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Towards a Unified Middleware for Ubiquitous and Pervasive Computing

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ABSTRACT

The broad variety of topics covered under the umbrella of ubiquitous computing led the research community to a fragmentation of the methods and tools used to achieve their goals. We however believe that different goals do not necessarily mean different approaches. For a number of years now, we have been proponents of a unified approach based on the distributed object abstraction which allows synergies to be better exploited. Remote device management, wireless sensor and actuator networks, hardware components and now even reconfigurable hardware platforms and service platforms are considered as part of a large evolving system sharing a common middleware and a single design methodology. Considerable effort was put into the design of basic services to allow autonomous implementations on the smallest micro-controllers in the market.

Keywords: *design methodology; distributed computing; integration architectures; object oriented methods; wireless sensor networks*

INTRODUCTION

Ubiquitous computing (UC) is all about heterogeneity, it deals with heterogeneity in heterogeneous ways. Some authors identify different areas of UC which lead to different approaches to building ubiquitous computing environments (Endres et al., 2005). Sometimes there

is an explicit distinction between ubiquitous computing and pervasive computing (Gaber, 2007) to differentiate the main focus. Pervasive computing deals with providing adaptive or emerging services to fit user needs in a given context, while ubiquitous computing would be mainly focused on globally accessible services (anytime, anywhere).

In addition most research topics in UC must also deal with the fact that the target systems are inherently distributed. Therefore UC environments have much in common with distributed heterogeneous object platforms developed in the nineties such as CORBA, EJB, DCOM and also with current grid computing platforms such as Globus and gLite. Our research tries to leverage the achievements of those platforms by defining a unified middleware able to interact with standard middleware but specially suited to the needs of UC. One major source of heterogeneity is the wide variety of devices connected by means of different networking technologies in almost every UC environment. The concept of residential gateway was coined in the field of residential services to mean a concentrator, a device with multiple network interfaces used to interconnect all the device networks available in a given scenario. Middleware like OSGi (OSGi, 2006) or Amigo (Georgantas et al., 2005) took advantage of this mediating device to provide a whole service management platform. Implicit to this approach is that most services will be running in the residential gateway. On one side this is positive from the point of view of manageability. The residential gateway may be controlled by the service provider or even by the telecommunications operator. But this device also constitutes a single point of failure which makes impractical the implementation of critical or very simple services such as door openings or lighting.

With more and more candidate technologies being integrated in ubiquitous computing environments it is increasingly harder to design a residential gateway at a reasonable cost, a single device with all required interfaces. From a business point of view, service providers are using residential gateways as a way to control the distribution of new services limiting users' freedom to choose alternative service providers. While a mature market would see this as a competitive advantage, an emerging market such as the residential services sees a reduction of the perceived utility and consequently a slowdown in the rate of new deployments. Currently DVB set-top-boxes, mobile phones, or public WiFi networks constitute alternative technologies for the interconnection of residential networks or device networks with an external service provider (e.g. through the Internet). Therefore the overall architecture of an ubiquitous environment is evolving from a star topology centered around a residential gateway to a fully distributed mesh network where several devices provide some capabilities traditionally associated to a residential gateway.

As a conclusion, nowadays no single device will be able to support all the features required to provide services in a given scenario. Instead an increasing number of devices will need to cooperate in order to provide transparent gateway services among the different technologies. This decentralized model also influences the design of the middleware:

- Management tasks (e.g. version control, start/stop commands, installation and removal of services, etc.) are distributed among a set of devices.
- The proper operation of the services in a UC environment does not depend on a single device. We may provide service replication procedures in order to increase the reliability.
- Security mechanisms will need to take into account the availability of several broadband and/or WAN interfaces (e.g. Internet).
- Service configuration is becoming increasingly complex.

We believe that object-oriented distributed middleware includes an attractive set of features to enable next generation ubiquitous computing environments. Six years ago we proposed an architecture based on the distributed object