Smart Device Collaboration for Ubiquitous Computing Environment

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Abstract. Although a ubiquitous computing has been widespread and computers embedded into physical objects and living environments have been increased, personal portable devices are still necessary for various interactions with embedded computers. Despite of importance of those devices, input and output capabilities of them are limited and relatively impoverished compared to those of laptop computers. Moreover, users must pay an explicit attention to an interaction with portable devices. To solve these problems, we propose a smart device collaboration for a ubiquitous computing, which aims to realize that each embedded computer complements the lack of capability of a portable device in the ubiquitous computing environment. Our proposed smart device collaboration allows users to have appropriate interactions with embedded computers, without explicit attentions to existences of these computers and interfaces to them. This paper describes InfoPoint and Smart Furniture which are our experimental devices demonstrating smart device collaboration. We also observe advantages and disadvantages of these devices, present future works, and conclude a scheme of the smart device collaboration.

1 Introduction

Thanks to recent improvements in the field of digital and network technologies, various kinds of computers are embedded in appliances, furniture, and buildings [1] [3] [9] [11]. These embedded computers can recognize users' context by sensors, share the context by communication with each other via wired/wireless networks and provide effective services to the users. However, in spite of an increase of embedded computers, personal portable devices such as cell phones and PDAs are still necessary because they allow users dedicated interactions with these computers. For example, when a user sits down in front of a TV, these computers can turn it on. On the other hand, it is difficult for a user to choose a TV program because they can not get neither who the user is nor what he/she wants. These computers provide the same interface, information, and service to everyone within the same context [10]. With the portable devices, users can transfer their personal data and commands to embedded computers, and also receive messages and lists/icons of available commands individually and select the command they wish.

When we use portable devices in such environment, however, we will encounter various problems, especially concerning the interaction between users and these devices. It can be said as one important example for those problems that their input and output capability are limited compared to those of laptop computers. Generally, displays are small and resolutions are low and keyboards, buttons and touch screens are also small and complicated for inputting. Another problem is that users must always pay an explicit attention to the interaction with portable devices. Suppose that a user, who is away from home, received a visitor with the mobile TV door phone system [7], which can transfer sounds and pictures between a user's cell phone and a home door phone remotely. On that occasion, although the user can check and talk with the visitor through his/her cell phone, its display is very small for confirming who the visitor is, even if there is a big and high resolutional display nearby and the user must always pay attention to his cell phone whether he/she has a visitor at his/her home or not. It would be quite useful if the user notices whether his/her portable device receives messages, by some indications on an appropriate display, speaker or lamp nearby, instead of his/her small cell phone display.

2 Smart Device Collaboration

In this paper, we propose Smart Device Collaboration for ubiquitous computing environment, which aims to establish the collaboration between portable devices and embedded computers, while realizing the basic function of portable devices and also applying the maximum advantages of embedded computers. We set users who are used to operating cell phones as the main target for our proposed smart device collaboration. Our experimental devices to demonstrate the smart device collaboration are described in the following subsections.

2.1 InfoPoint

InfoPoint [4] [5] is a small hand-held device as our first trial of the smart device collaboration. Figure 1 shows the external appearance of the hand-held part of InfoPoint which consists of a CCD camera to detect visual markers as IDs, three input buttons to select, get, or put data, a liquid crystal display, and a small computer. It acts as a universal commander for various kinds of appliances, including VCRs, TVs, and computers, as well as physical objects such as printed documents and business cards. We have applied the idea of "drag-and-drop" operation as provided in the GUIs of laptop and desktop computers. The InfoPoint provides a unified interface that gives different types of appliances

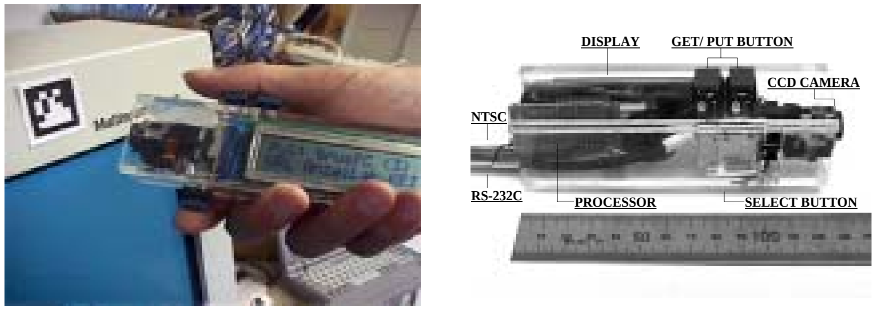

Fig. 1. Hand-held part of InfoPoint (left) and Configuration of hand-held part (right).

"drag-and-drop" -like behavior for the transfer of data. By recognizing affixed visual markers, the InfoPoint alters its function according to the object in front of it. Namely, the InfoPoint filters the data to find the appropriate message and commands that suits a given destination object automatically by collaborating with servers which have database of target objects and that of messages and commands. For example, when the InfoPoint device is pointing at a VCR, movie data will be suitable but music data will not. After the unsuitable data has been filtered out, the data that is suitable for sending as commands will be listed on the small display as visual feedback and the user will then select the required command. The InfoPoint has been designed to have a clear interaction since it applied "drag-and-drop"-like behavior. Therefore, the problem of users paying an explicit attention to the interaction with a portable device is still unsolved. Also, when the InfoPoint shows a lot of messages and lists of available commands, it is hard to confirm them and select one command from the list on its display. If a user can transfer the data to a near computer that is connected with a wide display, he/she can deal with it more easily using a mouse or a touch panel.

2.2 Smart Furniture

As another experimental device, we have developed Smart Furniture [2] [6], which aims to convert non-smart space, a space with no computers into a Smart Hot-spot that consists of computational services. Since the Smart Furniture is equipped with networked computers, many kinds of sensors, input, and output devices, it can provide various services by alone or by collaborating with other devices. Having considered some different situations, we have designed several types of Smart Furniture: pole type, lamp type, mirror type, and bulletin board type. Figure 2 shows the Bulletin Board Type and the Lamp Type Smart Furniture.

One application that we developed is a mobile TV-phone system as a prototype system of service roaming in the Smart Hot-spot using the Bulletin Board Smart Furniture. In generally-used TV phone service by a cell phone, the cell

Fig. 2. Bulletin Board Type Smart Furniture (left) and Lamp Type Smart Furniture (right).

phone has only a small display to show a pop-up menu and a picture of the person whom the user is speaking to, and a poor camera to photograph the user, or even nothing. This application enables to transfer a picture on a cell phone to a nearest wide display available at the time, by recognizing the location of the cell phone with the sensor inside the Smart Furniture. It also allows users to use the nearest camera, if it exists close to the cell phone, to take pictures instead of a poor camera on the cell phone. In this system, as the Smart Furniture with a positioning sensor, a display and a camera is used, it photographs with its camera consequently. In this application , three same-spec Smart Furniture were arranged in a row. As a user approaches the first Smart Furniture, it shows a picture transferred from a TV phone and its camera starts taking photographs. In the same way, as he/she passed by each Smart Furniture, the picture is shown on each display one after another, just like the picture is following him/her. And also pop-up menu is projected on the display of each Smart Furniture, which makes the user free from operating a portable device on its small display. Yet, the basic functions of a portable device has been maintained, because, as usual, a cell phone display can show pictures of a person on the other-side phone and a pop-up menu if there is no embedded device nearby.

We have also developed a Lamp Type Smart Furniture, which does not require any inputs by users. The input for this system is traffic of networks in some rooms. The input data is automatically measured by an embedded sensor and the output is reflected as a condition of brightness of the lamp that is divided into six parts. We have demonstrated the monitoring of surroundings, with applications using existing output devices and without suspension of user's other tasks or powering on a new display.

3 Conclusion and Future Work

In this paper, we have described the Smart Device Collaboration for ubiquitous computing environment by introducing two experimental devices, the InfoPoint and the Smart Furniture. The major advantage of the smart device collaboration is that an embedded computer complements the lack of capability of a portable devices and also users' explicit attentions to such devices can be alleviated. We have several problems to be solved for spreading the smart device collaboration. First of all, a unified communication protocol between a portable device and an embedded computer must be defined. It is an indispensable scheme to enable each personal portable device to interact with embedded computers without regard to where a user is. Another problem is how to define a mechanism for finding appropriate devices and services and also providing necessary services to each user [8]. The required services by a user keep changing depend on their context. A mechanism for recognizing needed services and for seeking the services within the context has to be examined.

Moreover, as one of our challenges to spread the Smart Device Collaboration, we have been designing Ubiquitous Core (uCore) which is a common platform for portable, embedded, wearable, and various computers. The uCore consists of a small main computer, optional I/O devices and sensors, and interfaces which can be attached to various kinds of devices. Therefore, its hardware and software can be customized depending on each target application dynamically. The goal of the uCore research is to remove a distinction between portable and embedded computers and also to adapt functional factors depending on each application. We will provide a new scheme to create various style of the smart device efficiently with the uCore.

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Background of the Author

Naohiko Kohtake is a PhD student in Graduate School of Media and Governance at Keio University since September 2003. He has been working for Japan Aerospace Exploration Agency since 1998 and he was in charge of development on avionics systems of Japanese launch vehicle, H-IIA until August 2003. His research focuses on collaboration between various kinds of computers and human-computer interaction in ubiquitous environments.

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