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Programming Multi-Agent Systems

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Preface

These are the proceedings of the 2nd International Workshop on Programming Multi-agent Systems (ProMAS 2004), held in July 2004 in New York (USA) as an associated event of AAMAS 2004, the main international conference dedicated to autonomous agents and multi-agent systems.

The idea of organizing such an event was discussed during the Dagstuhl seminar *Programming Multi-agent Systems Based on Logic* (see [2]), where the focus was on *logic-based approaches*. It was felt that the scope should be broadened beyond logic-based approaches, and thus ProMAS came into being (see [1] for the proceedings of the first event, ProMAS 2003).

Meanwhile, a Steering Committee (Rafael Bordini, Mehdi Dastani, Jürgen Dix, Amal El Fallah Seghrouchni) as well as an AgentLink III Technical Forum Group on *Programming Multi-agent Systems* were established (the latter one was founded on 30 June/1 July 2004 in Rome, Italy (see http:// www.cs.uu.nl/ mehdi/al3tf8.html). Moreover, a Kluwer book on the same topic is underway (to appear early in 2005) and the third workshop ProMAS 2005 will be organized within AAMAS 2005 (see http://www.cs.uu.nl/ProMAS/ for up-to-date information about ProMAS).

One of the driving motivations behind this workshop series is the observation that the area of autonomous agents and multi-agent systems (MAS) has grown into a promising technology offering sensible alternatives for the design of distributed, intelligent systems. Several efforts have been made by academic researchers, by industrialists, and by several standardization consortia in order to provide new tools, methods, and frameworks so as to establish the necessary standards for a wide use of MAS as a technology on its own, not only as a new paradigm.

However, until recently the main focus of the MAS 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 multi-agent systems. 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 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 multi-agent systems in a unified framework*. The success of agent-oriented system development can only be guaranteed if we can bridge the gap between analysis and design on the one hand, and implementation on the other hand. This, in turn, requires the development of powerful and general-purpose programming technology such that the concepts and techniques of multi-agent systems can be easily and directly implemented.

ProMAS 2004, as indeed ProMAS 2003, was an invaluable opportunity that brought together leading researchers from both academia and industry to discuss the design of programming languages and tools for multi-agent systems. In particular, the workshop promoted the discussion and exchange of ideas concerning the concepts, properties, requirements, and principles that are important for future programming technology for multi-agent systems.

This volume of the LNAI series constitutes the official (post-)proceedings of ProMAS 2004. It presents the main contributions that featured in the latest ProMAS event. Besides the final 10 high-quality accepted papers, we also invited two leading researchers, Milind Tambe and David Kinny, in academia and industry, respectively, to give invited talks at the workshop. Subsequently, they wrote invited contributions which are featured in these proceedings.

The main topics addressed in this volume are:

Agent-Oriented Programming: The first paper in this part of the proceedings, *Goal Representation for BDI Agent Systems*, by Lars Braubach, Alexander Pokahr, and Daniel Moldt, describes a goal model that shows how an agent achieves and manages his goals. It goes on to provide a generic life cycle that models different types of goals in BDI agent systems.

The second paper, *AF-APL – Bridging Principles & Practice in Agent Oriented Languages*, by Robert Ross, Rem Collier, and Gregory M.P. O'Hare, presents an agent-oriented programming language called Agent-Factory. The theoretical foundations of this language are based on principles from agent-oriented design that are enriched with practical considerations of programming real-world agents.

Agent Platforms and Tools: The first paper in this part is *A Toolkit for the Realization of Constraint-Based Multiagent Systems*, by Federico Bergenti. The paper has two main contributions: the first consists of an approach for modelling and a language (called QPL) for programming multi-agent systems where agents are seen as solvers of constraint satisfaction and optimization problems; the second, more practical contribution is the QK toolkit which provides a QPL compiler and a runtime platform for deploying such (constraint-based) multi-agent systems.

The next paper, *Debugging Agent Behavior in an Implemented Agent System*, by Dung Lam and Suzanne Barber, introduces a working tool for debugging BDI multi-agent systems (a research topic that should receive much attention in the future). As the tool is aimed for use with any agent platforms, users have to add their own code for logging run-time data on agents' attitudes; the approach also requires users to provide (usually domain-dependent) rules that relate agent attitudes. Such rules are used by the system to generate interpretations of observed behavior, which can then be compared to a given specification of expected behavior.

The final paper in this part is *A Mobile Agents Platform: Architecture, Mobility and Security Elements*, by Alexandru Suna and Amal El Fallah Seghrouchni. It presents the SyMPA platform for the execution of agents implemented in a high-level declarative agent-oriented programming lan-

guage called CLAIM, which supports also mobile agents. CLAIM is inspired by ideas from both agent-oriented programming and the Ambient Calculus. SyMPA provides mechanisms for both strong and weak mobility, various aspects of security, and fault tolerance.

Agent Languages: In this part, two papers discussing the implementation of communication models in multi-agent systems are included. The first paper, *Bridging the Gap Between AUML and Implementation Using IOM/T*, by Takuo Doi, Nobukazu Yoshioka, Yasuyuki Tahara, and Shinichi Honiden, presents an interaction protocol description language called IOM/T. This language has a clear correspondence with AUML diagrams and helps to bridge the gap between design and implementation since IOM/T code can be directly converted into Java.

The second paper, *Inter-agent Communication in IMAGO Prolog*, by Xining Li and Guillaume Autran, presents a communication model for a variant of Prolog called IMAGO Prolog. In this model, agent communication is implemented by mobile messengers, which are simple mobile agents that carry messages between agents.

Multi-agent Systems Techniques: The first paper in this part, *OMNI: Introducing Social Structure, Norms and Ontologies into Agent Organizations*, by Virginia Dignum, Javier Vazquez-Salceda, and Frank Dignum, describes a framework for modelling Agent organizations. An important point is to balance both global organizational requirements as well as autonomy of individual agents. Several levels of abstraction are distinguished, each with a formal logical semantics.

The second paper, *A Dialogue Game to Offer an Agreement to Disagree*, by Henk-Jan Lebbink, Cilia Witteman, John-Jules Ch. Meyer, deals with the problem of deciding whether several agents may reach an agreement or not. A particular game is described that allows agents to come to an agreement to disagree and thus to conclude an ongoing dialogue.

The last paper in this part, *Coordination of Complex Systems Based on Multi-agent planning: Application to the Aircraft Simulation Domain*, by Frederic Marc, Amal El Fallah Seghrouchni, and Irene Degirmenciyan-Cartault, is concerned with multi-agent planning in the tactical aircraft simulation domain.

In addition to the peer-reviewed papers listed above, the proceedings contain two invited papers related to the two invited talks given at ProMAS 2004:

- The first invited paper, *Coordinating Teams in Uncertain Environments: A Hybrid BDI-POMDP Approach*, by Ranjit Nair and Milind Tambe, addresses the issue of multi-agent team coordination in the context of multi-agent planning under uncertainty. The paper overviews coordination approaches based on POMDP (Partially Observable Markov Decision Processes) and discusses the limits of POMDP-based approaches in terms of tractability. Then, the authors introduce a hybrid approach to improve the tractability of the POMDP technique. The proposed approach combines two paradigms

to build multi-agent team plans: the BDI model (beliefs, desires and intentions) and distributed POMDP. It shows how the use of BDI techniques can improve distributed POMDP and how, reciprocally, distributed POMDP can improve planning performance.

The contributions of the hybrid approach put forward by the authors are: (i) it focuses on agents' roles and on their allocation in teams while taking into account future uncertainties in the studied domain; (ii) it provides a new decomposition technique that exploits the structure of the BDI team plans in order to prune the search space of combinatorial role allocations; and (iii) it proposes a faster policy evaluation algorithm suited to the proposed BDI-POMDP hybrid approach. The paper also presents experimental results from two significant domains: mission rehearsal simulation and the RoboCup Rescue disaster rescue simulation.

– The second invited paper, *Agents – the Challenge of Relevance to the IT Mainstream*, by David Kinny, discusses and evaluates the state of the art in multi-agent systems research by focusing on its relevance to enterprise computing. In particular, it poses the question of whether the agent paradigm and its various technologies are relevant to mainstream IT. To answer this question, the author points out some reasons why other paradigms that promised to transform software development have failed to be adopted by mainstream IT, and explains why and in which ways the agent paradigm has a better prospect of being adopted by the mainstream software industry. It is argued that the agent paradigm will be adopted by mainstream IT if it provides effective solutions to enterprise needs, and delivers substantial benefits that cannot be achieved by other paradigms. The paper presents some valuable aspects of agent technology for enterprise computing and indicates agent techniques and technologies that are ready for mainstream use. To conclude, some of the current research challenges in furthering the relevance of agent technology to mainstream IT are discussed.

The workshop finished with a panel session, moderated by Andrea Omicini, on *Current Trends and Future Challenges in Programming Multi-agent Systems*. The panelists, including again researchers and developers from both academia and industry, were: Monique Calisti, David Kinny, Michael Luck, Onn Shehory, and Franco Zambonelli. Besides various important remarks about how to foster the industrial take-up of MAS technology — such as the general indication that industry seems to be only willing to take small, simple technological advances at a time and in such a way that they can be integrated easily with their existing practices, and the need for working tools (for testing and debugging as well as programming) to support the activities of programmers in industry — a considerable part of the panel session was dedicated to discussing an essential mechanism for technological transfer which is often neglected: the point was that we need to recognize, and exploit sensibly the immense power that academics have in educating the next generations of programmers, who in turn shape the actual practice of the software industry.

We would like to thank all the authors, invited speakers, Programme Committee members, and reviewers for their outstanding contribution to the success of ProMAS 2004. We are especially thankful to the AAMAS 2004 organizers (in particular Simon Parsons) for their technical support and for hosting ProMAS 2004.

October 2004

Rafael H. Bordini
Mehdi Dastani
Jürgen Dix
Amal El Fallah Seghrouchni

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Organization

ProMAS 2004 was held as a workshop of the 3rd International Joint Conference on Autonomous Agents and Multi-agent Systems, in New York City, NY, on the 20th of July 2004.

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