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A Framework for Multi-User Support in Instrumented Public Spaces

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Abstract

The emerging trend towards complex technology that supports multiple users in public spaces is evidenced by the presence of shared displays in shopping malls, museums, and airports As sensing and interaction begin to play a greater role in these environments, application and interaction concepts are evolving to take the distribution and dynamics of users and devices into account. In this paper we describe a layered approach to support multiple in environments that allows concurrent interaction with multiple devices and displays. We further identify issues that arise in public, interactive spaces with multiple users and discuss how we address them in our proposed framework.

1 Motivation

Technology is becoming pervasive in public spaces, as evidenced by the presence of shared electronic displays in environments such as airports and shopping malls. Through the integration of sensor technologies and devices, these environments will be capable of providing complex interactive and context-aware services. While such services, such as personalized information and navigation assistance, may offer great benefit to users, providing these services in technology-rich, multi-user environments opens new design challenges for developers: How do we determine which user performed an interaction with a device? How do we integrate different user tracking and identification technologies with varying levels of accuracy? How can we integrate mobile and possibly private devices that enter and leave the environment? How can an application select the most appropriate display to show information for a user? Developers currently need to have detailed knowledge about the positions, properties and availability of displays to design their application logic; changes in the environment also often necessitate the restructuring of applications. Furthermore, having multiple independent applications serving users concurrently and sharing one display environment requires all applications to integrate conflict resolution mechanisms.

We are developing a framework to address these emerge issues for dynamic public spaces regarding devices, users and their tasks and a variety of parallel and distributed interaction possibilities. As a testbed for our research, we have simulated a typical instance of such a public space: An airport scenario, in which individuals or groups are involved in tasks such as shopping, exploring the environment or navigating to multiple destinations. Our layered framework provides reusable, extensible modular components to abstract the low-level architectural details away from the application development process, manage resources, and handle potential conflicts between devices, displays, and applications.

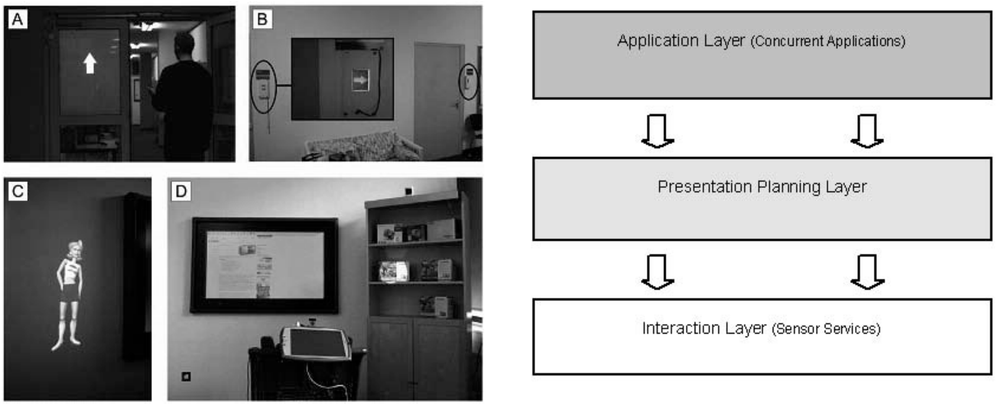

Figure 1: ***Left****: Images taken from our user assistance applications, showing navigational aid (A,B), a virtual character welcoming a user (C) and shopping assistance on a large screen (D).*
Right*: Structure of the multi-user framework*

2 Three layers of multi-user support

Our framework divides the design space into three layers: The interaction layer deals with the position and recognition of user interaction, determining who has interacted where and with what. The presentation layer uses this information and the knowledge about display locations and properties to provide an abstraction of available displays, distributing presentations over time and (display) space, such that the application layer (i.e. the application developer) does not have to deal with infrastructural details, e.g. availability of resources or visibility of displays to a target user. Applications can be developed and deployed without detailed knowledge about the setup of the environment or other independent and possibly interfering applications.

The *interaction layer* is based on an extensible sensor ontology that models sensors and their services according to their type (e.g. user identification, user tracking, object manipulation) and accuracy. This includes physical entities such as wireless sensor nodes embedded in objects or the environment, cameras, touch screens, active and passive RFID readers, biosensors or microphones. These sensor instances provide self-contained services, such as determining the temperature of a room or the walking speed of a user, but also more complex services based on multiple sensors and their services. For example, by using a Bluetooth identification service to recognize individuals in conjunction with a camera-based location tracking service, an environment can determine exactly which users are interacting with which devices. The separation of these concerns allows us to extend and modify the sensory layer without demanding the adjustment of higher layers.

The *presentation planning layer* (PPL) relies on spatial knowledge about the environment and its stationary displays, stored in our ubiquitous user modeling database, and on knowledge about user positions and mobile display locations provided by the interaction layer. The PPL provides an abstraction of these by allowing applications to issue presentation request that include a resource identifier (e.g. web site, video stream) a destination (user, user group, room) and type descriptor (image, video, sound, text or mixed). The PPL coordinates concurrent requests in a rule-based manner by distributing presentations among available display resources. The set of rules is intended to provide coherent presentations in public spaces and solves conflicts by dividing display resources in time and space, by considering requirements specified by the application, such as the intended time and duration of a presentation, privacy demands (e.g. will not show on public displays if other users in vicinity) or required input channels (keyboard, microphone etc.). The accuracy information of a user identification process helps the PPL to estimate whether privacy requirements of a presentation can be fulfilled.

The *application layer* hosts all applications that are utilizing the display infrastructure of the environment. Applications post presentation requests in a well-defined message format to a centralized message board (we currently use the *EventHeap* (Johanson & Fox 2002)) and receive acknowledgement after requests are successfully patched through. Main applications of our current laboratory setup are a navigation system, shopping assistants, a virtual room inhabitant, a personal passenger announcement system, and an advertisement manager.

3 Conclusions and Current State

We presented the components of our framework for developers of public instrumented spaces, which separates infrastructural concerns from application design. Our immediate goals are completing the implementation of the interaction layer and the sensor service ontology. The presentation planning module is implemented as a simplified prototype and needs to be enhanced to work with larger amounts of users and applications. The main goal of our work is to develop a very flexible and customizable system, such that the application layer can be easily extended to encompass new technologies, services and service inferences that will inevitably arise in new scenarios and domains. Robustness and accuracy of the final prototype has to be evaluated thoroughly to further improve the framework.

References

Johanson, B.; Fox, A. (2002): The Event Heap: A Coordination Infrastructure for Interactive Workspaces. In: Proceedings of the Fourth IEEE Workshop on Mobile Computing Systems and Applications, S. 83.