NAVIGATIONAL - AND SHOPPING ASSISTANCE ON THE BASIS OF USER INTERACTIONS IN INTELLIGENT ENVIRONMENTS

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ABSTRACT
This paper presents an overview about ongoing work in the project REAL, where we have set up the Saarland University Pervasive Instrumented Environment (SUPIE). In particular we introduce the intelligent environment’s architecture, which serves as the basis for different services and applications running in the environment and supporting their users in different task. On the basis of this information we outline our user and location-modeling component needed to establish the navigational – and shopping-assistants developed so far. Both assistants support their users with especially customized presentations. These presentations will be automatically scheduled and presented on public displays in the environment, as explained in the remarks about the presentation manager. Finally, we provide a short outlook on planned future work in the project.

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

Though our research prototypes are restricted to our lab environment, our motivation stems from public environments, where people are likely to benefit from assistance services. We focus our interest on two particular tasks in an airport scenario, navigation and shopping. In the shopping scenario, we explore how to assist the user in achieving their goal of the best possible buying decision within a given limited time. We employ an RFID-technology based infrastructure of readers and labeled products to sense implicit user interactions, such as picking up a product from the shelf or putting it into the shopping cart.

The user also pursues certain navigational goals in order to enter the shop and to pick up a certain product. Therefore, we have developed two services, which offer navigational aid on both macro and micro level, that is within the building and in the room. For the prior, we have developed an indoor positioning system, which uses a PDA to receive RFID and infrared beacon information and to process them with dynamic Bayesian networks. The estimated location triggers the presentation of directions and is optionally made available through a ubiquitous user model in order to activate location-based services, such as the navigation assistant.

Inside a room, on the micro level, we use a steerable projector to highlight products in the shelf.

System output, such as directions and product information, is presented to the user in a flexible fashion on either their own PDA if available or on suitable public displays nearby to the user, based on the requirements of the content and spatial knowledge about the positions of the displays and the user.

The proactive behavior of both assistants is complemented by mobile multimodal user interfaces running on a PDA. The ShopAssist application recognizes interactions at the shelf as extra-gestures, which can be mixed with intragestures on the display and speech. The PersonalNavigator application offers an exploration mode, which allows the user to query information on points of interest within a three-dimensional navigational map. The user may formulate their request using combined speech and stylus gestures.

In the next section we further discuss navigation tasks in an intelligent environment before we take a closer look at the application scenario. After that, we will introduce our intelligent environment’s architecture, which allows for the integration of different services and applications, before we take a closer look at the user- and location-modeling component needed for the positioning service introduced afterwards. After a brief introduction to our presentation manager responsible for scheduling presentations, the article closes with the related work section and with the summary and outlook.

NAVIGATION AND SHOPPING TASKS IN AN INTELLIGENT ENVIRONMENT
In the scenario described later in this section, some typical navigation tasks could be to find an electronics store inside the airport and finally to locate a certain product 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.

Micro-navigation and Macro-navigation
To differentiate between these two types of navigation tasks, we introduce the concepts of macro-navigation and micro-navigation. Macro-navigation is concerned with tasks, in which the navigational goal is beyond the user’s perception of the current environment, in the sense that the user has to move through the environment to reach their destination, which requires route and survey knowledge about the environment. By the term micro-navigation we conceive the task to focus the
user's attention to a spot within the perimeter of their perception, e.g. an interesting product in the shelf. Macro-navigation tasks can be decomposed into micro-navigation tasks, that is a sequence of transitions from one range of perception to another.

**The Airport Scenario**

Our interest in intelligent environments is motivated by their potential to create novel user interfaces, that are based on implicit interaction, such as sensed motion and gestures, and support the user by presenting situation-aware information. We will now present a comprehensive example scenario at an airport, that outlines how a traveler could be supported by their navigational and shopping tasks. Then we will relate the envisioned scenario to the implemented demonstration prototypes in our lab and discuss unresolved issues.

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 macro-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.

Upon entering the shop, the user picks up a shopping cart with a tablet PC based shopping assistant. A virtual salesperson appears and gives a short introduction to special sales offers and the shops departments, helping the user to find the electronics.

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: “What’s 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 micro-navigation in contrast to macro-navigation 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 cart’s 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.

Meanwhile, the alarm manager application has estimated that the user should leave the shop immediately in order to board their plane. The application advises the presentation manager to serve a reminder message with highest priority to the user. The message appears on the same plasma display which has been used before.

**User Assistance in the SUPIE Environment**

In order to develop prototypical implementations of the envisioned applications that provide a user with micro- and macro-navigational aid and shopping assistance as described above, we have instrumented our lab with a terminal-based position tracking system, a public display infrastructure and a shelf that is able to sense tagged objects inside.

The Personal Navigator (17) application resides on the same handheld device that is used for tracking, and provides a multimodal interface that allows the user to explore the environment through the combined use of speech and gesture, and to select from a set of routes and destinations. Once activated, the system responds to the user’s current location and provides macro-navigational aid between rooms and buildings. A graphical map is shown on the handheld device, which is supplemented by directions on stationary public displays. As the user approaches the displays, arrows are presented that guide the user to the next display, which continues up until the user reaches their goal. We have small public displays mounted next to the regular doorplates of five offices and a smart poster at the entry of our lab. An image of the rear-projected poster is shown in Figure 1A), the PDA based door displays are shown in Figure 1B).

Upon entering our instrumented shopping room, the virtual inhabitant called Cyberella (16) introduces the available products and services to the user. Her appearance is accomplished by a steerable projector, as depicted in Figure 1C), which is also used by the SearchLight (6) to present micro-navigational aid within the room, in particular highlighting certain products in the instrumented shelf as shown in Figure 1D).

Shopping assistance is available through two slightly different applications. The SmartShop (20) is implemented in the style of a Web application running on a server. As the user interacts with real products on the shelf and the shopping cart, the assistant proactively serves product information to the user in a Web browser, either on a tablet PC display, which is mounted at the shopping cart, or any other public display. Alternatively the user can use their own PDA for multimodal interaction with the ShopAssist (23), which entails the fusion of speech, handwriting, intra and extra gestures.

Whereas our applications successfully assist a single user within our lab, the airport scenario obviously requires support for multiple users. We have intentionally postponed this issue for future research projects, but we will briefly discuss the resulting problems. Considering the shelf, two or more users concurrently picking up products might confuse the system and receive inappropriate information. One approach would be to sense the number of users and adapt the system behavior accordingly. Regarding navigational aid, we believe that the use of public displays is a promising alternative to personal devices, where such an application would have to be implemented on a variety of platforms and operating systems. For tracking purposes, the user might pick up a baggage cart instrumented with a positioning tag such as Ubisenseét or BAT (1). But is it feasible to guide hundreds of users by a limited number of public displays? We think so, if navigational aid is only presented on displays nearby to the user, and if users are addressed in groups (by their destination) rather than as individuals (by their name).

Now that we have introduced the scenario and the user assistance applications of our intelligent environment, we will present its architecture and components.

**THE SUPIE ARCHITECTURE**

In order to investigate novel user interfaces, we set up the Saarland University Pervasive Instrumented Environment (SUPIE). The architecture has been designed for the seamless integration of various services and applications supporting different tasks such as our shopping assistant ShopAssist (23) and the pedestrian navigation system PersonalNavigator (17). The components of the SUPIE-architecture can be grouped into four layers, as shown in Figure 2, where assistance applications are considered as the top level. The applications have access to a knowledge representation layer, which includes location- and user-models. The service layer provides for indoor positioning and managing presentations on public displays. The bottom layer offers blackboard-style communication between the components. In the following we will briefly describe each of the layers, starting with the application layer.

**Application Layer**

The actual assistance applications of our intelligent environment use the knowledge representation and services of the lower layers to implement an intelligent user interface. The shopping assistant applications provide product information and personalized advertisements to the user, this also includes the animated presentation 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 suitable public displays via the presentation service. Additionally a steerable spotlight (6) helps the user to find certain products on the shelf, by guiding their attention to the product in

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1 Ubisense Website: [http://www.ubisense.net](http://www.ubisense.net)
question – a micro-navigation task. The navigation application is based on the information provided by the location model and the positioning service. It utilizes the presentation service to address directions to the user on nearby public displays. Other applications, such as the museum guide PEACH (15), the posting service PlasmaPoster (8) or the messaging service IM Here (13), could also benefit from the service layer and run simultaneously in the environment and use the same displays.

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. 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 buildings and the displays have to be known. Therefore the symbolic world model is supplemented by a geometric location model, containing the necessary data in XML.

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

For the positioning service we adopt a heterogeneous sensor approach, where a mobile terminal receives coordinates from infrared beacons as well as active RFID tags and estimates its own position using a dynamic Bayesian networks approach. The positioning service is presented later in section: Indoor Positioning Service.

The presentation service provides a simple interface that allows applications to present Web content such as HTML and Flash on any display which is connected to
the presentation manager by posting presentation requests on the blackboard. The presentation manager maintains a stack of presentations, and implements conflict resolution strategies to decide which content to present on which display. For more details on the presentation service see section: Managing presentations for multiple users on multiple displays.

Communication Layer
The communication and coordination within the SUPIE architecture is based on a commonly accessible tuplespace (11), which provides an indirect interaction mechanism featuring the portability, heterogeneity, economy and flexibility needed for an intelligent environment. 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 (14). 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 (24).

In the next section we present how we model the user and parts of the real world in order to establish services and assistant applications supporting the users of our instrumented environment.

UBIQUITOUS WORLD MODELING
Ubiquitous computing in an instrumented environment like SUPIE, as described so far, poses challenges and new applications to the field of user modeling, and also location modeling. In this section we describe the ubiquitous world model called UbisWorld, which unifies both user and location modeling.

UbisWorld² can be used to represent 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. Situational Statements (12) describe the state of the world in sentences made of a subject, predicate and object. The vocabulary is provided by concepts, instantiated individuals and relations. The underlying UbisWorld Ontology defines classes and predicates, such as a taxonomy of physical things, places, user characteristics and activities. It can easily be extended to specific domains, so the concept of situational statements provides for the flexibility that is needed to model any situational context that might be relevant to a specific ubiquitous computing application.

User modeling
User modeling is necessary to adapt the behavior of proactive assistants to the users’ personal preferences and situation, such as language, knowledge level, cognitive load and location. From the users’ perspective, it is crucial to have insight into the user model and to control privacy levels. Our user model server provides a comfortable web-based interface to transparently access the properties of any modeled object within the environment. Figure 3 shows the properties of the user Margeritta as an example. In the upper section, the web form allows the user to enter new properties as statements, by using the UbisWorld Ontology.

In our example, we are going to express that Margeritta has a high interest in festivals for recreation. Besides, the interface gives a listing of her modeled properties. For example, the first property says that she is a vegetarian. This statement about her nutrition habits is set by herself to be public and may be used by commercial services, like the shopping assistant presented in the following section. If the statement would have been the result of an automated inference, she could see the origin of creation and the confidence value of the assumption. If the inference were wrong, Margeritta could manually override the assumption.

Location modeling
In order to generate localized presentations and navigational aid, the assistants require a detailed spatial world model. Therefore the ontology of UbisWorld defines places at different levels of granularity, like city, building or room, and it is possible to express spatial topological relations like inclusion, see Figure 4.

This vocabulary is used to build a symbolic (or qualitative) location model that allows for a meaningful expression of location across different applications. In our scenario, this is particularly important for the integration of the shopping and navigation assistance. It is also possible to model various properties of spatial elements, such as room-temperature, noise-level or humidity. Additionally, the presence of persons and physical objects can also be expressed and visualized through the convenient Web-based user interface, as shown in Figure 5.

The symbolic model is supplemented by a geometric location model for tasks like map visualization, computation of Euclidean distances and the generation of navigational aid. It represents the building structure by the use of polygonal objects, which are described by their coordinates and a symbolic identifier to reference their corresponding representation in UbisWorld. Navigational beacons, landmarks and displays are represented by cones or spheres to describe their visibility. The model is created and maintained by the Yamamoto³ editor (19) as shown in Figure 6. A mesh of polygons is

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² UbisWorld website: http://www.u2m.org/

³ Yet Another Map Modeling Tool. Yamamoto website: http://w5.cs.uni-sb.de/~stahl/yamamoto/
drawn over a background image, such as an architectural plan or aerial photograph, to represent the logical and physical entities of the environment, like streets, places, buildings and rooms. Since a pedestrian is able to shortcut and cross large places, the edges of adjacent polygons are annotated by their pass-ability to support advanced route finding through polygonal spaces. Modeling in three dimensions and multiple layers allows to represent the different levels of a building and their interconnections, such as stairs.

Fig. 3: Web-based user model statement editing.

Fig. 4: Browsing spatial relations between locations.

Fig. 5: An instance of the symbolic location model.

Fig. 6: Editing the geometric location model.
INDOOR 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 task of a user, it is likely that a navigational sub-goal exists. Being aware of this, we have spent considerable research in the development of indoor and outdoor pedestrian navigation systems, as published in (2) and (17). Whereas the predecessor systems have been designed as stand-alone devices, we have now separated the positioning component from the navigational assistance application.

In our approach, we use wall- or ceiling-mounted senders (beacons) that transmit the coordinates of their position stored in their small internal memory, and are received by the user, holding a mobile terminal device. We use two kinds of senders in order to benefit from their complementary transmission characteristics: Infrared-beacons (IR-beacons), which emit a directional cone of IR-light that is limited by walls, and active Radio-Frequency-Identification (RFID) tags, which can be received from all directions. Whereas the IR signals can be picked up by the PDAs standard infrared-communications port, it requires an additional PCMCIA-card to read the RFID data. A received (or sensed) tag or beacon coordinate indicates that the user is near the location of the respective sender. If the user is in between multiple beacon locations, we calculate the true location of the user by a weighted combination of their coordinates.

Since the sensor readings are often noisy and unreliable, we have to apply filtering techniques to stabilize the position. Commonly Bayesian filters are implemented by Kalman-filtering, grid-based approaches or particle filtering. We have implemented a new approach, which is efficient in time- and space-complexity and that provides a high scalability for in- and outdoor-positioning. The so called geo-referenced dynamic Bayesian networks (3) overcome the necessity for building a grid and therefore enable the calculation of a user’s position on his own small hand-held device without a connection to an external server. Thus, position information is kept private and completely in the hand of the user. When a tag or beacon is sensed by the PDA geoDBNs are instantiated and associated with the induced coordinates. These induced coordinates depend on the stored coordinate and the type of the sender. Each networks belief represents the probability that the user is located at their respective position. The position of the user is then calculated by the weighted combination of the coordinates at which geoDBNs exist, where the weights depend on each networks’ belief. To reduce calculation cost and memory usage, the number of instantiated geoDBNs is reduced by deleting unused networks with lowest belief.

The resulting user coordinates are matched with the geometric location model, which is given by the knowledge representation layer, and result in a more meaningful symbolic location identifier. This symbolic name can be used to query the ubiquitous world model UbisWorld for the places’ properties and spatial relations. It is up to the user’s personal privacy considerations whether their position should be published in their user model or not. Even if it is published, the user can still restrict access to their position information to certain applications, such as the navigation assistant.

The information about the users’ position within the environment is used by the shopping assistant and the navigation assistant. The prior starts the presentation agent called Cyberella each time a user enters the shopping room, and the position data helps to synchronize the product selection on the PDA with the actual shelf in front of the user. The navigation assistant can provide the user with customized graphical navigation instructions. These presentations are posted on the event heap as presentation requests to be scheduled by the presentation manager on available public displays in the environment. The details of the presentation service will be explained in the following section.

MANAGING PRESENTATIONS FOR MULTIPLE USERS ON MULTIPLE DISPLAYS

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 use them for the design of intelligent user interfaces, so that multiple users can benefit from multiple displays, which might be mobile, embedded or stationary, personal or public. The displays should convey a variety of information, originating from multiple applications, so instead of running a specific application on the public displays, we favor all-purpose World Wide Web technology such as HTML and Flash. In the SUPIE environment, the presentation service provides transparent access to all available display resources via a centralized presentation manager, which controls the presentation devices.

Presentation Manager

We assume that multiple applications are running simultaneously and concurrently attempting to access display resources, so conflicts are likely to arise. Whereas canonical conflict resolution strategies could be first come, first served or priority based assignments of display 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 where and when presentations are shown. Applications post their presentation requests on the event heap, which include the URL of the content to be presented, the required display time, an expiration deadline and destination, which can be specified by either a display, a location or a user.
Based on these requests, the presentation service plans the presentation schedule for all displays in a continuous loop according to the following rules:

1. Make a context-dependent selection of all suitable displays, which are currently reachable by the network and in spatial proximity to the users’ location, which is looked up in the users’ profile.
2. Prefer display by: idle state, minimum requirements (e.g. size), general quality and release time.
3. Conflicting presentations are scheduled according to their deadline requirements and are delayed until resources are available (division by time). Screen space is shared if an appropriate device is available such that presentations are rendered simultaneously on the same screen in different windows (division by space).

Presentation Devices

The motivation behind the presentation service is to make all displays in the SUPIE environment accessible for applications, such as public displays, projectors, PDAs, notebooks and desktop machines. Therefore we have implemented a small server software, that runs on each device (currently Windows and WindowsCE operating systems are supported) as a background task and provides the required registration and presentation functionality. The server periodically announces the device’s presence to the presentation manager by posting registration events to the event heap, which include descriptive parameters, such as the network address, device type, screen size and resolution. Additionally, the owners of personal devices may restrict the use of their displays to private content by providing their user-id. After a successful registration, the presentation manager can connect each device to present the scheduled content. Therefore the server provides a customized Web browser, and it also supports the download and presentation of binary files, such as images or Powerpoint slides, by external helper applications. From the users’ perspective, it is crucial to be aware of presentations intended for them and to avoid confusion caused by similar presentations for other users, which means to preserve consistency in the presentations given. Therefore, the presentation service notifies the user via a personal device by an alarm signal (e.g. mobile phone vibration), that is synchronized with the appearance of the presentation on a public display. If no such notification device is available, the presentation service can automatically disambiguate the content by adding a personal graphical icon or playing a sound that is stored in the user model.

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 previously introduced approach relates or differs from the projects mentioned in this section.

In the project Hermes (7) two corridors of the computing department at the University of Lancaster have been equipped with interactive door display based on handheld devices. In Hermes these displays have been solely used to provide asynchronous graphical and textual messaging services between office occupants and anyone passing by the offices. In our project we have extended this approach, that it allows for the presentation of multimedia content and navigational instructions, despite the fact that multiple applications could request these displays to render their presentations. Churchill et al (8) use large plasma screens as digital 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 Huang et al (13) 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 our 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 ContextToolkit (18) aims to support the development of context-aware applications within computationally-enhanced ubiquitous computing environments. Context aware information services adapt to any information that can be used to characterize the situation of a user, such as their location and objects and persons in the vicinity. The goal of the EasyLiving research project (5) was the development of a prototype architecture and necessary technologies for intelligent environments in a home scenario. The project concentrated on applications where interactions with computing devices can be extended beyond the confines of the current desktop model. The project has included 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. Whereas the EasyLiving approach used computer vision to track the users’ position, our approach uses a hybrid sensor fusion method as described before. The Sentient Computing project (1) developed an ultrasonic 3D positioning device called BAT to track employees in an office environment. The Stanford Interactive Workspace iRoom (9) is a collection of linked software and hardware that allows users to interact with their application suite on three large smartboard displays. The iRoom architecture provides the EventHeap tuplespace for the coordination of its components. In comparison with the event messaging concept, the persistence of...
information within the tuplespace leads to several advantages, such as dynamic coordination, failure tolerance and anonymous communication. It is for these benefits that we have adopted the EventHeap as implementation for the blackboard in our environment. The Ambiente project at the Fraunhofer IPSI (Institut Integrerte Publikations- und Informationssysteme), pursues research on interactive communications- and collaboration landscapes. Several so-called Roomware components and artefacts have been developed. Their BEACH software (21) provides a model for the creation and handling of hypermedia data and for collaboration. Both the iRoom and Ambiente projects focus on collaborative workspaces, whereas we are interested in the design of proactive information and assistance systems. In the Smartkom (22) framework, a mobile handheld assistant was developed to process multimodal input and output (speech and gesture) during a navigational task. The presented information combined maps, natural language and a life-like character. Although the application scenarios of Smartkom and REAL are similar, our work is focused on the integration of implicit and explicit user interaction. In 2003, the METRO Group opened its FutureStore\(^4\) in Rheinberg, Germany, to the public. RFID technology is used to track the location of each individual product in order to develop new processes of inventory management. The store also offers new information possibilities for the customer, such as a personal shopping assistant, information terminals and advertising displays, all based on a traditional barcode scanner. Since the FutureStore is focused on inventory management, it lacks sophisticated user modeling and positioning techniques.

**SUMMARY AND FUTURE WORK**

In this paper we have presented the architecture of our intelligent environment located at the Saarland University. We gave a brief description of each of the components. Furthermore, we presented different services and applications developed to support the users of the environment in different tasks of our example scenario. We have pointed out the role of ubiquitous user modeling as the basis for the location and shopping assistant services developed. And finally, we outlined the concepts of our presentation manager, responsible for scheduling user adapted presentations on available public displays. In the near future we will integrate an affective layer in the system’s architecture. This affective layer will be used on the one hand to take into account the users’ affective state and on the other hand to generate affective responses from the instrumented environment. For this purpose we have planned to investigate two different anthropomorphic user interfaces. Firstly, the use of a virtual inhabitant of the instrumented environment, as extension to our virtual sales character, will be explored to guide and inform users of the environment. Secondly, we will implement and explore the paradigm of talking objects, objects that can respond to the user’s spoken requests directly in natural language, in more depth. Furthermore, our goal is it to enable users to delegate information requests to the virtual inhabitant, which can in turn assist the users proactively to accomplish their tasks at hand.

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