Chapter XIV
A Software Engineering Perspective on Ubiquitous Computing Systems

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ABSTRACT

We are now facing a migration from the traditional computing, based on personal computers, to an era of pervasiveness, on which computing devices will be spread all around us, seamlessly integrated into our lives. It is this new stage of computing that researchers have named of ubiquitous computing, also known as pervasive computing. There is no doubt that this vision is certainly a promising computing paradigm for the 21st Century. However, its completely new characteristics have an impact on the way that software is developed. We should emphasize that, for example, to achieve the seamless integration characteristic of ubiquitous computing environments, applications must implement mechanisms for discovering the needs of users in order to present them with relevant information at the right place and at the right time. This, and other intrinsic features of ubiquitous computing systems, makes necessary

the use of different software engineering techniques. Within this scope, we claim that service-oriented computing, component-based development, plug-in-based architectures, event-based systems, and dynamic software evolution are the main techniques that can be used in the development of ubiquitous systems. The purpose of this chapter is then to review the challenges involved in ubiquitous systems development as well as present a software engineering perspective for tackling such challenges. In addition, we will also present the way these techniques have been used by outlining some of the current ubiquitous computing solutions.

INTRODUCTION

Much has been said recently about the advances in computing-related technology. It is not hard to notice, for example, the shrink in the size of electronic components like memories, hard disks, and microprocessors. A direct consequence of this fact is the emergence of mobile devices like handhelds, cellular phones, and tablet PCs. Another interesting point within this scope is the increase of the computational power of such devices, which has enabled them to execute more complex applications. Electronic games, both 2D and 3D, and multimedia players are just some examples of these applications.

Looking at these advances from the viewpoint of computer networks, one cannot avoid mentioning the evolution that has taken place on the networking interfaces, which has culminated on the wireless solutions we have nowadays. Bluetooth, Wi-Fi (Wireless Fidelity), and Zigbee are maybe the examples that best represent such solutions. In addition, some of these interfaces are embedded with energy consumption techniques. As a mobile device works by using limited batteries, this feature has been providential as a way of extending their lifetime.

Considering all these advances, the popularity these mobile devices have gained is not surprising. Just take a quick look around and you will notice that many people carry a cellular phone nowadays. In addition, the use of other mobile devices like smart phones and handhelds has considerably grown in some industry sectors.

They can be found, for example, in solutions for supply chain management[1] and support for hospitals,[2] amongst others.

What can be perceived from all these facts is that there is, indeed, a migration from the traditional computing, based on personal computers, to an era of pervasiveness, on which computing devices will be spread all around us, seamlessly integrated into our lives. It is this new stage of computing that researchers have named of *ubiquitous computing*, also known as *pervasive computing*. Its ideas have been first exposed in 1991 by Mark Weiser (Weiser, 1991), a researcher of the Xerox Palo Researcher Center at that time. The primary vision of Weiser (1991) is a world where computing is embedded in every day objects, like televisions and cars, which will work in the background for performing tasks on our behalf.

Within this scope, the advances in hardware and networking technologies we have delineated previously are now leveraging the realization of the first environments contemplating the features of ubiquitous computing. It is not a surprise, thus, to see the emergence of many solutions in this field nowadays, like *Wings* (Loureiro, Bublitz, Barbosa, Perkusich, Almeida, & Ferreira, 2006), *Plug-in ORB* (d'Acierno, Pietro, Coronato, & Gugliara, 2005), *RUNES* (Costa, Coulson, Mascolo, Picco, & Zachariadis, 2005), and *PDP* (Campo, Rubio, López, & Almenárez, 2006).

There is no doubt that the vision conceived by Weiser (1991) is certainly a promising computing paradigm for the 21st Century. However, its completely new characteristics have an impact on

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