Chapter 20
Distributed Schema-Based Middleware for Ambient Intelligence Environments

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ABSTRACT

In this work we present a middleware developed for Ambient Intelligence environments. The proposed model is based on the blackboard metaphor, which is logically centralized but physically distributed. Although it is based on a data-oriented model, some extra services have been added to this middle layer to improve the functionality of the modules that employ it. The system has been developed and tested in a real Ambient Intelligence environment.

INTRODUCTION

The Ubiquitous Computing term was coined by Mark Weiser in 1991 (Weiser, 1991). From that moment on, many problems and opportunities have arisen from that vision of a world rich in information and interaction. Ambient intelligence environments (also called intelligent environments) are one of the fields where Ubiquitous Computing can be naturally applied. We can define an active environment as a space limited by physical barriers, which is capable to sense and interact with its inhabitants.

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The definition leads to the necessity of some kind of physical infrastructure for sensing and acting into the real world. However, as we will show below, these environments present some particular problems beyond hardware issues. For instance, the environment configuration changes dynamically and client applications should be notified of these changes. Thus, a software infrastructure is also needed to solve these problems.

The approach that we present in this work tries to solve these issues, making easier the developing task and the interaction among applications. For this, it employs a common, normalized and formalized definition of the reality. This definition, and the information that it stores, should be accessible and shared by clients and applications.

Moreover, some extra features have been added to the system to provide additional services, such as an historical registry, which shows all the activity carried out by the system or a rule-based service, which changes the behavior of the environment under some circumstances.

Another interesting feature is one that adds a description of the representation of the elements that compose the environment. This feature facilitates the definition and development of interfaces to interact with the environment. User Interfaces are becoming an important subject in the Ambient Intelligence field, because computers usually keep hidden from users and system services are obtained by means of context awareness interaction. Moreover, this interaction must be adapted to the task, the environment, its occupants and the available resources (Paterno & Santoro, 2002; Rayner et al., 2001). The integration of this description with the rest of the elements of the model helps to fulfill this task.

Finally, as an important aspect of our development, this model and its services have been tested in a real intelligent environment.

MOTIVATION

Any intelligent environment is composed by a heterogeneous set of software and hardware components (Haya, et al. 2001). This involves some challenges:

- **Bounded environment**. Human activities are usually taking place in a discrete and bounded environment. As Kindberg and Fox (2002) pose in their *boundary principle*, designers should be aware of this distribution. In this respect, each smart space partitions the whole domain in isolated management areas. That is, in a house environment, in example, management resource policies are spatially limited to the home extension, and homeowners should decide them. This is particularly true for privacy concerns since humans consider home as a private space and they would like to manage it following their own criterions.
- **Heterogeneous components**. Smart homes are populated by a heterogeneous set of numerous components that can be either software or hardware. So it is needed to integrate and manage different kind of technologies. This leads to a more complex development process. This complexity affects to every component of the smart home. In particular, the final user would like to interact with the environment using different modes (such as voice, gestures, tactile, etc.) This implies, practitioners have to deal with very different user interaction techniques. Besides, the distribution of the information required to choose among different communication networks depending on several factors such as bandwidth constraints, mobility or deployment cost.
- **Highly distributed components**. Both sensors, whose task is to catch informa-