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Multiagent Systems

In recent years, multi-agent systems have come to form one of the key technologies for software development. The aim of the Formal Approaches to Multi-Agent Systems (FAMAS) workshop has been to bring together researchers from the fields of logic, theoretical computer science and multi-agent systems in order to discuss formal techniques for specifying and verifying multi-agent systems. FAMAS addressed the issues of logics for multi-agent systems, formal methods for verification, e.g. model checking, and formal approaches to cooperation, multi-agent planning, communication, coordination, negotiation, games, and reasoning under uncertainty in a distributed environment.

This double special issue is based on a selection of papers presented at the first FAMAS workshop, which was a satellite event of the European Conference on Theory and Practice of Software (ETAPS'03) in Warsaw. It took place on Saturday, 12 April, 2003. Six of the twelve FAMAS speakers were then invited to contribute an extended version of their work to this special issue; two additional interesting papers were added as well.

All research reported here is squarely related to practice, even if the formal approach is taken. Thus, at FAMAS'03, speakers did not need to apologize for "using Greek" in their slides, as sometimes happens during general agent conferences.

The contributions selected for this issue highlight different fundamental aspects of formal approaches to multi-agent systems.

Cooperation: from coalitions to teams

O. Shehory's "Coalition Formation: Towards Feasible Solutions" focuses on efficient and effective methods to form coalitions, which can increase the gain both of benevolent agents, that may form cooperative teams, and of self-interested agents, that may for example form buying coalitions in e-commerce applications. Existing mechanisms for coalition formation have two important drawbacks: they are highly complex, and they pose unrealistic assumptions on the agents' information. Based on a mathematical model, Shehory presents two new mechanisms, one less complex than the usual ones, which allows scaling to thousands of agents, and another one that allows private, incomplete and inaccurate information. Even though this does not solve all problems, the new solutions are shown to be profitable in two specific electronic commerce domains.

Cooperative Problem Solving within teams of BDI agents couldn't be successful without collective motivational attitudes: collective intention constituting a team, and collective commitment leading to team action. In B. Dunin-Kęplicz' and R. Verbrugge's "A Tuning Machine for Cooperative Problem

Solving”, building on previous work of the authors, a notion of collective commitment is generalized, in order to reflect different aspects of Cooperative Problem Solving, as well as different properties of the environment. This leads to the construction of a sort of logical tuning machine for creating collective commitments. This abstract device is provided for the system developer to tune a version of collective commitment fitting the circumstances. For a few exemplar collective commitments resulting from instantiating the general tuning scheme, matching organizational (team) structures are briefly sketched.

On the other hand, H. Aldewereld, W. van der Hoek and J.-J. Ch. Meyer in “Rational Teams: Logical Aspects of Multi-Agent Systems” present an integrated logical framework to handle multiple agents. They extend the KARO framework, initially developed by Van der Hoek, Van Linder and Meyer. KARO makes use of epistemic and dynamic logics to express rational agents. However, where KARO primarily focuses on single agents, the contribution of this paper is a step towards real multi-agent systems, without fixing on any specific aspect of agency. When comparing this framework with Dunin-Kęplicz’ and Verbrugge’s approach, the authors incorporate more constraints on the agents.

Verification and dynamical aspects of multi-agent systems

In Jamroga’s and Van der Hoek’s “Agents that Know How to Play”, the emphasis is on a new formalism for specifying and verifying multi-agent systems, which can tackle combinations of knowledge, cooperation modalities, and time. The authors argue that inclusion of epistemic operators forces a restriction on possible strategies, taking into account agents’ uncertainty. Thus, if an agent cannot recognize whether he is in one situation or the other, he cannot proceed with one action in the first situation and a different one in the second. Two different solutions are presented. Interestingly, both Jamroga and Van der Hoek and Dunin-Kęplicz and Verbrugge make crucial use of the distinction between “de dicto” versus “de re” (as in “I believe there exists a spy” versus “there is someone of whom I believe he is a spy”) originating from the philosophy of language.

Kacprzak, Lomuscio and Penczek, in their paper “From Bounded to Unbounded Model Checking for Temporal Epistemic Logic”, focus squarely on the verification of multi-agent systems. In their language, higher-order concepts such as individual and common knowledge are added to the branching-time logic CTL. It turns out that the authors’ method of bounded model checking is useful for checking whether existential formulas of this language are satisfied by some finite witness among all traces of the multi-agent system. Sometimes, however, it is important to check universal formulas, like “p will remain commonly known among group Γ forever”. Thus the authors present a new method, unbounded model checking, which turns out to do the trick, even though its computational complexity is admittedly higher than that of bounded model checking.

De Haan, Hesselink and Renardel de Lavalette take a closer look at “Knowledge-based Asynchronous Programming”. Knowledge-based programs contain explicit tests for agents’ knowledge. In the past, the knowledge-based programming paradigm has been successfully applied to derive and prove correctness of many communication protocols. The usual semantics for such programs is problematic, though, on two accounts. First, usually synchrony is assumed, which is not always realistic; second, the meaning of knowledge-based programs as implicitly defined is in general not unique. The authors solve these problems using an iteration approach. They convincingly apply their solution to some well-known examples, such as the surprise examination paradox.

Situated MAS and communication

Weyns' and Holvoet's paper "A Formal Model for Situated Multi-Agent Systems", in contrast to many other papers in this special issue, does not focus on knowledge-based agents. *Situated* agents do not perform long-term planning to decide on a sequence of actions, but instead perform an action based on the agent's position, the perceived state of the world, and a very limited internal state. Weyns and Holvoet adapt a formal model by Ferber and Müller in such a way that they can avoid the difficulties entailed by using a global clock. Instead, in their new model, actions of subgroups of agents located close to one another are synchronized locally.

In Mazurkiewicz' paper "Multilateral Ranking Negotiations", the author investigates in which kinds of communication structures it is possible to achieve a ranking of participants by multi-lateral negotiation. The formal method used is that of local computations, where a structure is transformed by way of transforming its substructures, in this case "associations" of group members among whom direct communication is possible.

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