Chapter 4
CADEAU:
Supporting Autonomic and User-Controlled Application Composition in Ubiquitous Environments

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ABSTRACT

Networked devices, such as consumer electronics, digital media appliances, and mobile devices are rapidly filling everyday environments and changing them into ubiquitous spaces. Composing an application from resources and services available in these environments is a complex task which requires solving a number of equally important engineering challenges as well as issues related to user behavior and acceptance.

In this chapter, the authors introduce CADEAU, a prototype that addresses these challenges through a unique combination of autonomic mechanisms for application composition and methods for user interaction. These methods differ from each other in the degree to which the user is involved in the control of the prototype. They are offered so that users can choose the appropriate method according to their needs, the application and other context information. These methods use the mobile device as an interaction tool that connects users and resources in the ubiquitous space. The authors present the architecture, the interaction design, and the implementation of CADEAU and give the results of a user study that involved 30 participants from various backgrounds. This study explores the balance between user control and system autonomy depending on different contexts, the user’s needs, and expertise. In particular, the study analyses the circumstances under which users prefer to rely on certain interaction methods for application composition. It is argued that this study is a key step towards better user acceptance of future systems for the composition of ubiquitous applications.

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CADEAU

INTRODUCTION

Our everyday living, working and leisure environments are rapidly becoming ubiquitous due to the wide availability of affordable networking equipment, advances in consumer electronics, digital media appliances and mobile devices. This, combined with the increasing importance of web technologies for communication (e.g., Web Services, Cloud Computing and Social Networking) is resulting in the emergence of innovative ubiquitous applications. These applications usually involve multiple resources and Web Services at the same time. Examples of such resources are mobile devices, displays, portable players and augmented everyday objects. Web Services utilize these resources and provide the interfaces through which users can interact and control the ubiquitous environment. Ubiquitous applications differ from traditional applications that are static and bound to resources as specified at design time. Ubiquitous applications, on the other hand, are composed (or realized) from the available resources and Web Services at run-time according to user needs and other context information.

Depending on the degree of autonomy, application composition can be autonomic or user-controlled. A system supporting autonomic composition fully controls all processes (including the application’s behavior) and does not assume any user involvement. In contrast, user-controlled composition systems involve users in control. These systems can be further classified as manual composition systems (users themselves control everything) and semi-autonomic composition systems (both users and the system collaborate to control the composition through, e.g., a visual interface). For instance, a semi-autonomic system can rely on a mixed initiative interface which guides users through a sequence of steps that result in a composed application.

In general, systems for autonomic application composition aim to ensure better usability by keeping user distraction during the composition to minimum (although user attention may be distracted while (s)he is using the composed application). These systems focus on abstracting user activities from their system-level realization and allow users to concentrate on what they need, rather than on how these activities have to be realized by the system (Sousa et al., 2006, 2008b; Masuoka et al., 2003). User activities are users’ everyday tasks that can be abstractly described in terms of 1) the situation (context) in which the tasks take place, 2) the system functionalities required to accomplish the activities, and 3) user preferences relating to QoS, privacy and other requirements.

In order to support the user in these activities, the automatic system captures the user’s goals and needs by means of user context recognition facilities (Ranganathan & Campbell, 2004) or through dedicated user interfaces (Davidyuk et al., 2008a; Sousa et al., 2006; Kalasapur et al., 2007). Some systems allow users to express their intent vaguely, for example in their natural language as suggested by Lindenberg et al. (2006). Then, the system reactively or even pro-actively searches for possible ways to compose the required application using the appropriate resources.

In spite of the advantages in autonomic application composition, users might feel out of control, especially when the system does not behave as anticipated or when the resulting application does not match the users’ original goal. Moreover, as pointed out by Hardian et al. (2006) and confirmed through user experience tests by Vastenburg et al. (2007), involving users in application control is essential to ensure that users accept autonomous prototypes, especially those intended for home or office automation domains. In addition, our earlier studies on user control for application composition (Davidyuk et al., 2008a) reveal that users still need to be provided with control interfaces even if the system is autonomic and users do not intend to control the composition of each application.

In this chapter, we present CADEAU, a prototype that supports the composition of applications from ubiquitous resources and Web Services. This