The Final Oral Examination for the Degree of

DOCTOR OF PHILOSOPHY
Computer Science

Norha Milena Villegas Machado
2002  Icesi University  B. Systems Engineering
2005  Icesi University  EM. Mgmt Information Systems

“Context Management and Self-Adaptivity for Situation-Aware Smart Software Systems”

February 18th, 2013
1:30 pm
Engineering/Computer Science Bldg., Room 660

Supervisory Committee:
Dr. Hausi A. Müller, Department of Computer Science, UVic (Supervisor)
Dr. Margaret-Anne Storey, Department of Computer Science, UVic
Dr. Ulrike Stege, Department of Computer Science, UVic
Dr. Pan Agathoklis, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Patrick Martin, School of Computing, Queen’s University

Chair of Oral Examination:
Dr. Colin Bradley,
Department of Mechanical Engineering, UVic
Abstract
Socio-technical ecosystems comprise dynamic and interdependent communities of users, organizations, and computing infrastructures that coexist in complex and changing environments. With the rapid growth of socio-technical ecosystems, our society is increasingly demanding situation-aware smarter software (SASS) systems, whose goals change over time and depend on context situations. A system with such properties must sense their dynamic environment and respond to changes quickly, accurately, and reliably, that is, to be context-aware and self-adaptive.

The problem addressed in this dissertation is the dynamic management of context information, with the goal of improving the relevance of SASS systems' context-aware capabilities with respect to changes in their requirements and execution environment. Therefore, this dissertation focuses on the investigation of dynamic context management and self-adaptivity to: (i) improve context-awareness and exploit context information to enhance quality of user experience in SASS systems, and (ii) improve the dynamic capabilities of self-adaptivity in SASS systems.

Context-awareness and self-adaptivity pose significant challenges for the engineering of SASS systems. Regarding context-awareness, the first challenge addressed in this dissertation is the impossibility of fully specifying environmental entities and the corresponding monitoring requirements at design-time. The second challenge arises from the continuous evolution of monitoring requirements due to changes in the system caused by self-adaptation. As a result, context monitoring strategies must be modeled and managed in such a way that they support the addition and deletion of context types and monitoring conditions at runtime. For this, the user must be integrated into the dynamic context management process.

Concerning self-adaptivity, the third challenge is to control the dynamicity of adaptation goals, adaptation mechanisms, and monitoring infrastructures, and the way they affect each other in the adaptation process. This is to preserve the effectiveness of context monitoring requirements and thus self-adaptation. The fourth challenge, related also to self adaptivity, concerns the assessment of adaptation mechanisms at runtime to prevent undesirable system states as a result of self-adaptation.

Given these challenges, to improve context awareness we made three contributions. First, we proposed the personal context sphere concept to empower users to control the life cycle of personal context information in user-centric SASS systems. Second, we proposed the SMARTERCONTEXT ontology to model context information and its monitoring requirements supporting changes in these models at runtime. Third, we proposed an efficient context processing engine to discover implicit contextual facts from context information specified in changing context models.
To improve self-adaptivity we made three contributions. First, we proposed a framework for the identification of adaptation properties and goals, which is useful to evaluate self-adaptivity and to derive monitoring requirements mapped to adaptation goals. Second, we proposed a reference model for designing highly dynamic self-adaptive systems, for which the continuous pertinence between monitoring mechanisms and both changing system goals and context situations is a major concern. Third, we proposed a model with explicit validation and verification (V&V) tasks for self-adaptive software, where dynamic context monitoring plays a major role.

The seventh contribution of this dissertation, the implementation of SMARTERCONTEXT infrastructure, addresses both context-awareness and self-adaptivity.

To evaluate our contributions, qualitatively and quantitatively, we conducted several comprehensive literature reviews, a case study on user-centric situation-aware online shopping, and a case study on dynamic SOA governance.

Awards, Scholarships, Fellowships


2011 Project of the Year Award: Managing Dynamic Context to Optimize Smart Interactions and Services. IBM Centre for Advanced Studies of IBM Canada

2010-2013 CAS PhD Student Award-Fellowship. IBM Centre for Advance Studies, Toronto (Canada)

2009-2011 University of Victoria Award-Fellowship (Canada)

2009-2011 Colfuturo Award-Fellowship for PhD Studies (Colombia)

Selected Publications

Book Chapters


Conference Proceedings


