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Integrating Sensor Nodes into a Middleware for Ambient Intelligence

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ABSTRACT

The development of infrastructures enabling dynamic and automated composition of IT systems is a big challenge. This paper addresses a new idea of allowing component-based systems to reconfigure themselves. Therefore, the authors propose DAiSI - a Dynamic Adaptive System Infrastructure for dynamic integration of components as well as their reconfiguration during runtime. Thereby, one of the features of the infrastructure is that it is capable of binding components based on their availability. In this paper the authors concentrate on presenting how resource constrained sensor nodes can be integrated into a system using this infrastructure.

Keywords: *Ambient Intelligence, Networking, Pervasive Computing, Sensor Networks, Ubiquitous Computing, Wireless*

INTRODUCTION

The vision of Ubiquitous Computing or Ambient Intelligence aims towards supporting people in their daily life at home or at work. In recent years more and more embedded components have become available trying to make this vision come true. Unfortunately these components rarely work together allowing the formation of dynamic systems with emerging capabilities. Building infrastructures for dynamic and automated composition of these components to exchange data and form new systems is a big challenge. For allowing components to work in an ambient manner, these components have to be bound. Moreover, Ubiquitous Computing or Ambient Intelligence systems have to be dynamically adaptive since some components are mobile and may appear suddenly during runtime. The dynamic integration of components into a system at runtime therefore is crucial for these kind of systems (Bartelt et al., 2005). For simplicity we will refer to those systems as *Dynaptive*[1] *Systems* in the following. This paper addresses a new idea of allowing Dynaptive Systems to reconfigure themselves and introduces an approach for integrating resource constraint sensor nodes.

We propose the Dynamic Adaptive System Infrastructure DAiSI. It is an infrastructure for component reconfiguration and dynamic integration. The heart of DAiSI is a Configura-

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tion Component which manages the automatic binding of components based on their required and provided services. We present the general component model and the DAiSI Configuration Component. Moreover we show how a specific sensor node can be integrated in such a self-configuring system.

The work presented in this paper was (partially) carried out in the BelAmI (Bilateral German-Hungarian Research Collaboration on Ambient Intelligence Systems) project (Bilateral German–Hungarian Collaboration Project on Ambient Intelligence Systems, 2009), funded by the German Federal Ministry of Education and Research (BMBF), the Fraunhofer-Gesellschaft and the Ministry for Science, Education, Research and Culture of Rhineland-Palatinate (MWWFK). DAiSI has initially been developed to serve as basis for binding components of the BelAmI project. The application domain of the BelAmI project is assisted living, where a demonstrator for elderly care has been built (Nehmer, Becker, Karshmer,&Lamm, 2006). In this demonstrator multiple embedded sensors collect data within an intelligent home environment. The goal was to aggregate this sensor information to probabilistically gather results about the constitution of elderly people and to support them in various manners. One application, we realized within the BelAmI project, was an intelligent fridge running on top of DAiSI (Klus, Niebuhr, & Rausch, 2007). This fridge was able to detect spoilt food or provide recipes based on its contents.

In the following sections we further elaborate on DAiSI in order to achieve *dependable* dynamic adaptive systems by binding only components, which are semantically compatible. This extended version of DAiSI has been elaborated within the Resist project funded by Siemens. We exhibited an application demonstrator from the emergency management domain at CeBIT 2009 visualizing the benefits of our approach (Niebuhr, Schindler, & Herrling, 2009). This demonstrator will also serve as application example within this paper.

The paper is structured as follows: First of all we distinguish our middleware platform from related work. Then we continue with a short description of the application example which will be used to explain our concepts in the following. Afterwards, we describe how DAiSI is structured, how DAiSI application components are integrated into a system, and how they are configured automatically. Finally we sketch a concept how ressource constrained sensor nodes can be integrated into DAiSI and end up with conclusions we derived from this work.

RELATED WORK

The core of DAiSI is the Configuration Component, which enables the automatic reconfiguration of a component landscape. In the following we present a selection of technologies, both state of the art and state of the practice that deal with automatic reconfiguration.

State of the Art

There are several middleware solutions from the research community supporting proactive and reactive system adaptability (Sadjadi, Survey, & Exam, 2003). These can be further categorized in component and system adaptation frameworks. DAiSI falls into the category of reactive system adaptation. In other words it supports changing the configuration of a system without (a) the necessity of knowing all possible types of components in advance and (b) without knowing the explicit description of the reconfiguration behavior. In (Oreizy, Medvidovic, & Taylor, 1998) reactive system adaptation is also supported. The C2 (Taylor, Medvidovic, Anderson, Whitehead, & Robbins, 1995) architectural style comes into play when one sees architectural connectors as well as components as first class entities.

The authors have developed an infrastructure that allows adding and removing components and connectors at runtime by using a special scripting language. Moreover, they support modifying associations between connectors and components. Finally, a special validator component checks whether the modifications