Chapter 15
A Primer of Ubiquitous Computing Challenges and Trends

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ABSTRACT
The growing availability of wireless networks and the proliferation of portable devices have made mobile computing a reality. Furthermore, the widespread use of location systems stimulates the creation of context-aware and adaptive systems. Ubiquitous computing integrates and extends these approaches through a new proposal where users’ applications are available in a suitable adapted form, wherever they go and however they move. In this scenario, issues related to development of software need to be tackled. This chapter reviews essential concepts of the ubiquitous computing area, its evolution, and challenges that must be managed. To deal with these issues, the authors describe the main requirements for the development of ubiquitous software. This analysis starts with the discussion of limitations in the use of traditional programming models, and then goes on to the proposition of techniques to address these limitations. The authors trust that this discussion can help the future development of ubiquitous applications.

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INTRODUCTION

Nowadays, studies about mobility in distributed systems are being stimulated by the proliferation of portable electronic devices (for example, cell phones, handheld computers, tablet PCs, and notebooks) and the use of new interconnection technologies based on wireless communication (such as WiFi, Bluetooth, and WiMAX). This new mobile and distributed paradigm is called mobile computing (Satyanarayanan, 1996). What is more, the dissemination of location systems (Hightower, LaMarca & Smith, 2006) is enabling the use of mobile computing tailored to the physical location of the user. This scenario fosters the development of context-aware applications (Dey, 2001). The idea consists in the perception of characteristics related to the users and their surroundings. These characteristics are normally referred to as context, i.e. any information that can be used to describe the circumstances concerning an entity. Based on perceived context, the application can modify its behavior. This process, in which software modifies itself according to sensed data, is named adaptation (Satyanarayanan, 1996). In this scenario ubiquitous computing is emerging (Weiser, 1991).

Current practical approaches to the ubiquitous computing usually rely upon traditional computing paradigms envisioned when mobile applications were not a reality. Ubiquity aspects bring many new concerns, such as coping with the limited processing power of mobile devices, frequent disconnections, the migration of code between heterogeneous devices, context management, among others. These aspects demand a discussion of the issues involved in creating ubiquitous software.

In this chapter we review essential concepts of ubiquitous computer area, its evolution, and challenges that must be addressed. To address these issues, we describe the main requirements for the development of ubiquitous computing software. This analysis starts with the discussion of limitations in the use of traditional programming models, and then goes on to the proposition of characteristics and techniques to deal with these limitations.

The chapter is organized in six sections. In section two we present background, mainly discussing definitions and ubiquitous computing evolution. The following section focuses on the ubiquitous computing challenges. The fourth section discusses why traditional programming models alone are insufficient to develop ubiquitous applications. In the fifth section we describe the requirements that should be tackled in ubiquitous software. Section six presents future trends for the area. Finally, in the last section, we draw some conclusions.

BACKGROUND

We should begin by defining ubiquitous computing (also called ubicomp). Mark Weiser created this term, so he is considered one of the area’s fathers. He presents computer ubiquity as the idea of integrating computers seamlessly, invisibly enhancing the real world. Weiser (1991) formulates a “new way of thinking about computers in the world, one that takes into account the natural human environment and allows the computers themselves to vanish into the background” (p. 94). Computers will vanish as a consequence of human psychology: when people use things without consciously thinking about them, they focus beyond. This is a phenomenon defined by some philosophers and psychologists (Weiser, 1991): people cease to be aware of something when they use it sufficiently well and frequently. Philosopher Heidegger calls this phenomenon ready-to-hand¹ and Edmund Husserl calls it the horizon.²

Heidegger makes a phenomenological analysis of the way people deal with the world. According to him, our first behavior toward entities such as tools, devices, and systems within the world is one of use. These entities, viewed from their aspect