Comparing Interaction Styles for Shared Use of Pervasive Applications

Jan M.V. Misker[1], A.H.J. Oomes[1], Mark A. Neerincx[1,2]

[1]Delft University of Technology, Department of Mediamatics,
Man Machine Interaction Group
Mekelweg 4, 2628 CD Delft, The Netherlands
{j.m.v.misker, a.h.j.oomes}@tudelft.nl
[2]TNO Human Factors,
P.O.Box 23, 3769 ZG. Soesterberg, The Netherlands
mark.neerincx@tno.nl

Abstract. An issue often neglected in the design of pervasive display infrastructures and applications is the user interaction required to set up or start using the application. In this paper a system is described that makes it possible to compare different interaction styles for identifying and selecting resources in an environment shared by multiple users. An experiment was conducted to test two different interaction styles, one based on selecting devices by matching labels and another one in which participants selected devices by physically connecting to them with a personal token. This experiment showed that participants were more inclined to employ a cooperative selection strategy when using a personal token, as opposed to a solitary strategy when matching labels.

1 Introduction

In the future personal computing environments will consist of many (digital) resources that are dynamically connected in ad hoc networks. Resources can be content, devices or services/applications. Applications as we now know them will be replaced by a more dynamic compound of said networked resources. Users will have several groups of resources working for them, supporting them in their various activities.

There are many visionary papers describing scenarios made possible by such future environments [2], and also many papers describing in more detail the technological [7] and user interaction [1] issues that have to be solved in order to realize such scenarios. However, what is still lacking is a thorough understanding of how to compare and evaluate the possible user interaction styles in these smart environments.

We define a *Shared Computing Environment* to be the combination of a physical environment, consisting of private and public devices, with a virtual environment, consisting of (mainly) private content sources and public/generic services.

1.1 Interaction Styles

Many different interaction styles can be designed for interacting with a shared computing environment. We believe that it is vital to understand how a certain interaction style influences the way a user acts and perceives his environment. Some styles require little user interaction, e.g. the "follow-me" style, that is popular for demonstrating the versatility of technical systems. Other interaction styles require the user to engage in cumbersome procedures for setting up the environment, e.g. exchanging illegible pass phrases to pair two Bluetooth devices.

In previous work [5] two aspects were detailed: 1) identifying and 2) selecting appropriate resources. In a usability study [6] we investigated the effects of different ways of identification and selection with respect to a single user interaction with a personal computing environment, which showed that users want some control over their environment, as opposed to a fully automatic setup

1.2 Related work

Numerous interaction styles were tested, often without comparing them to other interaction styles [3], but sometimes comparisons with traditional interaction techniques were made [9]. In [4] and [10] some general considerations regarding identification and selection of devices are presented, that have an overlap with our previous work.

2 Design and Implementation

2.1 Architectural Design

The architectural design of a Shared Computing Environment system is based on an agent approach. All resources in the environment are represented by a *resource agent*. Users are represented by a *personal agent*. This approach implies that users as well as all resources are considered to be autonomous agents, which is useful because it forces us to focus on how to realize the dynamic cooperation between them.

The users' personal agent searches in the environment for useful agents, based on a distributed directory services approach. Discovered agents are grouped together in agent groups, that support the various user activities. For example, a photo viewing activity might be supported by a group consisting of a display device agent, a photo collection agent and a generic remote controller agent.

2.2 Implementation

The implementation is divided in two parts, the architecture and the specific resource agents. The agent architecture is based on the JADE framework. All nodes run an autonomously running agent platform with a local directory service and two architec-

ture agents: a connectivity agent to look for nearby nodes, and a group agent to manage the grouping process. Users carry a PDA that runs their personal agent.

The resource agents are of course very device or content specific. Agents were implemented for the following types of devices: display, GUI on users' PDA, Bluetooth keyboard, Bluetooth mouse, loudspeaker. Simple collection manager agents were implemented for digital music and photos. All resource agents have the ability to be grouped together. Most of them only execute fairly straightforward commands, e.g. "get music_collection", or they send a stream of information like pressed keys or mouse movements to a designated listener agent, usually the display agents involved.

2.3 Applications

Three applications were developed; game score keeping, music browsing and playing and photo viewing and annotating. These served as the testing material for the user tests.

Game Score. This application is quite simple, two users can join each other and keep track of the score of a non-computer game they are playing. They can add a display that shows a graph of the score development.

Music Browsing. Users can join and browse through their shared collection, either text based on their PDAs, or graphic based, using a bigger display to browse the album covers. In the latter case, they can use a mouse to control the album browsing and playing. A loudspeaker completes the music experience.

Photo Viewing and Annotating. Users can browse through their personal photo collection on their PDA. They can use a bigger display to show a photo to someone else. Up to two keyboards can be added, bound to a specific user, to add personal annotations to the photos.

3 User Experience Testing

3.1 Experimental Setup

The experiment was carried out with 10 pairs of participants, giving a total 20 participants. Each participant pair conducted a two hour session. The 2 styles of interaction were the main conditions:

1. Label: participants select resources by choosing the matching labels on their PDA.
2. Token: participants select resources by physically connecting their personal token to the device.

The three applications described above were sub conditions. The participant pairs were asked to execute a fixed task with all three applications. 5 of the participant pairs

started the session with the Label condition, 5 with the Token condition, after executing all three application, they switched to the other main condition.

A varied range of measurements were recorded. Participants filled out a Locus of Control survey and a general technological knowledge survey. After each task the participants filled out questionnaires regarding usability, trust and cooperation. Their actions were logged, e.g. selecting a resource by attaching a token. The experiment ended with a final questionnaire with rating questions, and a free-form interview.

3.2 Results

The most prominent result is the manifestation of two strategies for setting up the shared environment:

1. Single; one subject sets up the environment.
2. Together; both subject participate in setting up their shared environment.

Figure 1 shows an impression of the difference between these strategies. The shapes below the join indicate a device selection. Note that these diagrams do not show the time between selections, only the order in which selections occured.

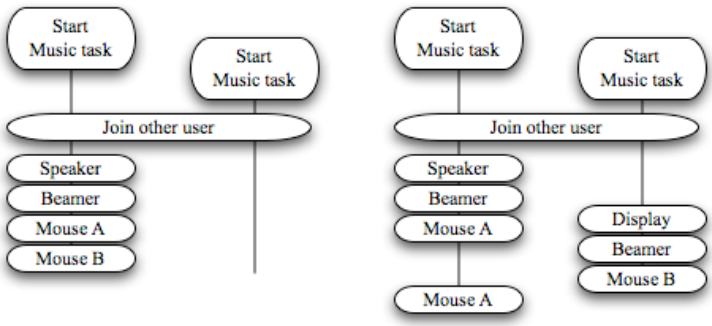

Fig. 1. Example flow diagrams of the different strategies. On the left: single user strategy, on the right: together strategy.

The different strategies are most apparent in the music task, because in that task 3 devices have to be combined in a shared computing environment. Table 1 below shows the distribution of the strategies chosen to accomplish the setup of music task, for the Label and the Token interaction style.

Table 1. The strategies chosen by the subjects.

	Single	Together
Label	5	4
Token	1	8

4 Conclusions

The main contribution of this paper is the comparison of different interaction styles for shared computing environments. That this is important is shown by the clear effect different interaction styles have on the cooperation strategies chosen by participants in the user experience experiment.

In future work we will broaden our approach to include different usage contexts and provide design guidelines for interaction in pervasive computing environments.

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