

Media Service Mediation Supporting Resident's Collaboration in ubiTV*

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Abstract. A smart home is an intelligent and shared space, where various services coexist and multiple residents with different preferences and habits share these services most of the time. Due to the sharing of space and time, service conflicts may occur when multiple users try to access media services. In this paper, we propose a context-based mediation method, consisting of service mediators and mobile mediators, to resolve the service conflicts in a smart home. The service mediators detect service conflicts among the residents and recommend their preferred media contents on a shared screen and their own mobile devices by exploiting users' preferences and service profiles. The mobile mediators collect the recommendation information and give the users personal recommendation. With combination of the service and mobile mediator, the residents are allowed to negotiate the media contents in the conflict situation. Based on experiments in the ubiHome, we observed that mediation is useful to encourage discussion and helps to choose a proper service in a conflict situation. Therefore, we expect the proposed mediation method to play a vital role in resolving conflicts and providing multiple residents with harmonized services in a smart home environment.

1 Introduction

With an increasing number of researches on smart homes and offices, the interest for context-aware applications, aimed at multiple users, is growing as well. Unlike applications intended for a single user, applications for multiple users have to deal with different preferences of users. Therefore, those applications have related mechanism for service provision such as priority assignment and policy management [1].

Most researches, aimed at resolving conflicts, have been done on smart homes and intelligent offices. MusicFX, a music arbiter, selects music stations based on the group preferences to reflect multiple users' preferences in a fitness center [3]. The reactive behavioral system (ReBa) resolves conflicts among devices in an office environment by applying a layered architecture of activity bundles consisting of

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users' activities and reactions of the environment [4]. Finally, Dynamo system supports media content sharing and data exchange between multiple users, based on social protocols [5]. However, the previous researches have following limitations when they are applied to a smart home. Firstly, autonomous selection as a resolution can also cause other conflicts since the selection may take a service away from another user who owned the service before, without his consent. Furthermore, conflicts are only temporarily resolved because users can not recognize and exchange their contrary opinions. Even though social protocols can manage the use of media content among them, the problem with unexpected resident's behaviors still exists.

In order to overcome the above mentioned limitations, we propose a context-based mediation method exploiting mobile devices for residents. The proposed method detects service conflict among users by exploiting service profiles as well as the individual user preferences. It then generates a list of common interest services from all conflicting users and displays this list to notify the conflict and the different preferences. Finally, the method mediates the selection of the recommendation list by gathering the users' inputs and highlighting the users' choices. Therefore, the proposed mediation method enables residents to negotiate on media services by recommending their interested media contents. Furthermore, it allows users to exchange their preferences and experiences related to media contents with the recommendation during mediation. Therefore, the proposed method resolves conflicts among users under their agreements while it supports sharing of their preference and experiences even though they have different preferences and habits.

The remaining part of this paper is organized as follows. In chapter 2, we describe conflicts and their mediation method considering ubiTV. We discuss how to mediate multiple users' requests in ubiTV in chapter 3. In chapter 4, we show implementation of the proposed mediation method. Experiments and related analysis are presented in chapter 5 and we conclude in chapter 6.

2 Resident's Collaboration in ubiTV

The ubiTV is a context-based media service for providing users with various media content by exploiting various kinds of context obtained from users and their environments [7]. In the ubiTV, conflicts among multiple users who want to access the same media service occur as follows. Firstly, service conflicts occur when multiple users try to access the same media service. In this situation, the media service recognizes the users' personalized services by exploiting his context. Furthermore, service conflicts often occur when multiple users access different media services which share the same space. In this situation, the media service can react on the user's context. However, the users cannot enjoy their media content due to interference of different media service such as sound and visual contents in a limited space.

In order to reflect the characteristics of a smart home and its residents, the proposed mediation approach handles service conflicts by exploiting the context such as the users' preferences and media service profiles. First of all, it detects a service conflict by utilizing the user's context as a triggering information of the deployed media services. The user context includes not only the profile such as identity,

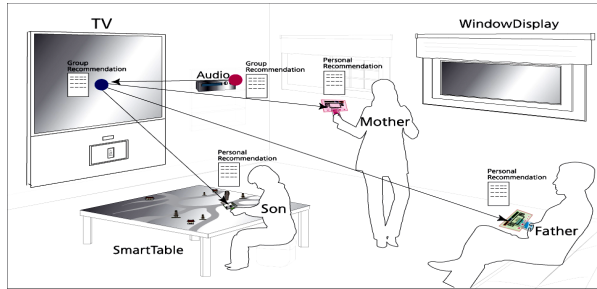


Fig. 1. Media Service Mediation

individual preferences and so on, but also media service profiles such as media service identity or required resources. The method displays (recommends) the users' commonly interested media contents on a shared screen and personal interested media contents on the user's own mobile device. With the commonly interested media content, the user can recognize other persons' interests while he can select an item out of the personally interested media contents. When the recommendation is given to the users, they can choose their preferred item among the recommended list. In order to provide a consented service, the method arbitrates the user inputs. Figure 1 shows a conflict resolution of the previous service conflict based on the proposed mediation method.

As can be seen in Figure 1, a recommendation list of TV content is displayed on a shared screen and the user's mobile devices when a service conflict is detected. According to family member's preferences, the recommendation list consisting of {drama, news, animation} reflects the preferences of father and son. The recommendation is given to the users and is reordered individually by each user's preferences based on user's profile manager. Therefore, the father can see the recommendation consisting of news, sitcom and animation, and the son can see the recommendation consisting of animation, sitcom and news. If they choose an item of the recommended content, the selection is highlighted on the TV screen. Therefore, they can recognize each others preferences and opinions. They can also discuss about proper contents among the recommendation. Furthermore, if the mother, the third user, wants to access the audio service, her media service is similarly managed by the proposed mediation method due to a service conflict with the TV service. Consequently a recommendation list, reflecting the mother's preferences is given to all conflicting users. Therefore, the users can choose an item of the media content to harmonize their preference and to solve the conflict in the shared space.

3 Media Service Mediation

In order to detect possible service conflicts among users who share media services and resolve them harmoniously afterward, the proposed mediation method exploits personal companions equipped with mobile mediators. In conflict detection, the proposed method utilizes unified context to reflect rich information about users. It then recommends commonly interested media contents of users to resolve the detected

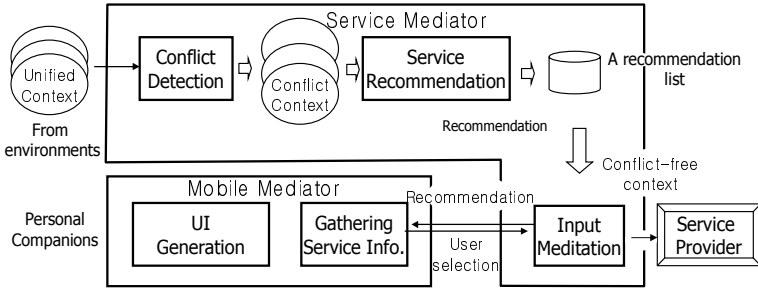


Fig. 2. Media Service Mediation Framework

conflicts by exploiting personal companions as well as a shared screen. Figure 2 shows the overall procedure of the proposed mediation framework.

As shown in Figure 2, the proposed method gathers two types of unified contexts to detect possible service conflicts: unified contexts describing users who are using the same media service and unified contexts describing users who want to access different media services. In the conflict detection component, service conflicts among users accessing the shared screen to visualize the users’ choices, until the users consent on an item the same media service are detected by exploiting those unified contexts. In the conflict resolution component, the recommendation information is generated for user centered conflict resolution by exploiting the context of the conflicting users. As a result, a recommendation list is displayed for the service mediation after the conflict management process. In the last step, the mediator highlights user inputs on of recommended contents. During the mediation between two users, the recommendation list can be updated with different preferences of new users who try to use the same service. Finally, the conflict-free context as a result of the service mediation, containing user’s consented service is delivered to a service provider.

3.1 Context for Media Service Mediation

The proposed mediation method requires context information in order to manage service conflicts. The method utilizes unified context describing two kinds of information: the user profile and the media service profile. The following Table 1 describes part of the unified context consisting of user profile and service profile used for media service mediation. The user profile includes the users’ dynamic and static information when they access a media service. The media service profile contains dynamic and static information of the media service.

3.2 Service Mediator

First of all, the proposed method detects service conflicts by utilizing unified contexts. As mentioned before, the unified context includes the user’s contextual information and the media service profile. Let ACS be the set of currently active

Table 1. Unified context for media services

Context Elements	Description
<i>User</i>	A unique identifier indicating a user giving a command to the media service implicitly or explicitly.
<i>MediaService</i>	A unique identifier indicating a media service that generated this unified context as a consequence of a user issuing a command to it
<i>ContentItems</i>	A set of identifiers for contents the <i>MediaService</i> provides.
<i>UserPreference (UP)</i>	A function mapping the <i>ContentItems</i> to preference values for the user. It is represented as an M: 1 relation. The values range from 0 to 10, 10 being the highest preference.
<i>Resource</i>	Resources that the <i>MediaService</i> needs to provide its media services. It is represented as a set of resources. According to <i>MediaService</i> , more than one resource can be included.
<i>The Number of Users (NU)</i>	The number of users associated with <i>UP</i> . It is generally 1; otherwise it has higher value to indicate multiple users for group preference.

contexts in a space and MCS be the subset of ACS for a specific media service kept locally by the media service. Service conflicts are detected by Eq. (1) with a set of collected unified contexts MCS in the specific media service.

$$\begin{aligned}
 \text{Service_Conflict}(C_A, C_S) \Leftrightarrow & \text{User}(C_A) \neq \text{User}(C_S) \wedge \neg \exists x : (\text{PreferredItem}(C_A, x) \\
 & \wedge (\text{PreferredItem}(C_S, x)) \vee (\text{MediaService}(C_A) \neq (\text{MediaService}(C_S) \\
 & \wedge \text{Resource}(C_A) \cap \text{Resource}(C_S) \neq \emptyset))
 \end{aligned} \quad (1)$$

where C_A is a unified context of a user accessing a media service and C_S is the unified context of currently active service state which was the result of another action. *PreferredItem*, obtained from Eq. (2), is an item having the highest preference among the set of media contents.

$$\text{PreferredItem}(C, x) \Leftrightarrow \exists x \forall y : UP(C, x) \geq UP(C, y) \quad (2)$$

where x and y are elements of *ContentItems* of a particular media service.

The mediator then generates recommendation information containing commonly interested media contents of all conflicting users by utilizing user profile and media service profiles. For the purpose, the method obtains a recommendation list from the unified contexts describing all users who access the same media service by ordering media contents. Therefore, we rearrange the items of media contents by applying group preference and utility errors. The group preference (GP) is a function mapping

ContentItems to degree of preference in [0, 10]. It is obtained by summing and normalizing the *UPs* as shown in Eq. (3).

$$GP(Item) = \frac{1}{|MCS|} \sum_{C \in MCS}^N UP(C, Item) \tag{3}$$

The utility error is a mean square error (MSE) of individual user’s preferences. Especially, the media content having the smallest MSE has a higher priority than other media contents. It means that the items which have a lower preference distribution have a higher priority than other items even though they have the same group preferences. Eq. (4) shows UtilityMSE of group preferences.

$$Utility_{MSE}(Item) = \frac{1}{|MCS|} \sum_{C \in MCS}^N (UP(C, Item) - GP(Item))^2 \tag{4}$$

Finally, the proposed method obtains new *UP* consisting of $\{(Item, Preference)_{(0)}, (Item, Preference)_{(1)}, \dots, (Item, Preference)_{(K)}\}$ ordered by the *GP* and utility errors.

Finally, the proposed method mediates the user inputs in order to allow the media service to only react on items all conflicting users agree with and to remain consistency when dealing with multiple individual input devices. The proposed technical augmented social mediation handles potentially conflicting explicit user input from multiple input devices. Especially, it utilizes three parameters to make a final decision among multiple inputs because the media service cannot guarantee that all users give inputs corresponding to the recommendation. The parameters include individual *weight*, *decision_threshold* and *decision_timeout*. *Individual_weight* is a weight on an individual user input. The individual weight is assigned when mediation starts with recommendation. The weight is also assigned differently according to users and policy since user’s selection is not always the same. *Decision_threshold* is a threshold weight when a final decision is made. We assume that all users agreed on one selection if the sum of individual weights is greater than this value. *Decision_timeout* is a waiting time until a final decision is made automatically. The timeout is used to finish mediation ahead of time, because no more user input is expected. Users need to some time limitation to decide their choices with others although they easily select their preferred contents among recommended media content.

3.3 Mobile Mediator

When a conflict occurs, users involved in the conflicting situation need to be notified. As an interface between the media service and users, we introduce a user interface called personal companion. Each user has his or her own personal companion to interact with services. The mobile mediator receives group recommendation information whenever its user causes or encounters a service conflict with other users. It also generates a personalized recommendation list onto a user interface by exploiting user

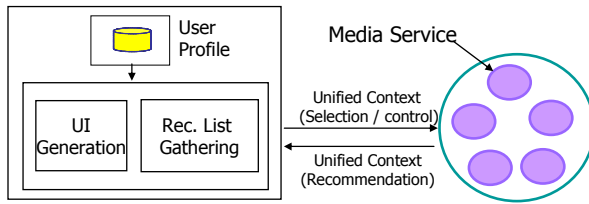


Fig. 4. Mobile Mediator

profile from the obtained group recommendation information. Figure 4 shows the overall architecture of the mobile mediator.

As shown in Figure 4, the mobile mediator gathers recommendation information as unified context from a conflicting media service. The obtained group recommendation list is refined and tailored into a personalized recommendation list by utilizing user profile on the conflicting media service. A personalized recommendation list is constructed by including items of a user's interest and excluding any irrelevant items from group recommendation list. The items on the personalized recommendation list are sorted based on a user's preferences, so a highly preferred item is placed on top for easy access. After constructing the personalized recommendation, UI generation uses this information to build a proper user interface for selecting items from the recommendation list. The recommendation list is graphically represented and each item is mapped with corresponding command and content. Whenever a selection is made in the conflicting situation, the unified context is transferred to the conflicting media service to notify the selection.

4 Implementation

In order to implement the proposed mediation method, we utilized the ubi-UCAM 2.0. The ubi-UCAM 2.0 is a unified context-aware application model for ubiquitous computing environments, supporting the independence between sensors and services [6]. The proposed method was implemented as a part of the context manager of the ubiService in the ubi-UCAM 2.0. We then applied the ubiService to the ubiTV application [7]. Furthermore, in order to control these services, users can utilize personal companion with a remote controller, implemented with Personal Java. Based on the media services and sensors, the ubiTV application is able to mediate multiple residents with media services according to users and their context. For example, the ubiTV application starts to mediate while displaying the available contents ordered by their preferences on the screen as shown in Figure 5(a). In addition, each user's mobile personal companion shows his/her preferred items as shown in Figure 5(b).

Based on the mediation, they are able to share their preferences through the recommended information. After their discussion about media contents with the recommended contents, they decide their proper program in this conflict situation.



Fig. 5. Media Service Mediation in ubiTV

5 Experiments

In the following experiment we wanted to get a first impression on how users react on recommendation and mediation. In order to do that, we carried out the experiment in two different scenarios with 16 people aged from 20 to 35. The users were divided into groups of two persons and experienced both scenarios to form an opinion about the TV service. In the first scenario (ordinary TV watching) we tried to create a relaxed atmosphere like a home environment. The participants were told to make themselves comfortable in the ubiHome and to do everything like on a normal day, when they come home from work or school. No service recommendation and only an ordinary remote control were provided. The second scenario was designed exactly like the first one, with the difference in a recommendation list which was displayed on the TV and on the users own personal companion, which were the new input device to mediate the input for the TV application.

We also designed two different questionnaires for each scenario which the participants were asked to answer after each experiment. In the first questionnaire we were only interested in the user's normal behavior about the TV usage with their families. Additionally we were interested if family members verbally fight over the TV program and how satisfied they are with the decisions about the TV content home. Table 2 shows those questions for participants over the scenario 1.

Table 2. Questions for scenario 1

	Questions	A	B	C
1	<i>Do you think the personal companion mediation can prevent one person from making all the decisions over the program?</i>	60	20	20
2	<i>What do you think about the personal companion mediation?</i>	60	10	30

A: Positive answer, B: Don't Know, C: Negative answer

As shown Table 2, Question 1 clearly shows that the main opinion of the asked users is that the personal companion-based mediation provides an equitable input device (60 %). This result hardens the idea that a technology augmented mediation can

prevent family members from feeling passed over in the TV content decision making process. In this question we wanted to find out the general opinion of the users about the personal companion-based mediation (an instance of the technical augmented social mediation). Our concern was that most people find it boring and disturbing to use multiple personal companions as input devices for a context aware TV service. The evaluation showed that most people like the personal companion-based mediation (60%) and will accept this new equitable input device. Only 20% answered that it is too laborious to use. This result indicates that the personal companion-based mediation is a acceptable approach to provide equitable input but we also should consider the fact that some users felt disturbed by this new mediated input technique.

After the observation of the users in the second scenario we could investigate that the recommendation list encouraged people to discuss about each others interests. As soon as the recommendation list was displayed on the TV screen and the personal companion, most participants immediately started to talk about the recommended content. Additionally we asked the participants directly what they think about this new technique.

Table 3. Questions for scenario 2

	Questions	A	B	C
3	<i>Did the recommendation help you to discuss?</i>	70	10	20
4	<i>Did the recommendation help you to make a decision?</i>	60	30	10
5	<i>Can the recommendation list prevent fights?</i>	60	40	0

A: Positive answer, B: Don't know, C: Negative answer

Table 3 shows the result from the questions from the participants. According to the Question 3, 70 % of the users answered that they are supported by the recommendation list in the discussion process. This indicated that the visualization of other people's interests supports verbal discussion. Besides the support of the discussion about the TV content we were additionally interested if the recommendation technique can help the users to make a decision. That comes because the discussion is the first part of a convenient TV content decision for families. The goal of the recommendation list is besides supporting a discussion to help the users to make a fast and convenient decision. The whole process should be supported by visualizing each family member's preferences. The analysis of the results show that 60% of the experiment participants felt that the recommendation list had supported the decision making process, as shown in Question 4. This indicates that the recommendation list seems to be a proper technique to support the whole process of harmoniously choosing the TV contents for a family.

In the last question we asked the participants directly if they think that the recommendation list can prevent fights. This would be an important factor to harmonize the TV content decision from multiple family members. Question 5 clearly shows that most users think that verbal fights can be prevented (60%). More interesting observation is that no participants disagreed with this assertion. Accordingly it seems that recommendation and mediation can be used to harmoniously resolve conflicts caused by multiple users.

6 Conclusion

In this paper we proposed a mediation method to support collaboration among multiple residents for sharing media services in a smart home. In order to support the collaboration, the proposed method detected service conflicts and recommended harmonized service contents by utilizing users' preferences and service profiles. We applied the mediation method to the ubiTV in a smart home. According to the result, more than half of the participants thought that the ubiTV was useful to share the media services by helping them to negotiate their preferences. Furthermore, we found out that discussion and mediation among residents are meaningful to resolve conflicts in the aspect of user's view and that the proposed method can support finding a harmonious decision. Therefore, the proposed method can play an important role to resolve service conflicts among multiple residents by regarding the preferences of all users.

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