ubiController: Design and Implementation of Mobile Interactive User Interface

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***Abstract*—In ubiquitous computing, service environment is intelligent and provide users with relevant and timely service to meet demands of users. To realize this, the research for ubiquitous computing have stressed on logical processes required by the smart environment to trigger proper services at the right moment. However, little attention is paid to an actual user interface that can lead to richer interaction with the smart environment. In this paper, we analyze requirements of a user interface in ubiquitous computing environment through a prototypical implementation of user interface, ubiController. ubiController aims to support user and service interaction via a direct service control and user to user interaction with conflict notification and recommendation, all in an integrated intuitive interface on a mobile device.**

***Index Terms*— Service Discovery, Universal Control, Situation-aware**

I. Introduction

In ubiquitous computing environment, it is essential to provide a user interface for interactions with the environment. Previous research theme for ubiquitous computing have emphasized on logical processes required to provide appropriate services, therefore populating context-aware and intelligent services in ubiquitous computing domain. However, inadequate attention is paid to an actual user interface that is utilized to interact with such intelligent environment. Numerous studies have been initiated on user interface to give more support by choosing mobile devices as the key interaction tools between users and the environment [1][2].

In this paper, we propose a mobile user interface, ubiController, to support intuitive interactions with the environment. To realize this, ubiController provides service discovery and universal control, situation-awareness and multi-user support. We identify requirements of user interface in ubiquitous computing environment by analyzing ubiController and present an outlook for mobile user interface.

II. UBICONTROLLER

We have developed a mobile user interface, ubiController, to be used in ubiquitous computing environment. Such an interface for user can provide both input and output for context-aware service. Here, we list three requirements for mobile user interface as follows, service discovery and universal control, situation-awareness and multi-user support. We analyze these requirements against our prototypical mobile user interface, ubiController, to see how these requirements are considered.

Fig. 1. Three Features of ubiController

A. Universal Plug and Play (UPnP) and Universal Control

As a first step toward interaction with the environment, a user must know what kinds of services are present and available for the user to access. When available services are notified to the user, then users can take further steps to control or interact with the services, preferably using a single device. The first step is known as *service discovery*, and the second step is referred as *universal control*.

ubiController first discovers available services as a control point in the environment using UPnP [4]. Each service is connected with the UPnP service module in ubi-UCAM for compatibility. Service discovery allows and notifies users for potential functionality and universal control mechanisms allow exploration with discovered services. Service discovery requires conformity between services in the environment and the user. This conformity takes a form of standard and we utilize such a standard, Universal Plug and Play (UPnP). A service in the environment corresponds to an UPnP service and the user's side is represented by an UPnP control point. UPnP service advertises itself to the network which can be discovered by UPnP control point. UPnP establishes basic connection between the environment and the user. However UPnP alone does not support communication based on context, so we introduce additional middleware, ubi-UCAM (Unified

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Context-aware Application Model for Ubiquitous Computing). By combining UPnP and ubi-UCAM, we establish service discovery and universal control. ubi-UCAM consists of ubiService and ubiSensor for logical distinctions for services and sensors, where UPnP service is incorporated into ubiService for compatibility with other context-aware services.

B. Situation-awareness

When a user carries small device that can provide information of user, the device can provide useful information. In a sense, mobile device satisfies two roles, context sensing and service discovery and control.

To use the situation of a user as an implicit input to create user interface for services, we define the notion of 'relevancy' of a service in a situation (Situation-Service Relevancy). First, a user's current situation is defined in terms of a set of attributes of the user's movement (location, direction, etc) and a service. With respect to currently available services, a user's situation is,

- *Irrelevant* when it has no influence on the service;
- *Negatively relevant* when it disables the service;
- *Minimally relevant* when it activates the service;
- *Operationally relevant* when it requires a moderate controls of the service;
- *Maximally relevant* when it requires a full control of the service.

The more relevant a user's situation is to a service (SSR), the more specific and detailed is the service control menu that is generated. For example, consider a user's situation of 'Watching TV', represented by,

$$WatchingTV = \{location = couch, direction = facingTV, velocity = 0\}$$

In our exemplary implementation, this situation makes TV service maximally relevant and the full TV control user interface is created. In this case, all service control buttons are selected from the TV service since the situation is considered maximally relevant with the TV service. In a similar fashion, a user's situation of "Entering the living room" and "Leaving the living room" can be represented with a set of attributes and its corresponding values. For the case of "Entering the living room," service control buttons are selected from the three services of different relevancy. Different relevancy levels of each service contribute on determining the numbers of control buttons from each service to display on the user interface. For the case of "Leaving the living room", which is negatively relevant with all six services, is accordingly reflected by displaying off or disable function buttons from each service. Figure 1 shows the service control menu augmented on the user interface for situations of 'Entering the living room'.

C. Multi-user Support

When a user is provided with a personal mobile device to interact in ubiquitous computing environment, the mobile device serves as an information container or personal database. Since ubiquitous computing environment involves multi-user interaction and user to user interaction, we also need to consider support for multi-user interaction. Context-aware services encounter problems when different users request for different services that conflict with one another [5]. In this case, ubiController enacts as a personal view to get notified of service conflict and provide a mechanism to take a part in resolving the conflict. When a conflict is arose for a service, that service notifies each ubiController of involved users. Involved users then see the notification of arisen conflict as a form of recommendation list in the side view.

As a container of personal information, it is possible to carry personal photos or multimedia files within the mobile device. In this case, users will be able to share personal media with others. Conventionally they can show the screen of their device, however that is inconvenient and only small screen size is provided. In this case, ubiController can share multimedia through some display services such as ubiTV [3], which can receive files from ubiController and allows other users to download the uploaded files.

III. DISCUSSION

We have implemented a prototypical mobile user interface for ubiquitous computing environment. Here we list three key requirements for the mobile user interface, ubiController as service discovery and universal control, situation-awareness and multi-user support. ubiController first discovers available services in the environment and establishes connection between user and services for universal control. Then a user's situation sensed from the mobile device is used as an implicit context to generate a relevant user interface. Also interactions for multiple users are enabled by including conflict notification and recommendation along with personal media sharing.

Open questions remain in refining representation of a user's situation and prioritizing attributes for situation-awareness. Also visual user interface will be gradually replaced by AR (Augmented Reality) to increase intuitiveness and immersion to the UI.

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