

Preface

Advances in networking technology have revitalized the investigation of agent technology as a promising paradigm for engineering complex distributed software systems. Agent technology has been applied to a wide range of application domains, including e-commerce, human-computer interfaces, telecommunications, and software assistants. Multi-agent systems (MASs) and their underlying theories provide a more natural support for ensuring important properties such as autonomy, mobility, environment heterogeneity, organization, openness, and intelligence. As a consequence, agent-based systems are likely to provide new approaches to dealing with the complexity of developing and maintaining modern software. However, developing robust large-scale agent-based systems will require new software engineering approaches. There are currently many methods and techniques for working with individual agents or with systems built using only a few agents. Unfortunately, agent-based software engineering is still in its infancy and existing software engineering approaches are unable to cope with large MASs.

The complexity associated with a large MAS is considerable. When a huge number of agents interact over heterogeneous environments, various phenomena occur which are not as easy to capture as when only a few agents are working together. As the multiple software agents are highly collaborative and operate in networked environments, they have to be context-aware and deal with environment uncertainty. This makes their coordination and management more difficult and increases the likelihood of exceptional situations, such as security holes, privacy violations, and unexpected global effects. Moreover, as users and software engineers delegate more autonomy to their MASs, and put more trust in their results, new concerns arise in real-life applications. However, many existing agent-oriented solutions are far from ideal; in practice, systems are often built in an ad hoc manner, are error-prone, not scalable, not dynamic, and not generally applicable to large-scale environments. Commercial success for MAS applications will require scalable solutions based on software engineering approaches in order to ensure effective deployment and to enable reuse.

The papers selected for this book represent advances in software engineering approaches to the development of realistic multi-agent systems. Research presented in this volume illustrates a broad range of techniques and methods that are being used to cope with the complexity of systems like these and to facilitate the construction of high-quality MASs. Furthermore, the power of agent-based software engineering is demonstrated through examples that are representative of real-world applications. These papers describe experience and techniques associated with large MASs in a variety of problem domains.

Given the comprehensive selection of case studies and software engineering solutions for MAS applications, this book provides a valuable resource for a vast audience of readers. The intended primary audience for this book includes re-

searchers and practitioners who want to keep up with the progress of software engineering for MASs, individuals keen to understand the interplay between agents and objects in software development, and those interested in experimental results from MAS applications. Software engineers involved with particular aspects of MASs as part of their work may find it interesting to learn about using software engineering approaches in building real systems. A number of chapters in the book discuss the development of MASs from requirements and architecture specifications to implementation. One key contribution of this volume is the description of the latest approaches to reasoning about complex MASs.

This book brings together a collection of 16 papers addressing a wide range of issues in software engineering for MASs, reflecting the importance of agent properties in today's software systems. The papers presented describe recent developments in specific issues and practical experience. The research issues addressed consist of: (i) integration of agent abstractions with other software engineering abstractions and techniques (such as objects, roles, components, aspects, and patterns); (ii) specification and modelling approaches; (iii) innovative approaches for security and robustness; (iv) MAS frameworks; and (v) approaches to ensuring quality attributes for large-scale MASs, such as dependability, scalability, reusability, maintainability, and adaptability. At the end of each chapter, the reader will find a list of interesting references for further reading. The book is organized into five parts, which deal with topics related to: (i) requirements engineering, (ii) software architecture and design, (iii) modelling, (iv) dependability, and (v) MAS frameworks.

This book is a natural continuation of a previous one¹. The main motivation for producing this book was the *2nd International Workshop on Software Engineering for Large-Scale Multi-agent Systems* (SELMAS 2003)², organized in association with the 25th International Conference on Software Engineering, held in Portland, Oregon, USA, in May 2003. SELMAS 2003 was our attempt to bring together software engineering practitioners and researchers to discuss the multifaceted issues arising when MASs are used to engineer complex systems. It was later decided to extend the workshop scope: inviting several workshop participants to write chapters for this book based on their original position papers, and inviting other leading researchers in the area to prepare additional chapters. Following an extensive reviewing process involving more than 80 reviewers, we selected the papers that appear in this volume.

We are confident that this book will be of considerable use to the software engineering community by providing many original and distinct views on such an important interdisciplinary topic, and by contributing to a better understanding and crossfertilization among individuals in this research area. It is only natu-

¹ Garcia, A., Lucena, C., Castro, J., Zambonelli, F., Omicini, A. (editors): *Software Engineering for Large-Scale Multi-agent Systems*. Lecture Notes in Computer Science, vol. 2603, Springer-Verlag, April 2003.

² Garcia, A. et al.: *Software Engineering for Large-Scale Multi-agent Systems - SELMAS 2003* (Workshop Report). ACM Software Engineering Notes, Vol. 28, No. 6, November 2003.

ral that the choice of contributors to this book reflects the personal views of the book editors. We believe that, despite the volume of papers and work on software engineering for MASs, there are still many interesting challenges to be explored. The contributions that can be found in this book are only the beginning. Our thanks go to all our authors, whose work made this book possible. Many of them also helped during the reviewing process. We would like to express our gratitude to Juris Hartmanis, and Alfred Hofmann of Springer-Verlag for recognizing the importance of publishing this book. In addition, we would like to thank the members of the Evaluation Committee who were generous with their time and effort when reviewing the submitted papers. We gratefully acknowledge the support and cooperation of Cláudio Sant'Anna (LES, PUC-Rio) who helped us in the preparation of this volume.

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