Chapter 3.7
Ontological Engineering in Pervasive Computing Environments

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ABSTRACT

Pervasive computing is a broad and compelling research topic in computer science that focuses on the applications of technology to assist users in everyday life situations. It seeks to provide proactive and self-tuning environments and devices to seamlessly augment a person's knowledge and decision making ability, while requiring as little direct user interaction as possible. Its vision is the creation of an environment saturated with seamlessly integrated devices with computing and communication capabilities. The realisation of this vision requires that a very large number of devices and software components interoperate seamlessly. As these devices and the associated software will pervade everyday life, an increasing number of software and hardware providers will deploy functionality in pervasive computing environments (PCE). That poses a very important interoperability issue, as it cannot be assumed that the various hardware and software components share common communication and data schemes. We argue that the use of Semantic Web technologies, namely the ontologies, present a intriguing way of resolving such issues and, therefore, their

application in the deployment of PCE is a highly important research issue.

INTRODUCTION

The vision of pervasive computing presents many technical issues, such as scaling-up of connectivity requirements, heterogeneity of processors and access networks and poor application portability over embedded processors. These issues are currently being addressed by the research community; however the most serious challenges are not technological but structural, as embedded processors and sensors in everyday products imply an explosion in the number and type of organisations that need to be involved in achieving seamless interoperability (O'Sullivan, 2003). In a typical pervasive computing environment (PCE) there will be numerous devices with computing capabilities that need to interoperate (Nakajima, 2003). These devices might be of different vendors and may operate based on different protocols. Therefore, the key issue in deploying a PCE is achieving application level interoperability. The complexity of such a venture is considerable. It is extremely difficult to reach agreements when the players involved expand from all the hardware and software providers (e.g., IBM, HP, Microsoft) to all the organisations that will equip their products with computing and communication capabilities (e.g., coffee machines, refrigerators). Therefore, we cannot rely on shared a priori knowledge based on commonly accepted standards to resolve the issue. Instead, software components must adapt to their environment at runtime to integrate their functionality with other software components seamlessly. An intriguing way of resolving this issue is the use of semantics, namely the use of Semantic Web technologies such as ontologies. In this manner, software entities provide semantically enriched specifications of the services that they provide and the way they should be invoked. Moreover, the data that are exchanged are also semantically enriched, enabling the entities to reason and make effective decisions. This is particularly important for the description of contextual information, which is of main interest in a PCE. As context we identify any information that is, directly or indirectly, associated with any entity in the environment.

The novelty of the Semantic Web is that the data are required to be not only machine readable but also machine understandable, as opposed to today's Web which was mainly designed for human interpretation and use. According to Tim Berners-Lee, the Director of World Wide Web Consortium, "the Semantic Web's goal is to be a unifying system which will (like the Web for human communication) be as un-restraining as possible so that the complexity of reality can be described" (Berners-Lee, 2001). With the realisation of a Semantic Web it would be easy to deploy a wide range of services that would be almost impossible to manage in the current Web. Semantics enable developers to create powerful tools for complex service creation, description, discovery, and composition. The application areas of the Semantic Web extend from knowledge repositories to e-commerce and from user profiling to PCE.

New standards are being developed as a first step in realising the Semantic Web. The Resource Description Framework (RDF), which is a Web mark-up language that provides basic ontological primitives, has been developed by the W3C (Beckett, 2004). RDF is a language for representing meta-information about resources in the World Wide Web. However, by generalising the concept of a "Web resource", RDF can also be used to represent information about things that can be identified on the Web, by means of URIs. The DARPA Agent Markup Language + Ontology Inference Layer (DAML+OIL) extends RDF with a much richer set of modelling primitives (Rapoza, 2000). The DAML+OIL have been submitted to W3C as a starting point for the Web Ontology Working Group and led to the creation

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