements in a particular context of use. In the designed architecture, the user profile is handled by the profiling management agent and not by the service provider like the case today. This allows the sharing of the user profile between different stakeholders involved in providing mobile location services. The service provider can only utilize the user profile when the user wants to use the service. This will minimize the privacy concern towards the use of any mobile service. It is obvious that the profiling management agent plays an important role in providing mobile services in the future. The profiling management agent must be trustworthy and the users should feel safe and comfortable allowing the agent to protect the use of their personal information as well as their location information. The developed service architecture supports the

provisions of new kinds of mobile location services that have not been possible on the current network. The services such as global-level tracking service and location-based information services that allow the user to access the information utilizing the location information of other users on the all-IPv6 network will be possible. Adaptability is one of the new and important features of the proposed service architecture. This new feature will improve the quality of a mobile user experience and improve the possibility of being success for mobile location services on the next generation wireless network.

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