

Introduction of ‘ubiHome’ Testbed

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ABSTRACT

This paper introduces ‘ubiHome’ which is a testbed for applying ubiComp-enabling technologies to smart home environments. ‘ubiHome’ guarantees benefits in various senses. Firstly, ‘ubiHome’ provides distributed computing environments where contexts are directly exchanged between Sensors and Services without any centralized context-managing server in most smart home environments. Secondly, ‘ubiHome’ manages user conflictions by exploiting user’s priority in terms of context. Finally, ‘ubiHome’ provides a personalized service that autonomously takes appropriate action by exploiting an individual’s situation rather than general conditions applicable to all users. We illustrate the usefulness of ‘ubiHome’ by implementing a number of sensors and applications that have been prototyped using the ubi-UCAM. We also demonstrate how such a ‘ubiHome’ can support the investigation of important research challenges in the area of ubiquitous computing.

Keywords: ubiHome, Distributed Context Management, Conflict Management, Personalized Service.

1. INTRODUCTION

Many people are familiar with the concept of ubiquitous computing (ubiComp) and consider it as a paradigm to innovate our everyday life in the near future. We expect that ubiComp-enabling technology will bring a lot of changes in daily life. Especially, most research that has been conducted on ubiquitous computing and context-aware environments has concentrated on convenient services for users at home. This is because most people spend more time at home than in any other place. However, it is true that home automation technologies have not been widely adopted in resident environments because users hesitate to use complicated or unfamiliar technologies. However, the ubiComp-enabling technology, hiding away the complexity from users and providing simpler interaction with technology, will be at the core of home environments.

In this paper, we introduce ‘ubiHome’ which is a testbed for applying ubiComp-enabling technologies to home environments. As shown in Figure 1, ‘ubiHome’ consists of various ubiSensors and ubiServices that are based on unified context-aware application model (ubi-UCAM) [1]. A ubiSensor is responsible for detecting the change in situation of users or environments and

then providing preliminary contexts in the form of 5W1H (Who, What, Where, When, Why and How) to all ubiServices. Examples include ubiKey [2], ubiFloor [3][4], SpaceSensor [5], ubiTrack [6], RFID Sensor [7][8], etc. A ubiService takes appropriate actions according to a final context based on user-specified conditional contexts. Examples include c-MP (context-based Media Player) [1], c-Mail checker (context-based eMail checker) [2], TMCS (Tangible Media Control System) [7][8], cPost-it (Context-based Post-it) [9][10], ubiTV, etc.

‘ubiHome’ guarantees benefits in various senses. Firstly, ‘ubiHome’ provides distributed computing environments where contexts are directly exchanged between ubiSensors and ubiServices without any centralized context-managing server in most smart home environments. This enables a ubiSensor or ubiService to easily join (withdraw) to (from) ‘ubiHome’. Secondly, ‘ubiHome’ manages user conflictions by exploiting user’s priority in terms of context. User confliction is a situation that several users access the same service at the same time so that the service cannot take any action. If confliction occurs, the ubiService will react to the user who has the highest priority among others. Finally, ‘ubiHome’ provides a personalized service that autonomously takes appropriate action by exploiting an individual’s situation rather than general conditions applicable to all users. This is because users with a GUI are able to specify their conditional context to trigger an individual service.

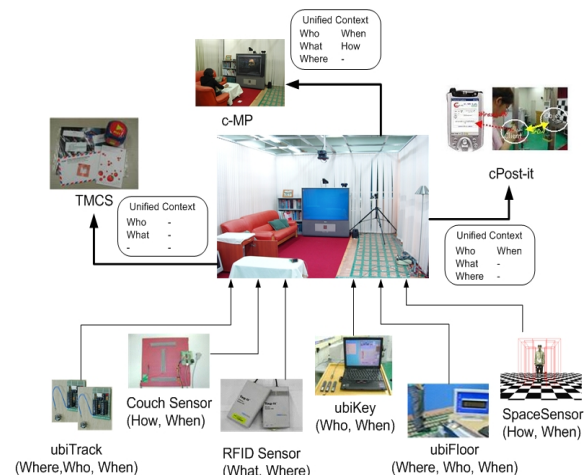


Figure 1: ‘ubiHome’ Testbed

This paper is organized as follow: In section 2, we briefly introduce the infrastructure, ubi-UCAM, implementing ‘ubiHome’ testbed. We show examples of ubiSensors and

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ubiServices that are working in ‘ubiHome’ in section 3. Finally, the conclusion and future works are discussed in section 4.

2. ubi-UCAM: Unified Context-aware Application Model

Several sensors and services in ‘ubiHome’ are based on ‘ubi-UCAM’, a unified context-aware application model, which can be used to implement ubiComp-enabled home environments [1][2]. The unified context is user-centric information in terms of 5W1H (Who, Where, When, What, How, and Why). This depicts “a certain user (Who) is”, “in a certain location (Where)”, “in a certain time (When)”, “paying attention to a certain object/service (What)”, “representing a certain expression with physical signs (How)”, or “because of a certain intention or emotion (Why)”. The ubi-UCAM consists of two main blocks, namely, ubiSensor and ubiService. A ubiSensor generates a preliminary context. Then, ubiSensors distribute the resulting preliminary context to ubiServices through networking modules. A ubiService yields the integrated context by merging preliminary contexts from a set of ubiSensors, and generates the final context by refining the integrated context with the current state of ubiService. Finally, a ubiService triggers personalized services according to the final context based on user-specified conditional context. In addition, ubiServices exchange final contexts in order to trigger services without conflicts.

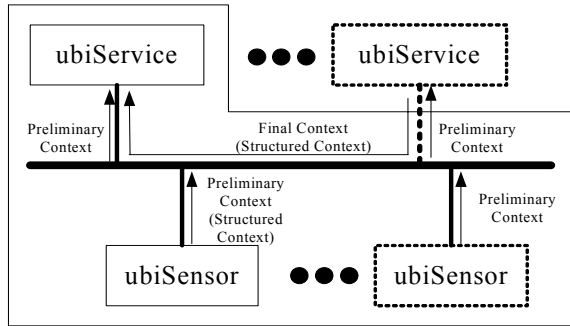


Figure 2: ubi-UCAM architecture

3. ‘ubiHome’ Testbed

3.1 Implementation of ubiSensors

In ‘ubiHome’, ubiSensor is responsible for detecting the change in situation of users or environments and then providing preliminary contexts in the form of 5W1H to all ubiServices. The ubiSensors, e.g. ubiKey, ubiFloor, SpaceSensor, and ubiTrack are described in the following.

• ubiKey [2]

The ubiKey uses portable memory to generate the user identity (Who) and entry/exit time (When). Each user brings ubiKey that contains user’s profile such as identity, and list of favorite services.

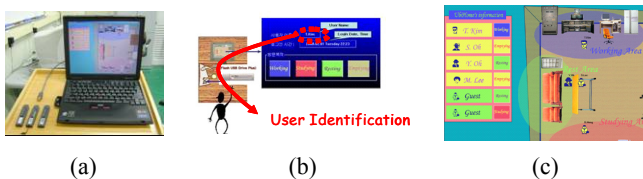
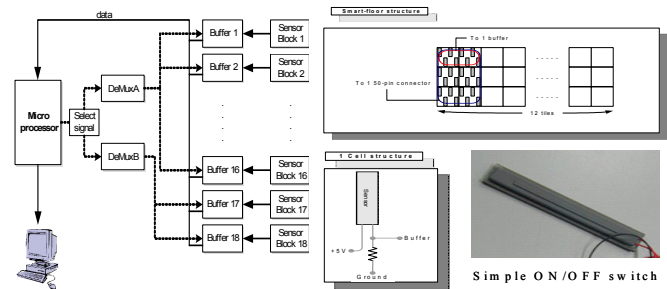


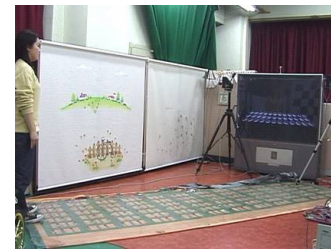
Figure 3: ubiKey; (a) System (b) Example of User Identification (c) Application of ubiKey

• ubiFloor[3][4]

The ubiFloor, where on/off sensors are attached per 2cm * 5cm space, determines user’s position (Where) by sensing the pressed sensors; detects user’s identity by analyzing his walking pattern (Who); and also generates time (When).



(a) (b)

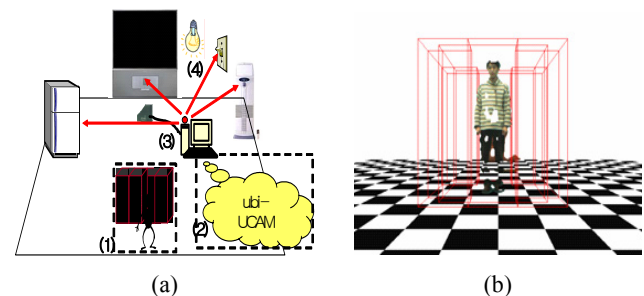


(c)

Figure 4: ubiFloor; (a) System (b) One Cell of ubiFloor (c) Example of ubiFloor

• SpaceSensor[5]

The SpaceSensor using a 3D camera analyzes hand/body gestures (How) and time (When). The movement of gestures can be tracked by observing how the touched position moves through 3D virtual boxes surrounding a user.

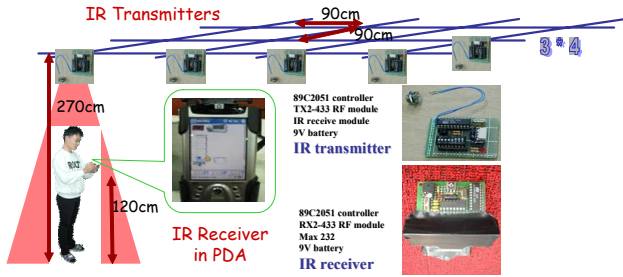


(a) (b)

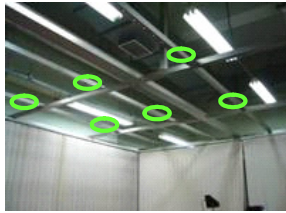
Figure 5: SpaceSensor; (a) System (b) 3D boxes surrounding a user

• ubiTrack [6]

The ubiTrack, with IR transmitters attached every 90cm * 90cm region on the ceiling, tracks a user carrying PDA with IR receiver (Where). In addition, ubiTrack also provides user profiles (Who), stored on the PDA, to services only if permitted by the user.



(a)



(b)



(c)

Figure 6: ubiTrack; (a) System (b) Layout of IR receivers (c) Example of ubiTrack

• RFID Sensor [7][8]

RFID Sensor, where RFID tags are attached to daily objects and an RFID reader is installed under a table in living room, detects the identity of the object (What) or URL linking information related to the object (Where).



(a)



(b)

Figure 7: RFID Sensor; (a) RF Reader and antenna (b) RFID tags attached to objects

• SofaSensor, IR and Web Camera [2]

The SofaSensor, where three on/off sensors are embedded in couch, determines the pose of the body (How), standing up/sitting down, and time (When). In addition, the IR sensor and Web Camera detects whether someone is at the door or not. Therefore, it provides the image of the person at the door (What), and time when someone touches IR sensor (When).

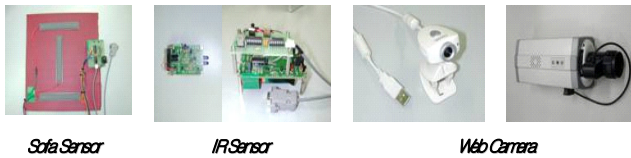


Figure 8: SofaSensor, IR Sensor and Web Camera in 'ubiHome'

3.2 Implementation of ubiServices

In 'ubiHome', ubiService provides residents with personalized services according to user's context. The ubiServices, e.g. c-MP, TMCS, cPost-it, ubiTV are described in the following.

• c-MP (context-based Media Player)[1][2]

The c-MP is a media player providing user-centered services by exploiting the context such as user's identity (Who), user's location (Where), time (When), gesture (How), object for movie player (What) and user's intention to control movie player (Why). For example, after a resident enters a living room with ubiKey, he/she sits down on a sofa in front of the TV. Then, a ubiService menu automatically appears on the monitor. If the resident selects movie player from the menu, the c-MP displays a list of movie titles with user-wise history. When the resident rises from his/her sofa, c-MP automatically pauses the movie. If he/she comes back and sits down within 30 seconds from the kitchen for snacks or beverages, c-MP resumes the movie. While, he/she does not come back in 30 seconds or goes out of 'ubiHome', c-MP saves the paused status and time and automatically stops. The resident can control the movie player by his/her gestures as well as by remote controller. For example, he/she can increase volumes by raising a right hand up and decrease volumes by putting it down. He/she can enlarge screen size by raising a left hand up and lessen screen size by putting it down.

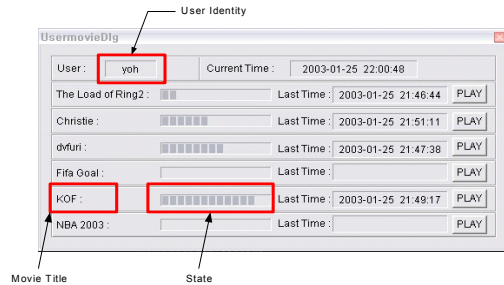


Figure 9: Personalized Interface of c-MP

• TMCS(Tangible Media Control System)[7][8]

TMCS is a tangible user interface providing intuitive ways to access and control digital media contents with identity (What) of object such as CD, picture, and movie title. It offers personalized contents to a user by utilizing the user context such as user's identity and profile (Who). For example, a movie plays automatically when a resident puts the case of the movie on the table. He controls the digital media content, e.g. Play, Pause, Stop, Fast forward, Rewind, and Increase/Decrease Volume by rotating RFID-enabled object instead of a remote controller. In addition, TMCS prohibits a resident to play the movie which the resident has no right of watching, e.g. a child tries to watch adult movie in home.



(a)

(b)

Figure 10: Implemented TMCS; (b) Tangible Media Object and Controller

- cPost-it (Context-based Post-it)[9] [10]

The cPost-it is information-sharing system allowing residents to share various types of media data with PDA by exploiting context such as the user's identity (Who), location (Where), time (When), and object's identity (What). For example, when a resident carrying PDA approaches the TV containing augmented information such as personal notes, video manuals, and today's program, cPost-it provides the resident with personalized information such as retrieving parts of the information according to user's identity and classifying the information by exploiting time or user profile about information of interest entities. In addition, cPost-it guarantees to keep the individual notes and to share personalized messages among just group members between husband and wife. Because all messages are categorized into three parts; 'Personal', 'Group', and 'All', it provides residents with proper messages according to the access right which the resident will specify.



Figure 11: Implemented cPost-it

- ubiTV Service[11]

The ubiTV is multimedia service that resolves service conflicts among multi-residents. The ubiTV automatically select a channel and volume level according to resident's preferences. However, if there are two more residents who are going to watch a TV, ubiTV detects service conflict that they want to see different channel or program at the same time. Then, ubiTV is adjusted to the resident who has the more priority over others.

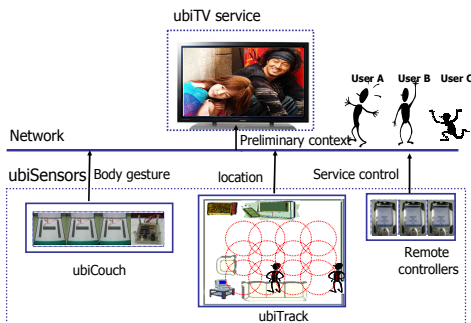


Figure 12: Implemented ubiTV

4. Conclusion

In this paper, we have introduced "ubiHome" which is a testbed for applying ubiComp-enabling technologies by means of enumerating various sensors and services. 'ubiHome' provides convenient services by exploiting resident-centric context, i.e. identity, location, time, gesture, etc. We make a summary of 'ubiHome' as follows:

Home Environment of Ubiquitous Sensors and Services: Because all sensors and service are implemented according to ubi-

UCAM, 'ubiHome' provides distributed computing environments where contexts are directly exchanged between Sensors and Services without any centralized context-managing server in most smart home environments. This shows that all computing resources are pervasive in daily life and allows a user to access them anywhere at any time.

Home Environment of Intelligence: 'ubiHome' can be aware of resident's context such as "a certain user (Who) is", "in a certain location (Where)", "in a certain time (When)", "paying attention to a certain object/service (What)", "representing a certain expression with physical signs (How)", or "because of a certain intention or emotion (Why)" to appropriately react to each residents. Also, 'ubiHome' resolves service conflict by exploiting user's priority in terms of context.

Home Environment of User-centric Service: 'ubiHome' provides a personalized service that autonomously takes appropriate action by exploiting an individual's situation rather than general conditions applicable to all users.

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