# Software Infrastructures for Smart Spaces: Bridging the gap between Global Computing and Situated Devices

Position Paper

Rui José, Helena Rodrigues
University of Minho

### Introduction

Pervasive Computing has been emerging as a new paradigm for computing systems that dramatically changes our perception of what a computer system is, since the entire environment, with all its integrated devices and associated services, becomes indistinguishable from the computer. This concept of smart environment has become an active topic of research in Pervasive Computing, with the ultimate goal being the creation of some sort of meta-operating system for physical environments. Such software infrastructure should be able to transparently manage the relevant resources and provide an integrated execution environment in which applications, seen here as orchestrated collections of services, could be executed in association with the corresponding physical environment.

Research in middleware for Smart Spaces has been in progress for a few years, both in academia and industry, and many middleware architectures have been proposed that in some way aim to provide the necessary glue to integrate an open, diverse and a priori unknown set of services into a functioning system. Examples include the Event Heap [1], One.World [2], Aura [3] and GAIA [4]. Typical issues addressed by these systems include the architectural approach, the discovery, selection and spontaneous interaction between entities, naming, context management, event notification, and the ability to enable cooperation between entities even if separated in time and space.

Even though it is now possible to study and compare a diverse number of approaches and their accomplishments, the goal of having a widely accepted middleware that had been used by multiple developers of smart environments is yet to happen. From our own experience in creating smart spaces, we believe that there are essentially two main reasons: The first is that the field has not matured yet to have a sufficient body of shared knowledge, concepts and vocabulary to allow developers to understand what they need and how the various platforms can provide it. The second is that creating a generic pervasive computing infrastructure (even if using an already existing general purpose middleware) is normally an overwhelming effort when compared with the anticipated benefits of the prospective applications. At least initially, it will always seem simpler to create the specific functionality required by that one application than dealing with the generality and consequent complexity of a generic middleware. An additional and much more significant set of limitations can be identified when we consider the issue of wide deployment. By looking at the potential number of smart spaces, and the variety of tasks that people may want to perform in each of those spaces, it becomes obvious that creating a complex software infrastructure dedicated to a particular space is an approach that does not scale. Widespread deployment means some type of functionality, nearly anywhere, and for nearly any type of activity.

## *The case for Global Computing and Situated Displays*

In this position paper, we argue that a wide deployment of Pervasive Computing should combine two complimentary approaches. The first is to make extensive use of global services as a way to provide functionality to any place without having to create dedicated services. The second is to leverage situated displays as a general purpose gateway between those services and the physical environment.

### Global Computing

Recent years have seen the emergence of many global, but personalised, services, such as flickr, google earth, myspace, wiggle, blogs, and many others, most of which provide some sort of programmatic access that allows their functionality to become an integral part of other systems. This trend, and the overall evolution towards Service Oriented Architectures, is likely to continue and become an important alternative path for Pervasive Computing [5]. Instead of focusing on the functionality that can emerge from the ad-hoc interaction between proximate devices, Pervasive Computing may increasingly focus on the integration of functionality from global services, with significant scalability, maintainability and even personalisation advantages. Pervasive and Global Computing already share many objectives and design goals. They both aim to enable systems composed by loosely-coupled components, where functionality emerges from unanticipated cooperation, and where the adaptation to the changing conditions of the environment and particularly to the current needs of the user plays a central role. The differences have

essentially been that Pervasive Computing has traditionally been more focused on functionality emerging from networks of "things", i.e. physically close devices that cooperate between each other to provide integrated functionality, while global computing is more focused on functionality emerging from dynamic combinations of globally available services. Software infrastructures for smart spaces provide a ground where competences from both fields converge.

### Situated Displays

Digital displays, in many forms and based on various types of technology, are becoming increasingly pervasive and remain the most effective way to create an ubiquitous presence of digital visual information in our physical world. If equipped with cameras or other sensors, digital displays can also sense information about their surrounding environment and promote the collection of information from the physical world into the virtual world. They can thus play an important role in enabling the mutual awareness between both worlds and effectively become gateways rather than simple terminals.
Additionally, a display is a very generic device that can easily be tailored for many different purposes, and designed to become a seam that represents the integration between physical and virtual in a way that is well understood by users. From this perspective, they provide an interesting migration path because, despite having a usage model that is radically different from the desktop, situated displays can still provide a familiar interaction model that will allow users to perceive more easily the affordances of the space and reason by themselves on how to use them for their particular needs. This should enable users to create their own meaning for the interaction, instead of being passive players in a pre-orchestrated interaction flow.

## *Display-centred software infrastructures for situated applications*

We are currently running a research program in situated displays in which we aim to develop and evaluate a new concept of situated display as a general purpose and strongly situated information artefact that is part of a larger ubiquitous computing infrastructure and acts as gateway to a virtual and physical environment. This work is based upon a vision of situated displays as shared, networked, and pro-active devices that are embodied into their environment and provide an execution environment for situated applications. One of our key goals is to study how that notion of situated display can be used as an enabler for certain types of situated applications. We are therefore, very interested in identifying common abstractions, models and design patterns toward interoperability and portability to help us identifying more clearly the design space in which our approach is appropriate. In particular, we want to identify the sub-set of smart spaces functionality that can be built from the combination of local generic devices, such as situated displays, personal devices and personalised global services and applications.

## *References*


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