Pontifícia Universidade Católica
do Rio de Janeiro

José Viterbo Filho

Decentralized Reasoning in Ambient Intelligence

Tese de Doutorado

Thesis presented to the Postgraduate Program in Informatics of the Departamento de Informática, PUC-Rio, as partial fulfillment of the requirements for the degree of Doutor em Informática.

Advisor: Prof. Markus Endler

Rio de Janeiro
September 2009

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To my father (in memoriam) and mother,
for the unconditional support.

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Resumo

Viterbo F., José; Endler, Markus. **Inferência Descentralizada em Ambientes Inteligentes**. Rio de Janeiro, 2009. 114p. Tese de Doutorado — Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

A computação ubíqua prevê a integração de sistemas computacionais ao nosso dia-a-dia para prover informações e funcionalidades em qualquer momento e lugar. Sistemas desse tipo englobam diferentes tipos de sensores e dispositivos móveis interconectados através de uma combinação de várias tecnologias de rede sem fio. Uma tendência particular nessa área é explorar o paradigma dos Ambientes Inteligentes (AmI), o qual visa à integração de tecnologias inovativas para criar ambientes mediados por computador que, através de serviços específicos, auxiliam os usuários em suas atividades com mínima intervenção. Em sistemas de AmI, mecanismos de inferência são fundamentais para disparar ações ou adaptações de acordo com situações que podem ser significativas e relevantes para aplicações. Muitos sistemas adotam uma abordagem centralizada para seus mecanismos de inferência. Em AmI, entretanto, essas operações podem ter que avaliar dados de contexto coletados de fontes distribuídas e armazenados em diferentes dispositivos, uma vez que geralmente nem todo dado de contexto está prontamente disponível para os serviços de inferência. O objetivo desta tese é propor uma abordagem descentralizada para executar inferência de contexto baseada em regras. Para isso, definimos um modelo de contexto assumindo que os dados de contexto são distribuídos em dois lados, o *lado do usuário*, representado pelos usuários e seus dispositivos móveis, e o *lado do ambiente*, representado pela infrastrutura computacional fixa e os serviços do ambiente. Formalizamos a operação de *inferência cooperativa* — na qual duas entidades cooperam para executar a inferência descentralizada baseada em regras — e definimos um processo completo para realizar esta operação. Finalmente, para mostrar que essa abordagem é possível, projetamos, implementamos e avaliamos o protótipo de um serviço de middleware que executa inferência baseada no processo de *inferência cooperativa*.

Palavras–chave

Ambientes Inteligentes, Inferência Baseada em Regras, Inferência Distribuída

Abstract

Viterbo F., José; Endler, Markus. **Decentralized Reasoning in Ambient Intelligence**. Rio de Janeiro, 2009. 114p. DSc. Thesis — Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

Ubiquitous computing features the seamless integration of computer systems into the everyday lives of users to provide information and functionalities anytime and anywhere. Such systems encompass different kinds of sensors and mobile devices interconnected through a combination of several wireless network technologies. A particular trend in this area is exploring the Ambient Intelligence (AmI) paradigm, which aims at the integration of innovative technologies to create computer-mediated environments that support user activities through specific services, with minimal user intervention. In AmI systems, reasoning is fundamental for triggering actions or adaptations according to specific situations that may be meaningful and relevant to some applications. Most middleware systems adopt a centralized approach for their reasoning mechanisms. In AmI environments, however, these reasoning operations may need to evaluate context data collected from distributed sources and stored in different devices, as usually not all context data is readily available to the reasoners within a ubiquitous system. The goal of this thesis is to propose a decentralized reasoning approach for performing rule-based reasoning about context data targeting AmI systems. For this sake, we defined a context model assuming that in AmI environments context data is distributed over two sides, the *user side*, represented by the users and their mobile devices, and the *ambient side*, represented by the fixed computational infrastructure and ambient services. We formalized the *cooperative reasoning* operation — in which two entities cooperate to perform decentralized rule-based reasoning — and defined a complete process to perform this operation. Finally, to show the feasibility of this approach, we designed, implemented and evaluated a middleware service supporting decentralized reasoning based *cooperative reasoning* process.

Keywords

Ambient Intelligence, Rule-based reasoning, Distributed Reasoning

Summary

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