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Managing Variability of Ambient Intelligence Middleware

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ABSTRACT

AmI technologies have to produce software embedded in a wide variety of everyday objects and devices with critical resource limitations. Furthermore, they must provide support to different types of applications and to many different kinds of users. The application of a Software Product Line approach would be very useful to express the different requirements of either devices or applications in terms of commonalities and variabilities when defining a family of AmI middleware platforms. A feature model for the AmI domain will help to specify and automatically derive different configurations of middleware tailored according to a large number of constraints. The aim of this article is to highlight the complexity of managing different types of variability during the development of applications for AmI environments. A generic process for automatically generating a custom configuration of a middleware variant is also presented.

Keywords: *AmI technologies; middleware platforms; software product line approach*

INTRODUCTION

AmI applications have to deal with a wide variety of devices ranging from mobile phones and PDAs with medium capacities to sensors, actuators, consumer electronics and wearable devices (Pervasive, 2003) with critical resource limitations. These devices are networked and operate across highly heterogeneous computing environments in terms of network access types, typically consisting of wireless (e.g. WiMAX, WBRO, etc.), cellular (e.g. UMTS, GSM, GPRS, etc.) and short/medium range (e.g. Bluetooth, Wifi, UMB, etc.) systems. Middleware platforms could play a key role in hiding the complexity and heterogeneity of lightweight devices connected via high-speed networks, by providing specific services (e.g. location, context-awareness, security, etc.) to support and facilitate AmI applications development.

The large number of heterogeneous devices and the diversity of communication technologies and AmI application requirements make it unfeasible to construct a single middleware platform that can be deployed and configured

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on all kind of devices and providing services that fulfil the requirements of all AmI applications. Instead, the developer of a middleware platform for AmI applications should create *families* of middleware platforms that can be instantiated and customised according to the different hardware and software constraints imposed by both devices and applications. Thus, the application of a Software Product Line (SPL) approach would be very useful to express the different requirements of either devices or applications in terms of commonalities and variabilities defining a family of AmI middleware platforms (Apel & Böhm, 2005). Since device resource constraints (e.g. in memory, processor throughput, etc.) is an important consideration in AmI, only a specific middleware platform configuration that is suitable for the device capacities must be installed. Resource limitation is not the only variable dimension that AmI developers have to deal with however. Other factors can be identified relating to the communication protocols supported, the kind of interfaces or the high diversity of operating systems as well as the different APIs available for each operating system delivered for specific devices. Not all the devices support the same version of a given operating system, and not all the APIs are available for all kinds of devices. Middleware for AmI should benefit from the SPL approach in terms of configurability, reusability and evolution management (White & Schmidt, 2008). AmI applications will benefit from a highly-optimized and custom middleware, which will offer appropriate services consistent with device configuration and resource constraints.

In a family of middleware for AmI, the product-line architecture (PLA) is common for all the product members. The PLA of the middleware is composed of different fine-grained services realizing domain (AmI) specific features, either common or variable features. So, a first step towards the definition of a middleware for AmI product line consists of specifying the feature model specific for the AmI domain. Feature modeling analyzes commonality and variability from a domain perspective (Lee et al, 2002). Then, a feature model allows specifying where the variability is independently of the core asset, and enables reasoning about all the different possible configurations. A feature model for the AmI domain will help to specify and automatically derive different configurations of middleware tailored according to a high diversity of constraints (e.g. device capacities, user preferences, application requirements, etc.).

The aim of this article is to highlight the complexity of managing different types of variability during the development of applications for AmI environments. The inherent variability of the AmI domain will be characterized by feature models. These feature models will enable different versions of a specific middleware for AmI to be generated, with the minimum number of services being required either by the devices and/or applications. A generic process for automatically generating a custom configuration of a middleware variant is also presented. Several benefits are obtained using a SPL to define a family of middleware for AmI. The responsibility of device users to carry out device and application configuration is drastically reduced, decreasing user headaches and runtime errors. Moreover, since the management of the intrinsic variability of the AmI domain is tackled at the middleware level, it can be ensured that only the correct version of middleware services will be invoked by final applications. Hence, the development and deploying tasks of AmI applications is also simplified, since the middleware hides the device variability complexity and provides custom-made services.

CHARACTERIZING THE VARIABILITY OF THE AMI DOMAIN

A Software Product Line aims to create the infrastructure for the rapid production of software systems for a specific market segment. These software systems are similar and therefore share a subset of common features,

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