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Rafael H. Bordini
Mehdi Dastani
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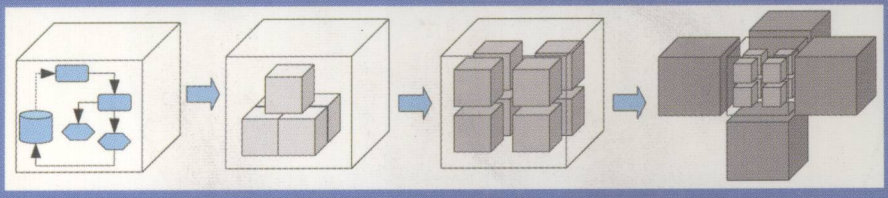
Programming Multi-Agent Systems

4th International Workshop, ProMAS 2006
Hakodate, Japan, May 2006
Revised and Invited Papers



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Preface

These are the proceedings of the 4th International Workshop on Programming Multi-Agent Systems (ProMAS 2006), held on May 9, 2006 in Hakodate (Japan) as an associated event of AAMAS 2006: the main international conference on autonomous agents and multi-agent systems (MAS). ProMAS 2006 was the fourth of a series of workshops that is attracting the increasing attention of researchers and practitioners in multi-agent systems.

The idea of organizing the first workshop of the series was first discussed during the Dagstuhl seminar Programming Multi-Agent Systems Based on Logic (see [6]), where the focus was on *logic-based approaches*. It was felt that the scope should be broadened beyond logic-based approaches, thus giving the current scope and aims of ProMAS [see [4] for the proceedings of the first workshop (ProMAS 2003), [1] for the proceedings of the second workshop (ProMAS 2004), and [3] for the proceedings of the third workshop (ProMAS 2005)]. All four events of the series were held as AAMAS workshops.

Besides the ProMAS Steering Committee (Rafael Bordini, Mehdi Dastani, Jürgen Dix, and Amal El Fallah Seghrouchni), an AgentLink III Technical Forum Group on *Programming Multi-Agent Systems* has been very active in the last couple of years (see http://www.cs.uu.nl/~mehdi/al3promas.html for details on that group). Moreover, we have edited a book on *Multi-Agent Programming* [2], and ProMAS 2007 will be held with AAMAS 2007 on May 12 or 13, in Honolulu, Hawaii (see http://www.cs.uu.nl/ProMAS/ for up-to-date information about ProMAS).

At the next edition of this workshop series, ProMAS 2007, a Multi-Agent Contest was organized (see [5] and http://cig.in.tu-clausthal.de/AgentContest/). This contest was the third in a series that has been co-organized with the CLIMA workshop series (Computational Logic in Multi-Agent Series). The contest is an attempt to stimulate research in the area of multi-agent programming by *(1) identifying key problems* and *(2) collecting suitable benchmarks* that can serve as milestones for testing agent-oriented programming languages, platforms and tools. A simulation platform has been developed to test MAS which have to solve a cooperative task in a dynamically changing environment.

In addition, preparations for editing a special issue of the *International Journal of Agent-Oriented Software Engineering* are under way. Indeed, we plan to publish this special issue in the Autumn of 2007. It will emphasize the close relation between current research on agent-oriented programming languages and agent-oriented software engineering (*ProMAS meets AOSE*). More information about this special issue can be found on the following Web page: http://www.cs.uu.nl/ProMAS/ProMASSpecialIssue.htm

Finally, we would like to mention the Dagstuhl Seminar on Foundations and Practice of Programming Multi-Agent Systems that recently took place (see

http://www.dur.ac.uk/r.bordini/Dagstuhl06261/). This seminar was organized to bring together researchers interested in programming languages for multi-agent systems, agent-oriented software engineering, and various related aspects such as verification and formal semantics. In this seminar, participants presented their views on the most advanced techniques being currently investigated throughout the world. They also collected the most important open problems of our research community. The seminar was particularly successful in elucidating the relationship between work being done by the *programming languages for multi-agent systems* (ProMAS) research community and the *agent-oriented software engineering* (AOSE) research community. Even though the initiative for this seminar arose from the ProMAS community, many prominent researchers from the AOSE community were attracted as well. This clearly shows the tight connection between ProMAS and AOSE research.

One of the driving motivations behind the ProMAS workshop series (and all associated activities) was the observation that the area of autonomous agents and MAS has grown into a promising technology offering sensible alternatives for the design of distributed, intelligent systems. Several efforts have been made by researchers and practitioners, both in academia and industry, and by several standardization consortia in order to provide new languages, tools, methods, and frameworks so as to establish the necessary standards for a wide use of MAS technology. However, until recently the main focus of the MAS research community has been on the development, sometimes by formal methods but often informally, of concepts (concerning both mental and social attitudes), architectures, coordination techniques, and general approaches to the analysis and specification of MAS. In particular, this contribution has been quite fragmented, without any clear way of "putting it all together," and thus completely inaccessible to practitioners.

We are convinced today that the next step in furthering the achievement of the MAS project is irrevocably associated with the *development of programming languages and tools that can effectively support MAS programming* and the *implementation of key notions in MAS in a unified framework*. The success of MAS development can only be guaranteed if we can bridge the gap from analysis and design to effective implementation. This, in turn, requires the development of fully-fledged and general purpose programming technology so that the concepts and techniques of MAS can be easily and directly implemented.

ProMAS 2006, as indeed ProMAS 2003, ProMAS 2004 and ProMAS 2005, was an invaluable opportunity for leading researchers from both academia and industry to discuss various issues on programming languages and tools for MAS. Showing the increasing importance of the ProMAS aims, the attendance to our workshop has been growing steadily over the years.

This volume of the LNAI series constitutes the official (post-)proceedings of ProMAS 2006. It presents the main contributions that featured in the latest ProMAS event. It contains 12 high-quality accepted and revised papers and, in addition, two invited papers. The structure of this volume is as follows:

Invited papers: We were honored to have Onn Shehory, a leading researcher in the area, giving the invited talk at ProMAS 2006. Onn Shehory has contributed to theoretical research on game-theoretic coalition formation, but also has an interest in agent-oriented software engineering, with significant industrial experience, thus an ideal speaker for the ProMAS workshop series. Subsequently to his talk, he wrote a paper to feature in these proceedings. The paper, based on the invited talk, entitled "A Self-Healing Approach to Designing and Deploying Complex, Distributed and Concurrent Software Systems," discusses a recent project addressing the important area of "self-*" systems. Computing systems with the ability to heal themselves, by diagnosing the cause of failures or inadequate performance and automatically restructuring software components or operating parameters, would make a major impact in the quality of complex dependable systems to be developed in the future.

We also invited Jörg Müller to contribute a paper on his latest work on combining BDI agent and P2P protocols. He wrote the paper, co- authored with Klaus Fischer, Fabian Stäber, and Thomas Friese, entitled "Using Peer-to-Peer Protocols to Enable Implicit Communication in a BDI Agent Architecture." The paper describes research aimed at extending current agent platforms so that agents can interact both through the usual message-based communication but also through document-based communication, as is typical in business processes. Their ideas were practically realized by combining the JACK Agent Platform and the P2P Business Resource Management Framework.

Part I: The first part of these proceedings contains four papers.

The first paper, "Asimovian Multiagents: Applying Laws of Robotics to Teams of Agents and Humans" by Nathan Schurr, Pradeep Varakantham, Emma Bowring, Milind Tambe and Barbara Grosz, investigates the first two laws of Isaac Asimov formulated in the 1940s. It turns out that operationalizing these laws in the context of mixed human-agent teams raises several problems. Among them the uncertainty of agents with respect to their knowledge of the world.

The second paper, "Persistent Architecture for Context-Aware Lightweight Multi-Agent System" by Aqsa Bajwa, Obaid Malik, Sana Farooq, Sana Khalique and Farooq Ahmad, is about an architecture for lightweight devices (e.g., PDAs). An important aspect is to minimize communication latency and to develop a FIPA-compliant context-aware system that can be used for business and e-commerce applications.

The third paper, "Design of Component-Based Agents for Multi-Agent-Based Simulation" by Jean-Pierre Briot, Thomas Meurisse and Frédéric Peschanski, presents a component-based approach to developing agent systems, based on an explicit control flow between components. Complex behaviors can be modelled by composite components. The framework supports both bottom-up as well as top-down approaches.

The fourth paper, "Incorporating Knowledge Updates in 3APL – Preliminary Report" by Vivek Nigam and João Leite, extends the belief base and

the goal base of the 3APL programming language for MAS to use dynamic logic programming, which allows for the representation of changing knowledge. The advantages of the extension include: evolving knowledge and goal bases, the use of strong negation as well as negation as failure, and goals and communication can be more expressive; as a consequence of increased expressiveness, there is also an increase in the complexity of computing an agent reasoning cycle.

Part II: The second part contains four papers.

The first paper, "Comparing Apples with Oranges: Evaluating Twelve Paradigms of Agency" by Linus Luotsinen, Ladislau Bölöni, Joakim Ekblad, Ryan Fitz-Gibbon and Charles Houchin, uses 12 different notions of agency such as rule-based agents, affective agents, and reinforcement agents in order to implement agents that act in an environment similar to artificial life and game environments. The paper provides a comparative analysis of these notions of agency and indicates which type of problems a development team will face if it decides to use a particular agency notion to implement their system.

The second paper, "Augmenting BDI Agents with Deliberative Planning Techniques" by Andrzej Walczak, Lars Braubach, Alexander Pokahr and Winfried Lamersdorf, investigates the application and coupling of state-based planners to BDI agent frameworks. In this proposal, the BDI framework is responsible for plan monitoring and re-planning while the state-based planner is responsible for plan generation.

The third paper, "ALBA : A Generic Library for Programming Mobile Agents with Prolog" by Benjamin Devèze, Caroline Chopinaud and Patrick Taillibert, presents a generic library to be used by mobile agents written in Prolog. This library supports the creation, execution, mobility and communication of agents.

The fourth paper, "Bridging Agent Theory and Object Orientation: Agent-Like Communication Among Objects" by Matteo Baldoni, Guido Boella and Leendert van der Torre, compares the message-sending mechanism between agents and the method-invocation mechanism of objects. They propose an extension of the method-invocation mechanism with ingredients such as the sender identity, the state of interaction protocol, and the roles played in the interactions.

Part III: The third part contains four papers that tackle the issues of validation, debugging and testing agents and MAS. All these papers consider an MAS as a particular type of distributed system in which the active entities, i.e., agents, are autonomous and run concurrently.

The first paper, "Validation of BDI Agents" by Jan Sudeikat, Lars Braubach, Alexander Pokahr, Winfried Lamersdorf and Wolfgang Renz, addresses the issue of testing and debugging BDI-based MAS. The authors examine how the reasoning mechanism inside agent implementations can be checked and how static analysis of agent declarations can be used to visualize and check the overall communication structure in closed MAS. They

also present the corresponding tool support, which relies on the definition of crosscutting concerns in BDI agents and enables both approaches to the Jadex Agent Platform. The second paper, "A Tool Architecture to Verify Properties of Multiagent System at Runtime" by Denis Meron and Bruno Mermet, describes an architecture allowing one to verify the properties of agents and MAS at runtime. The paper defines a notion of *property* and describes the proposed architecture and the way to check MAS.

The third paper, "On the Application of Clustering Techniques to Support Debugging Large-Scale Multi-agent Systems" by Juan A. Botía, Juan M. Hernansáez and Antonio F. Gómez-Skarmeta, situates the problem of debugging distributed MAS by firstly studying the classical approaches for conventional code debugging and also the techniques used in distributed systems in general. From this initial perspective, it tries to situate agent and MAS debugging. It finally proposes the use of conventional data mining techniques like clustering to help, by summarizing, in debugging large-scale MAS.

The fourth paper, "Debugging Agents in Agent Factory" by Rem Collier, describes how debugging has been supported for the Agent Factory Agent Programming Language (AFAPL). This language employs mental notions such as beliefs, goals, commitments, and intentions to facilitate the construction of agent programs that specify the high-level behavior of the agent.

We would like to thank all the authors, the invited speaker, the authors of the second invited paper, the Program Committee members, and reviewers for their outstanding contribution to the success of ProMAS 2006. We are particularly grateful to the AAMAS 2006 organizers for their technical support and for hosting ProMAS 2006.

January 2007

Rafael H. Bordini
Mehdi Dastani
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Amal El Fallah Seghrouchni

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