Context Hand-Over: Managing User Context for Seamless Service in Changing Places

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Abstract. This paper describes context hand-over that is a user-context-management mechanism enabling a user to be continuously provided with personalized services along with user's location changes. In pervasive computing environments, the increase of user's mobility causes that a service environment surrounding a user frequently changes. This change usually disturbs user's concentration on his works caused by service discontinuity or repeated demands of user profile settings. The proposed context hand-over, managing context between user service space and environment service space, plays an important role in reducing service interruption caused by user's mobility and providing users with harmonious service with the space where the users stay.

1 Introduction

Due to the increase of user's mobility, service environments surrounding a user rapidly change. Such a change enforces users to react on service for harmonizing with a new environment. For example, when a person while listening to music enters to a lounge where other persons are listening to music loudly, the person may react on his service concerning the new environment, e.g. turn-off, volume-up, etc. Although a service environment changes, in general, a user often continues to exploit the previous-place services in the current place. This often causes conflicts between inhabited people and new comers in a place. To avoid conflicts, each user needs to manipulate services whenever user's environment changes. As a result, such a user cannot enjoy service seamlessly and concentrate his attention on the service.

In this paper, we propose context hand-over that is a way to manage context by registering user's context to services in a space where a user enters, and removing the context from the previous space where the user stayed. This enables services to be

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seamlessly provided to a user by delivering the user's context to services in a new space along with the change of a service environment of the user. For providing a user with seamless service but harmonious with a new space, context hand-over differently deals with user's context according to the place type of the space where the user stays. A place type of the space is generated by comparing the place type of environment service space with that of user service space. According to the place type, the user context are registered, updated, and removed on the space by means of context hand-over. And then, some services harmonized with the place type are continuously triggered or recommended to the user. As a result, context hand-over enables services to be harmonized and seamlessly with a new environment surrounding a user by means of continuous registration, update, and removal of user's context along with user's location changes.

2 Service Environments: Space & Place

User's behaviors are heavily affected by "Space" and "Place" where a user stays [1]. This is because service resources are differently installed according to a space, and the way to use the service resource there depends on a place. "Space" represents the boundary and its entity of physical or computational service resources that a user can access [2]. In that, space falls into two groups. First group is user service space (USS) that is generated by a user who brings service resources by means of mobile or wearable devices. The other is environment service space (ESS) that is the area of pervasive service resources in a real or cyber space. On the other hand, "Place" is the valued space with cultural, social, and personal elements by inhabiting a space [3]. Place provides a user with guidelines how to use services in the space where he/she stays. The guideline is generated in terms of cultural backgrounds of potential people who share the space.

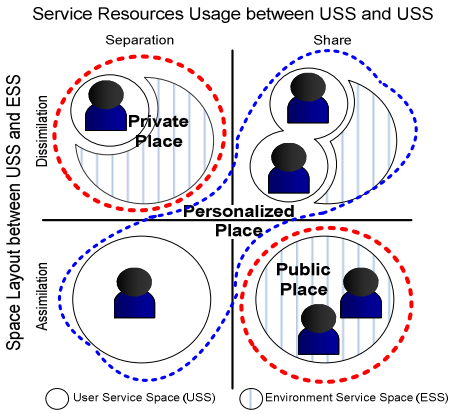

Fig. 1. Three place types depending on space layout and service-resource usage between USS and ESS.

As USS becomes larger, conflicts between USS and ESS increase. Before mobile or wearable computing technology was introduced, USS was too weak to provide a service. Therefore, a user should move himself to an ESS for services. For example, a user went to a phone booth while making a phone call outside. Now, USS becomes powerful through a personal device, e.g. mobile phone, and individual place in the USS grows. However, USS of a user often collides with that of others or conflicts with ESS, since the way of using USS depends on each person. To achieve non-conflict, harmonious and seamless service for any mobile user, therefore, it is necessary context management that negotiates the relationship between USS and ESS from a viewpoint of how a user exploits services in a place, generated by combining both spaces.

3 Context Hand-Over between the User and the Environment Service Space

3.1 A Place Decision Method in Context Hand-Over

One of way to generate a place type for USS and ESS is to investigate the relationship between them. Such relationship divides into two cases: relations between a USS and ESS, and between one's USS and the others.

The relationship between a USS and ESS is about space layout among them, and indicates whether USS or ESS provides user with services. The space layout consists of dissimilation and assimilation between USS and ESS. The dissimilation shows a place where USS is disconnected from ESS, so that a user can keep private space independent of environment space. Therefore, a user is provided with service that comes from only USS. On the other hand, the assimilation shows a place where ESS becomes USS, and vice versa. The place where ESS becomes USS is that the space is completely personalized by adapting itself to one user. In this place, all service resources in ESS are exploited like those of USS. Meanwhile, the place where USS becomes ESS is that the space is public completely, so all private spaces disappear. In this place, all service resources in USS are exploited like that of ESS.

The relationship between one's USS and the others in the same ESS is about overlap among USSs, and implies whether a user shares service with one another or not. The overlap relation consists of separation and share among USSs. The separation shows a place where one user monopolizes all service resources in the spaces. In this place, when a user is provided with services, only service resources in the user's USS are exploited. Or, all service resources are monopolized by one user as if the user stays alone in the space. Besides, the share shows a place where users are provided with a service in common by exchanging a part of service resources in USS or exploiting service resources in ESS.

We assume that a space would have one of three place types, i.e. private, personal, and public, by considering the above relationships between USSs and ESSs, as shown in figure 1. These place types have the following features. First of all, the private place that is the most personalized space allows services to be provided by the only service resources in USS, and disallows services to be shared with other users. An example

can be a body space where a user is listening to music through a mobile phone, while the user is walking in a street. In this case, no user context will be delivered to ESS. Secondly, the personal place is a space that allows one user to monopolize all service resources by extending his USS to the ESS, or enables a part of services in USS to be shared with the other's USS. For example, it can be a lounge where a user is staying alone and listening to music loudly through speakers installed there. Additional example is a space of a young couple listening to the same song together by a mobile device in a lounge where many people stay together. In this case, service information (e.g. service name, parameters, etc) in one's USS is delivered as context into ESS or the other's USS. Finally, the public place is a space where USS changes to ESS, so all service resources in USS are open to be shared by other users in the same ESS. An example for this case is a concert hall where all users are listening to music through speakers installed there as well as mobile radio in order to hear it more clearly. In this case, information about available service resources in USS is delivered as user context to ESS.

A place type of USS and ESS is determined by the following. First of all, a place type of USS is configured by the owner of USS during he/she selects or triggers services in USS. On the other hand, a place type of ESS is primarily set by administrator who manages the ESS. However, the place type of ESS is updated by comparison with the place type of one's USS who enters to the ESS through the expression 1. If nobody occupies ESS, the place type will automatically recover with a default place type.

$$ESS_{Place}(User(i), t+1) = \wedge\{USS_{Place}(User(i), t), ESS_{Place}(User(i), t)\}. \quad (1)$$

Here, $ESS_{Place}(User(i), t)$ and $USS_{Place}(User(i), t)$ represent a place type among private, personal, and public. We assume that the place type would have the descendent order (i.e. public < personal < private). $User(i)$ is an instance of a user who is in USS or ESS. Symbol t is time.

If the place type of USS or ESS is private at time t, the ESS seems to be private place to the user at time $t+1$. This means that the services activated in a previous place continue to be provided within the service resources of USS after the place changes. For example, a music service within a personal device continues to a user who walks in a street, or a music service within a speaker in a lounge is seamlessly provided by switching into each user's personal devices after a stranger comes.

If the place type of USS or ESS is personal at time t and the both are not private, the ESS seems to be personal place to the user at time $t+1$. This means that services of USS are continuously provided through service resources of ESS or other's USS. While a music service was provided within mobile devices, for example, a user enjoys the music service through speakers of ESS when the user stays alone there. In addition, a user passes the information about his favorite music to other's USS so that the other enjoys the music within his mobile device.

If the place type of both USS and ESS are public at time t, the ESS seems to be public place to the user at time $t+1$. This means that individual service for each user is unacceptable in this space. Therefore, individual services of USS are interrupted and replaced with services of ESS. For example, when users are in the meeting all individ-

ual services are inactivated such as mobile phone call and music service. The users are provided with meeting services through ESS as well as USS, and control the meeting service by means of their mobile devices.

3.2 Context Hand-Over

Context hand-over is a context-management method delivering user's context from USS to ESS whenever a user enters into a new space. Relationship among USSs and ESSs provides a guideline to decide whether user's services in USS are continued or not. The context enables services in ESS to adapt to the user. In the context hand-over, the place type of those spaces plays an important role in negotiating the relationship between USS and ESS. By comparing place types of USS and ESS, the place type for both ESS and USS is regenerated and set. According to the regenerated place type, then, what will deliver as user context from USS to ESS is determined.

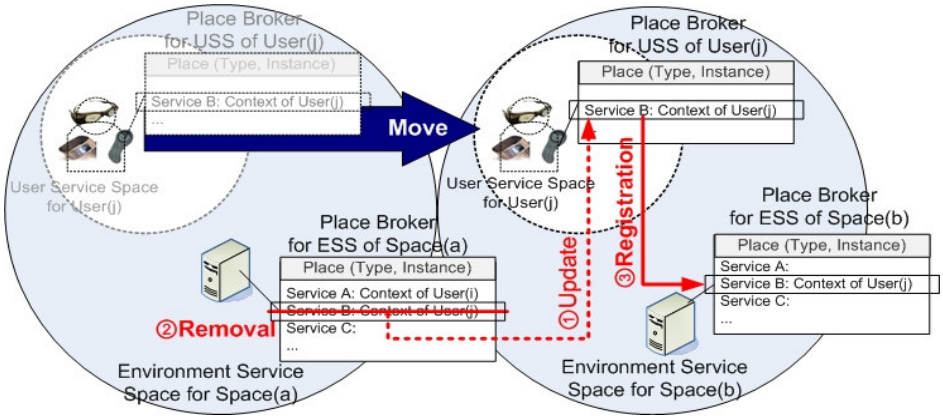

Fig. 2. Context Hand-Over: user context registration, update, and removal

After deciding the place type of a new service space, user context is handed over from USS to ESS. In case of private place, a user can be continuously provided with services in USS without delivering any context to ESS. In case of both personal and public place, user context in USS is registered to ESS. Before registration, however, user context in USS is updated with the user context in the previous ESS where the user stayed. This is because the user context can be modified due to some reasons during services are provided in the previous ESS. After update, the user context in the previous ESS is removed. To achieve it, both USS and ESS are managed by place broker that contains information for context hand-over such as user context, place type, and so on. Figure 2 shows the process of context hand-over.

4 Scenario

By applying context hand-over to ubiquitous education environment that is one of branch of ULAN project [4], we have implemented applications that represent education services with different format (e.g. audio, visual, etc) depending on a place type of the space where a student stays. In addition, we have implemented applications that provide seamless service by exploiting user context such as student ID, progress-status, place, etc. The follow is one scenario of context-hand-over applications that supports seamless, harmonious services when user's location changes.

"After a class, user *i* is solving the exercise through web service in a classroom. As an appointment with a friend is coming, he cannot help stopping the exercise. So he registers the exercise to his 'to do list' in a laptop. When he leaves the classroom, the exercise-progress-status is saved with the exercise item in 'to do list'. When a friend rides in user *i*'s car, the exercise that is represented in terms of audio contents instead of visual content is quit. After coming back home and then entering his room, user *i* is automatically provided with the exercise within a desktop. The exercise starts from the problems that he solved in the car. He checks problems that he is unable to solve for exercise. When he goes to take the class, the unsolved problem list will be delivered to the class professor."

5 Discussion

A beginning and ending of human's behavior is ambiguous. Therefore, it is not easy to provide proper services by recognizing user's behaviors. However, detecting place changes is a way to divide user's behaviors. Context hand-over can be used to determine when a service begins, continues, or stops according to user's place change. Furthermore, it can provide more seamless and harmonious services by changing policy of place-decision methods according to situations on each space. This paper emphasizes on continuity of individual services along with user's location change. To achieve this, the private place has the highest priority among three place types. However, we believe that more flexible context hand-over could be proposed by modifying place-decision method, e.g. reordering of three place types, changing comparison equations between USS and ESS, and keeping several polices for the method on each space, etc.

References

1. Ciolfi, L.: Understanding Spaces as Places: Extending. Interaction Design Paradigms. Cognition Technology and Work 6.1 (2004) 37-40
2. E. Hornecker, E.: Space and Place - setting the stage for social interaction. Workshop: Setting for Collaboration: the Role of Place in ECSWC05 (2005)
3. Harrison, S. and Dourish, P.: Re-Place-ing Space: The Roles of Place and Space in Collaborative Systems. In Proceedings of CSCW'96 (1996) 67-76
4. ULAN, http://www.ulan.jp/