Managing Presentations in an Intelligent Environment: Navigation Tasks in a Shopping Scenario

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ABSTRACT

Intelligent environments enable users to receive information from a variety of sources, i.e. from a range of displays embedded in those environments. From a services perspective delivering presentations to users in such an environment is not a trivial task. While designing a service it is, for example, not clear at all which displays will be present in the specific presentation situation and which of those displays might be locked by other services. It is further unclear if other users are able to see the presentation, which could cause problems for the presentation of private information in a public space. In this paper we propose a solution to this problem by introducing the concept of a presentation manager that provides services with an abstraction of the available displays. The presentation manger is able to detect conflicts that arise when several users and services try to access the same display space and provide strategies to solve these conflicts by distributing presentations in space and time. Finally, we will report our experiences that were gained within an intelligent environment with a presentation manager managing parallel presentations from a navigation and a shopping service.

Keywords

Smart environments, Public Displays

INTRODUCTION

As the price trend for large plasma screens continues to drop, more and more public displays are being installed. Within the next years, polymer and organic LED displays of arbitrary size will enter the market, and they are likely to be integrated into all kinds of objects at negligible cost.

In anticipation of displays emerging everywhere, we investigate how to integrate them into the design of intelligent user interfaces. Today, public displays are typically poster sized and non interactive and present product information, advertisements or transport time-tables at regular intervals. In the research lab, public displays are mostly used in the context of CSCW[1] projects. Whereas these projects use a single large display to share information between multiple workgroup members, we are more interested in how individual users can benefit from multiple distributed displays of all sizes.

We use public displays in a flexible fashion for a system that provides a user with shopping assistance and navigational aid. The key to such personalized and localized presentations is spatial knowledge about the environment, i.e. the position of the displays and the user. Given this information, the presentation service is able to present individual content on a suitable display nearby to the user.

Instead of running a single custom application on the public display, we favor all-purpose World Wide Web technology such as HTML and Flash for interactive presentations. This approach allows for a non-exclusive usage of the displays by multiple applications. Besides product information and navigational aid, the same display might also provide messages and postings that are maintained by completely different applications.

In such a scenario of multiple users and applications, conflicting presentation requests are likely to arise and need to be resolved. Therefore the presentation service has to implement intelligent rule-based strategies to allocate the most suitable display for a certain content and to divide the available displays by time and screen space, if necessary.

The next section briefly describes related work, followed by the architecture of our intelligent environment. We further discuss navigation tasks and the management of presentations on public displays and close with an outlook on future work.

[1] Computer Supported Cooperative Work

RELATED WORK

In the following we give a brief overview about related work in the field of instrumented and intelligent environments and we point out where our approach relates or differs from the projects mentionend in this section.

In the project HERMES [6] two corridors of the computing department at the University of Lancaster have been equiped with interactive door display based on handheld devices. In the project REAL we extended this approach. Whereas these displays have been solely used to provide asynchronous graphical and textual messaging services between office occupants and anyone passing by the offices. Our approach as described in the following sections, allows for the presentation of multimedia content and navigational instructions, despite the fact that multiple applications could request these displays to render their presentations.

[7] use large plasma screens as digitial interactive poster boards in public spaces to facilitate informal content sharing within groups. In their case study these displays are used to promote everyday information and offer interaction capabilities to users as they go about daily business. Another approach described by [12] uses large displays to present the information of an instant messaging system to support users in a public space during their work tasks and enables them to communicate in a quick and lightweight fashion. In their approach large plasma screens are only one of many different display devices, which can be requested from different applications in order to provide interaction and information presentation capabilities.

The goal of the EasyLiving research project [4] is the development of a prototype architecture and necessary technologies for intelligent environments. The project concentrates on applications where interactions with computing devices can be extended beyond the confines of the current desktop model. The project aims to include computer vision, person tracking and visual user interaction together with multiple modality sensor fusion and the use of a geometric model to adapt the user interface. Wheras the EasyLiving approach uses computer vision to track the user's position, our approach uses a hybrid sensor fusion method as described later.

As described by [19] and [18] the project M3I aims to develop a Mobile Multi-Modal Interaction platform for mobile devices. It is designed to easily support different input and output modalities. Whereas 2D/3D-graphics and synthesized speech are used to present useful information to the user, the system allows for multimodal input using speech and gesture recognition engines. The M3I platform and their range of input and output modalities serves as basis for the services that support the user in a navigational or shopping task.

THE SUPIE ARCHITECTURE

The project REAL is concerned with the main question: How can a system assist its user in solving different tasks in an intelligent environment? Such environments consist of distributed computational power, presentation media and sensors, and also entail the observation and recognition of implicit user interactions. This offers the possibility to infer about a users plan and intentions, and to proactively assist in solving their task.

In order to investigate novel user interfaces, we have set up the *Saarland University Pervasive Instrumented Environment* (SUPIE). Its architecture has been designed for the seamless integration of the shopping assistant *ShopAssist* [18] and the pedestrian navigation system *Personal Navigator* [15]. It is organized in four hierarchical layers, which provide in bottom-up order blackboard communication, positioning and presentation services, knowledge representation and the applications. We will now have a detailed look at each layer.

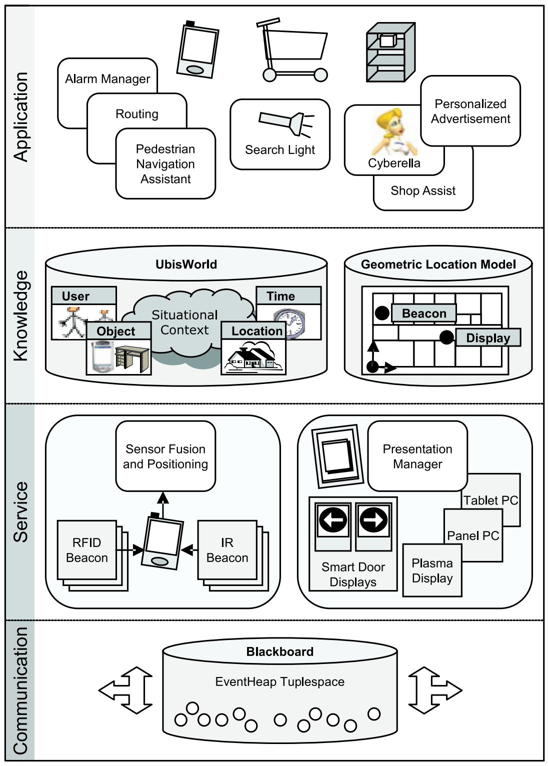

Figure 1: The four-layered SUPIE architecture.

Communication Layer

The communication and coordination within the SUPIE architecture is based on a commonly accessible tuplespace, which provides an indirect interaction mechanism featuring the portability, heterogeneity, economy and flexibility needed for an intelligent environment [11]. Processes post their information to the space as tuples (collections of ordered type-value fields) or read them from the space in either a destructive or non-destructive manner. In comparison to client-server designs, the anonymity and persistence of tuples offers a high degree of failure tolerance in dynamically changing environments [13]. If a requested service is temporarily unavailable due to a network failure or reboot, the stability of the client process will not suffer. We have chosen the *EventHeap* server and API, which have been developed at Stanford University as a framework for their *iRoom* [9] project. Similar implementations are available by Sun [10] and IBM [20].

Service Layer

The service layer provides multiple applications at the same time with information about a users position and access to the public presentation service. It hides the technical complexity of these services behind a simple interface, which is based on blackboard events.

Positioning Service

Being at the right place at the right time is an essential precondition for any user interaction within the real world. Thus for any given user task, it is likely that a navigational sub-goal exists. Being aware of this, we have spent considerable research effort in the development of indoor and outdoor pedestrian navigation systems, as published in [1] and [15]. Whereas the predecessor systems have been designed as stand-alone devices, we have now separated the positioning component from the navigational assistance. We adopt a hybrid sensor approach, where a mobile terminal receives signals from infrared beacons as well as active RFID tags that have been placed at fixed positions. These sensor readings are transmitted to the positioning server, which uses georeferenced dynamic Bayesian networks [3] to fuse the heterogeneous sensor information and to estimate the position. The server matches the position with the geometric location model, which is given by the knowledge representation layer, and provides a symbolic location identifier as well as geometric coordinates.

Presentation Service

The presentation service provides a simple event-based interface that allows applications to present Web content such as HTML and Flash on any public display. The applications post presentation requests on the *EventHeap*, which are assigned to displays by the presentation manager. The presentation manager maintains a stack of presentations, and implements rule-based conflict resolution strategies to decide which content to present. The service curently supports devices with *Windows CE* (PocketPC) and *Windows 2000/XP* operating systems. For more details on the presentation service see section *Managing Presentations In An Intelligent Environment*.

Knowledge Layer

This layer models some parts of the real world like an office, a shop, a museum or an airport. It represents persons, things and locations as well as times, events and their properties and features. The ubiquitous world model *UbisWorld*[2] describes the state of the world in sentences made of a subject, predicate and object. The vocabulary is provided by concepts, instantiated individuals and relations. An underlying ontology defines classes and predicates, such as a taxonomy of physical things, user characteristics and activities.

A hierarchical symbolic location model represents places at different levels of granularity, like cities, buildings and rooms, and serves as a spatial index to the situational context. In order to generate localized presentations and navigational aid, the positions of the user, the landmarks and the displays have to be known. Therefore the symbolic model is supplemented by a geometric location model, which is created and maintained by the *YAMAMOTO*[3] editor [17]. It contains coordinates of the building structure, landmarks, beacons and displays, and also viewing angles and distances if necessary.

Application Layer

On the top layer are the actual applications in our intelligent environment, which use the services of the lower layers to provide an intelligent user interface.

The shopping assistant application provides product information and personalized advertisements to the user and also includes the animated agent *Cyberella* [16]. As the user interacts with real products on the shelf, their actions are recognized by a RFID reader and sent as events to the application. In response, the assistant proactively serves product information to the user on a tablet PC display, which is mounted to the shopping cart, or any other public display, via the presentation service. The user can also use their PDA for multimodal interaction with the *ShopAssist*, which entails the fusion of speech, handwriting, intra and extra gestures.

The navigation application runs on a PDA and is based on the information provided by the positioning service. On the handheld a graphical map and speech synthesis is provided. Besides the mobile device, the system utilizes nearby public displays to present arrows that indicate the direction to go. Inside the shop, a steerable spotlight helps the user to find certain products on the shelf [5].

Other applications, such as the museum guide *PEACH*[4],

[2] http://www.u2m.org
[3] http://w5.cs.uni-sb.de/˜stahl/yamamoto/
[4] http://peach.itc.it/home.html

the posting service *PlasmaPoster* [7] or the messaging service *IM Here* [12], could also benefit from the service layer and run simultaneously in the environment.

NAVIGATION TASKS IN AN INTELLIGENT ENVIRONMENT

The central theme of our research is a scenario, in which a user has some limited time to buy a digital camera at a duty-free shopping mall of an airport, before the departure of their flight. In this setting, some typical navigation tasks are to find an electronics store inside the airport and finally to locate a certain model on a shelf. The latter task is inherently different from the prior, since navigational directions are no longer helpful, yet assistance may be desired since it takes some time to find a specific item within a collection of similar objects.

To differentiate between these two types of tasks, we introduce the concepts of macronavigation and micronavigation. Our definitions are based on the immediate range of a users perception. A **macronavigation** task is given by a navigational goal beyond the users perception, which requires survey and route knowledge of the environment. By the term **micronavigation** we conceive the task to focus the attention of a user to a spot within the perimetry of their perception. Macronavigation tasks can be decomposed into micronavigation instances, that is a sequence of transitions from one range of perception to another.

In the SUPIE architecture, navigational assistance is provided to the user as follows: The navigation assistant finds a route from the starting point to the target, uses geometric knowledge about displays in the environment, and creates situated presentations of incremental micronavigational aid for each display along the route. It posts these presentation requests to the blackboard, where each triple encodes the addressed user, a display identifier and a presentation URL. It is now up to the presentation manager to handle these events and to decide which of the requested displays are currently visible to the user, and to resolve conflicts arising from multiple users.

MANAGING PRESENTATIONS IN AN INTELLIGENT ENVIRONMENT

In a public space with various displays we assume that a number of applications are running simultaneously and concurrently attempting to access display resources. A straightforward procedure for such applications would be to directly connect to the machines that control the displays - potentially creating conflicts with requests of other applications. In such a case each application would have to include its own routines to resolve conflicts. Our approach for the distribution of display resources is to insert a service between applications and public displays that hides the underlying display space with its possible conflicts and technical properties. The presentation management component resolves arising conflicts and distributes presentations in a context sensitive fashion. This centralized approach yields to a number of further advantages and enables us to apply new concepts as described in the following section.

The Presentation Manager

The presentation manager (PM) is an abstraction of the public display space from an applications point of view and provides a high-level interface to issue presentation requests. Whereas canonical conflict resolution strategies could be first come, first served or priority based assignments of resources we focus on rule-based planning: Presentation strategies are modelled as a set of rules that are applied to a list of available displays and queued presentation requests. These rules generate plans at runtime, which define how the presentations are distributed. We will elaborate a framework of such rules in the remainder of this section.

A presentation request sent to the PM must have the following syntax:

Source	URL of the media with the content
Destination	display or location or user
Type	image, text, video or mixed

Optional parameters can be provided to guarantee certain properties of the media rendering:

Minimum Display Time	e.g. 60 seconds
Minimum Display Size	small, medium, large
Minimum Resolution	e.g., 800x600
Audio Required	Yes / No
Input required	Yes / No

Based on this information the PM now plans the presentation in four steps:

1. *Generate a list of feasible displays:*
   This task is trivial if a particular display is given as the destination. If a room identifier is provided, *UbisWorld* is queried for local displays. If a person is the stated addressee of the presentation, first their location and orientation is retrieved from *UbisWorld* whereupon the spatial location model is inquired to determine nearby displays, which could either be based on the euclidean distance using coordinate vectors or - more reasonable - a qualitative distance, i.e. user and display reside in the same room. Having exact locations of users and displays we are moreover able to examine the visibility of the presentation, considering the visual demands of its content in relation to the size, distance and viewing angle of the display. All displays fulfilling these requirements now constitute the list of feasible displays for a given user.

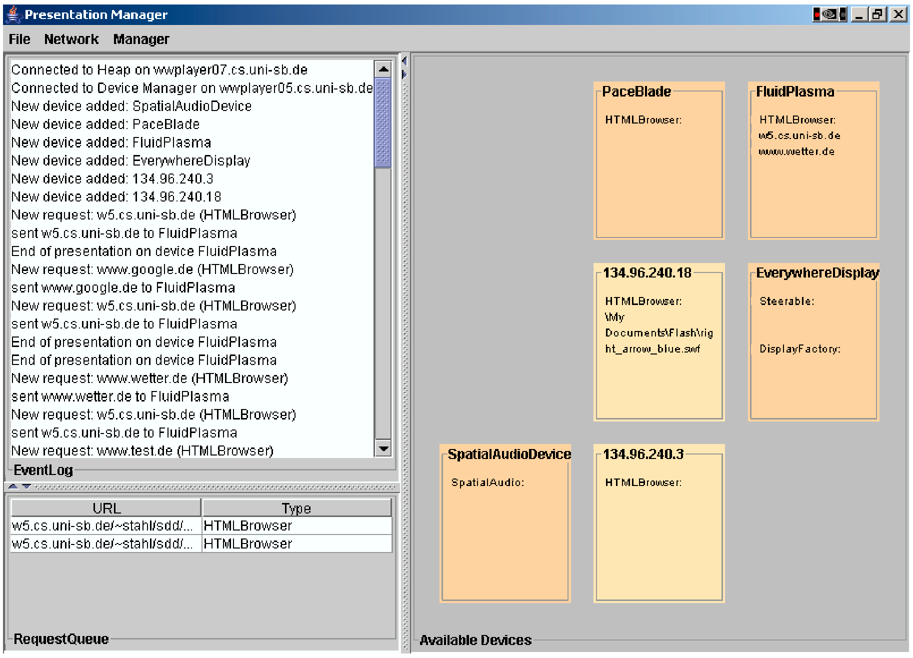

Figure 2: Screenshot of the Presentation Manager.

2. *Sort the list*
   The list generated by step 1 is now sorted applying the criteria in following order:

   - idle displays
   - given minimum criterium (e.g. size)
   - general quality (resolution, size)
   - release time

   The presentation will be displayed on the first available display on the current list.

3. *Resolve conflicts*
   If step 2 does not deliver any idle displays, we check if ending presentations will release a display before the deadline of the current request elapses. Displays for which this condition holds are sorted according to step 2 and the request will be queued on the first display (*division of time*). If still the request cannot be scheduled (the latter list is empty), we check if a display can be shared - preserving the given requirements (resolution, size) of the involved presentations (*division of space*). If this does not resolve the conflict, we attempt to re-plan currently playing presentations on different screens.

4. *Start over*
   After applying these steps without success, we start over and consider more distant displays in combination with an audio notification, which is automatically added to the presentation by the PM.

This set of rules provides coherent presentations in public spaces and resolves conflicts by dividing display resources in time and space: Presentations are scheduled according to their deadline requirements and are delayed until resources are available *(time)*. Screen space is shared if an appropriate device is available such that presentations are rendered simultanously on the same screen in different windows *(space)* [14].

So far we have only taken a single user into account. Conflicts that arise from multiple users interacting concurrently with the environment, can be handled by the same strategies. Privacy issues require additional rules: Each user can specify contents as private within the settings of *UbisWorld*, for instance navigational aid. The PM would now simply remove displays in step 1 which can be seen by other users.

Presentation Technology

The actual presentations on the displays are all done using a Web browser with Flash plugin, which is available for many platforms. A variety of authoring tools for Web based media already exist and we are particularly able to reuse existing contents in this environment immediately. Moreover HTML already provides resource adaptive layout techniques that adjust to different screen and window sizes.

The following devices are currently connected to our intelligent environment and used by the PM:

- a large wall-mounted plasma screen
- 2 wall-mounted panel PCs

- 5 PocketPCs as interactive office doorplates
- a tablet PC connected to a shopping cart
- a smart poster: a projection on a semi-transparent surface attached to a glass door
- a stationary projector used to display information on a table
- a steerable projector mounted on the ceiling

Implementation

The presentation manager is a component of the service layer, and permanently runs as a background task that listens for incoming requests on the *EventHeap*. It connects to the Device Manager through a remote method invocation interface to query available devices belonging to the *FLUIDUM* [8] project and receives notifications whenever devices log on or off. Displays are also activated over a RMI interface, which uses Active-X controls to access instances of the Microsoft Internet Explorer, managing their layout and contents.

The door displays are not connected to the Device Manager and must be queried over a TCP/IP socket connection: We have developed a process manager application that runs on each PDA and allows to start or stop processes on request, a Web browser in our case. The process manager automatically resets the device and restarts itself every night for stability reasons.

The PM currently resolves conflicts by considering the deadlines combined with priorities. A rule-based planner is currently under development in Prolog. Nevertheless we tailored the current presentation manager to scenarios in our environment such that it simulates the behavior of the proposed concept. Display positions are matched with the user's range, and presentations are queued until displays become available or multiple presentations share a screen by opening multiple browser windows beside each other (division in time and space).

APPLICATION SCENARIO

We present a comprehensive example scenario, in which the public display infrastructure is used to assist the user in different situations. In order to relate the prototypes of our lab environment to a practical situation, we have designed the applications according to a scenario of everyday life. Imagine a user, who has just checked in at a large airport, and wants to buy a digital camera at the duty-free zone before the boarding of the plane.

The first goal is to find an electronics shop which offers a good selection of digital cameras. The user activates their PDA to explore the environment, picks a shop and requests navigational aid. Since the user has to carry hand luggage, it is rather inconvenient to look at the display of their PDA, and it feels more comfortable to be guided by personalized directions given by public displays. In our lab, such navigational aid is provided by the Personal Navigator application and a smart poster at the entry of our university chair, but also by small displays mounted next to the regular doorplates of five offices. An image of the rear-projected poster is shown in figure 3A), the PDA based door displays are shown in figure 3B). The PDA picks up positional codes sent by RFID and infrared beacons and transmits them to the positioning server, which estimates the actual position and posts it to the common blackboard. The *Personal Navigator* application evaluates these postings and creates situated navigational aid for the user. It utilizes the presentation manager to address these presentations to public displays which are perceptible by the user.

Upon entering the shop, the user picks up a shopping cart with a tablet PC based shopping assistant and logs in to the system by a RFID customer card. A virtual salesperson appears and gives a short introduction to the shops departments and special sales offers, whilst in the background the advertisements around the user slowly adapt to the new profile. In the SUPIE environment, this presentation is held by the virtual inhabitant called *Cyberella*, whos appearance is accomplished by a steerable projector, as depicted in figure 3C). An advertisement application retrieves the gender of the user from the user model, which is represented in the *UbisWorld* database, and periodically advises the presentation manager to serve gender-related advertisements on the large plasma screen.

Facing the shelf with many digital cameras, the user remembers a certain model, which has been recommended by a friend. The user engages in a dialogue with the shelf: "Whats the price of the ACME 500 camera?" – "There is a special price for you today, only 399 euro" the shelf replies. Simultaneously a spotlight appears and directs the user's attention to the package, according to our definition of micronavigation in contrast to macronavigation as seen before. The user picks up the camera and continues the dialogue with questions regarding technical details, and the shopping assistant supplements verbose answers by visual information that is shown on the shopping carts display. Additionally, a browser window appears on the plasma display, replacing the advertisement by the product website, as it is provided by the vendor. As the user picks up a second camera, the system provides product comparison information. All of these services are implemented in the SUPIE room as shown in figure 3D).

Meanwhile, the alarm manager application has estimated that the user should leave the shop immediately in order to board their plane. By constantly analyzing biosensor signals through Bayesian networks, the alarm manager is convinced that the user is not aware of the urgency of their situation and advises the presentation

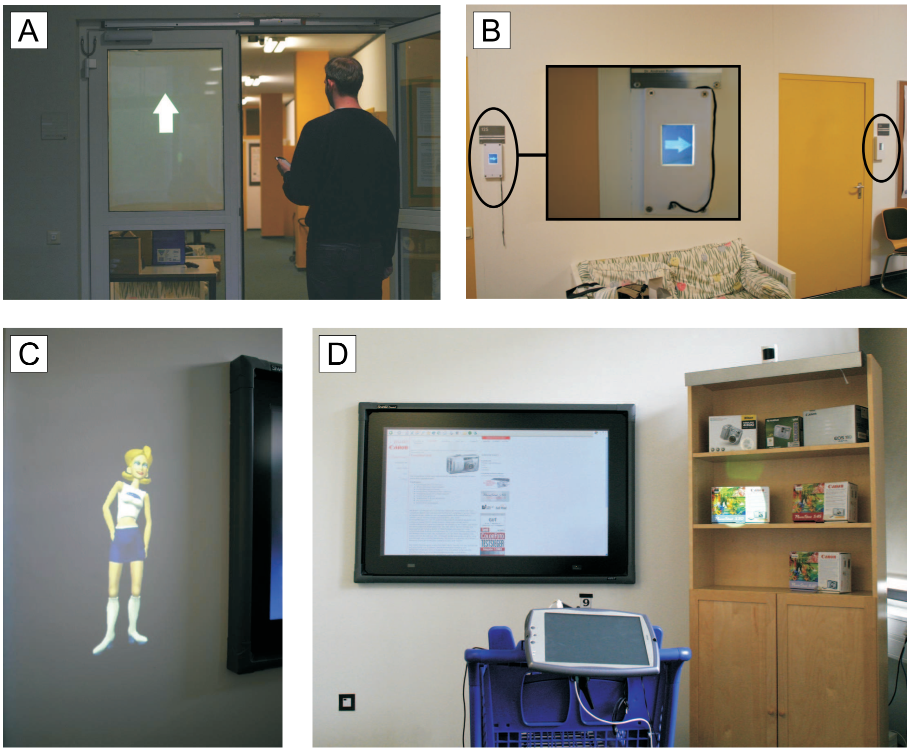

Figure 3: Presenting navigational aid and product information on public displays.

manager to serve a reminder message with highest priority to the user. Instantaneously the message appears on the plasma display, and the alarm manager recognizes that the user has received it, since skin resistance and heartbeat change accompanied by increased motion. Although biosensors are currently difficult to attach to the body, more advanced technologies may allow unobtrusive and wearable designs in the future. Current work at our lab already gives promising results, see [2] for more information.

SUMMARY AND OUTLOOK

In this paper we have presented the concept of a presentation manager for intelligent environments, a centralized service that provides other services with an abstraction of the available display space within the intelligent environment. The presentation manager allows the design of applications without bothering about the details of display allocation in the intelligent environment itself. We have elaborated on different conflict resolution strategies. The described rule-based approach helps to find appropriate display devices in a specific situation. It helps, for example, to resolve conflicts that arise if several applications want to prompt information to one single user at the same time as well as situations in which private information has to be revealed to a user in a public space. We have explained how the presentation manager is embedded into the intelligent environment SUPIE and how the presentation manager is supported by the different knowledge components of SUPIE. Finally, we have underlined the usefulness of the presented concepts by showing how the presentation manager handles parallel presentation requests in a combined navigation and shopping scenario.

The next steps involve further investigations of how a display space can be addressed as a display continuum rather than a collection of separated displays and projection surfaces. For this purpose, we plan to extend the rule-base by rules that help to guide the user's attention from one display surface to another. This will help to micronavigate users to displays in their vicinity that are not directly perceivable from their current position (e.g. when looking away from a display). We also plan to make use of the user model stored in the SUPIE to take into account the users habits while interacting with displays in their surroundings.

At the moment we have just discussed the use of visual presentations. In the future we plan to extend our work towards other output modalities, i.e. spatial audio and haptic output such as vibration alarms. It should be straightforward to design the appropriate entries to the rule-base of the presentation manager. We believe that the concept of the presentation manager is extendable to reason also on suitable input devices that could be associated with a particular display, which will enable the presentation manager to redirect presentations to a space of the environment that matches best the requested in- and output requirements. Finally, we will extend SUPIEs presentation capability (by new output devices) and add more services to the intelligent environment, which will enable us to evaluate our approach in more depth.

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