Chapter 2.9
Deploying Ubiquitous Computing Applications on Heterogeneous Next Generation Networks

Achilles D. Kameas

Hellenic Open University and Computer Technology Institute / DAISy group, Greece

ABSTRACT

This chapter describes a human centric approach for designing and deploying ubiquitous computing applications. These are considered as activity spheres consisting of tasks which must be executed using the resources available in an Ambient Intelligence space. Such resources include objects augmented with embedded ICT components and software modules. An architectural approach and a corresponding middleware are described, which enable the management of activity spheres. Then, the communication requirements are presented and the role of heterogeneous next generation networks in supporting this architecture is discussed.

INTRODUCTION

Ubiquitous computing constitutes a novel computational paradigm, which will pervade all aspects of everyday life in the coming decades. From a technology perspective, ubiquitous computing composes distributed systems, miniaturized hardware and wireless networks and builds on the achievements of these and other research and engineering disciplines. At the same time, it is expected to have a strong societal impact, as it will transform the way everyday and emergency human activity is carried out. This is because ubiquitous computing technology is inherently deployable on every object, task or process in people's immediate environment or activity. Moreover, tasks supported by this technology will eventually be easily accessible, safety enhancing and intuitive to use, thus realizing Mark Weiser's vision of calm technology (Weiser, 1991) or ISTAG's vision of Ambient Intelligence (ISTAG).

The vision of Ambient Intelligence (AmI) implies a seamless environment of computing, advanced networking technology and specific interfaces. An important characteristic of AmI environments is the merging of physical and digital space (i.e. tangible objects and physical environments are acquiring a digital representation). Still, people's interaction with their environment will not cease to be task-centric: we are still interested to carry out our tasks, using the skills, tools and information available in our heads or in the environment.

Every new technology is manifested with objects that realize it. These objects may be new or improved versions of existing objects, which by using the new technology, allow people to carry out new tasks or old tasks in new and better ways. Up to now, the ways that an object could be used and the tasks it could be used for have always been determining and depending on its shape. As the computer disappears in the environments surrounding our activities, the objects therein become augmented with Information and Communication Technology (ICT) components (i.e. sensors, actuators, processor, memory, wireless communication modules) and can receive, store, process and transmit information; in the following, we shall use the term "artifacts" for this type of augmented objects.

In the forthcoming AmI environments, artifacts will have a dual self: they are objects with physical properties and they have a digital counterpart accessible through a network. Thus, (a) people will realize their tasks using the available artifacts and the services they offer, (b) some of these artifacts will be public and some will be private, (c) knowledge will exist both in people's heads (in the form of upgraded skills) and in the environment (in the knowledge bases of the artifacts) and (d) successful execution of tasks will depend on the quality of interactions among artifacts and among people and artifacts.

It is the latter point (d) which provides the rationale for this chapter, as interaction entails communication, which requires a networking layer. Before dealing with it, we shall describe our task-centric approach in modeling ubiquitous computing applications in the next section. Then in section 3, we shall present a generic architecture of ubiquitous computing applications. Section 4 discusses GAS-OS, the middleware we have developed to support our world model. The discussion places emphasis on the communication aspects of GAS-OS, so that in the next section we introduce the requirements that our approach imposes on the networking layer and discuss why and how Next Generation Networks are expected to meet them.

AMI ARTIFACTS, ENVIRONMENTS AND ACTIVITY SPHERES

The AmI environment can be considered to host several ubiquitous computing applications, which make use of the infrastructure provided by the environment and the services provided by the artifacts therein (Zaharakis, 2008). A ubiquitous computing application is considered as an orchestration of services that are accessible via the AmI environment. Usually, AmI artifacts act as service bearers; therefore, a ubiquitous computing application is manifested by a set of co-operating artifacts (Zaharakis, 2006).

AmI Artifacts

AmI artifacts differ from traditional objects in a number of properties and abilities:

- **Information processing:** The information that an artifact processes can be descriptions of the context of use, data to be used for a task, guidelines on how to perform a new task (i.e. a program), messages to be sent or that have been received from other objects. The result of information processing is a set of services, that is, a set of abilities

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