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Organized Adaption in Multi-Agent Systems

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Revised and Invited Papers

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Preface

Adaptation, for purposes of self-healing, self-protection, self-management, or self-regulation, is currently considered to be one of the most challenging properties of distributed systems that operate in dynamic, unpredictable, and potentially hostile environments. Engineering for adaptation is particularly complicated when the distributed system itself is composed of autonomous entities that, on one hand, may act collaboratively and with benevolence, and, on the other, may behave selfishly while pursuing their own interests. Still, these entities have to coordinate themselves in order to adapt appropriately to the prevailing environmental conditions, and furthermore, to deliberate upon their own and the system's configuration, and to be transparent to their users yet consistent with any human requirements. The question, therefore, of "how to organize the envisaged adaptation for such autonomous entities in a systematic way" becomes of paramount importance.

The first international workshop on "Organized Adaptation in Multi-Agent Systems" (OAMAS) was a one-day event held as part of the workshop program arranged by the international conference on Autonomous Agents and Multi-Agent Systems (AAMAS). It was hosted in Estoril during May, 2008, and was attended by more than 30 researchers.

OAMAS was the steady convergence of a number of lines of research which suggested that such a workshop would be timely and opportune. This includes the areas of autonomic computing, swarm intelligence, agent societies, self-organizing complex systems, and 'emergence' in general.

In autonomic computing, for example, the intention is to go beyond standard definitions of fault-tolerance (the capacity to endure faults until fixed by the intervention of an external operator), by modeling a computer system as a self-regulating biological system, i.e., a system with the capacity to repair faults by itself. In particular, there is a requirement, *inter alia*, for an autonomic system to configure, and re-configure itself, in the light of unexpected events, and the system must have, find, or generate for itself rules by which to optimize this (re-)configuration. An important metaphor in this field of research is the human auto-immune system, in particular the immune system's pattern recognition, memory, and learning capabilities which enable it to develop appropriate responses to a changing environment.

Swarm intelligence also exploited metaphors from biological systems, in this case how the behavior of a population of relatively simple agents, each of whom were following local rules and interacting only with their 'nearest' neighbors, could produce systems with complex global properties. Such examples abound in nature, in mammal herds, fish schools, and bird flocks, but it was important pioneering work in ant colony optimization by Marco Dorigo, using a computational equivalent of pheromone trails, that showed how natural and artificial

systems could be bridged. The ant metaphor has subsequently been extended to develop systems of self-assembling robots which demonstrate collective behavior in order to accomplish tasks that are beyond a singe individual.

Agent societies are an idea introduced into the modeling and engineering of multi-agent systems (MAS), in part to deal with the issue of "intelligence at the edge" (a function of increasing autonomy, heterogeneity, and decentralization in communication networks), but also because that intelligence was increasingly social in nature. In other words, cognitive, socio-cognitive, and even legal concepts, for example, trust, reputation, and contracts, were important in forming and conditioning the links between network nodes; and furthermore the interactions between nodes were more like "speech acts" than object invocations, and had a richer semantics, particularly with respect to conventional significance. The rich body of literature in organizational, social, and legal systems theory is then also relevant in designing methodologies for engineering a new paradigm for social MAS.

However, it is a given of organizational, social, and legal systems that they change over time, and in response to environmental conditions. Equally, it is evident that increasing application complexity, and expected system longevity, requires engineered agent societies to also change. While adaptation is almost a property *since qua non* of autonomic systems and swarm intelligence, the development of agent societies had tended to be based on formal specifications, from which could be derived proofs of particular properties. The challenge now was to make those formal specifications *adaptable*, either by under-specification at design-time and completion – by the agents themselves – at run-time; or, a complete specification given at design-time and modification – again, by the agents themselves – at run-time.

We are primarily interested in the principles of social intelligence and social development that distinguish agent societies as a significant innovation in adaptive systems. We seek to go beyond emergent behavior seen, for example, in swarm intelligence, i.e., the non-introspective application of hard-wired local computations, with respect to physical rules and/or the environment, which achieve unintended or unknown global outcomes; in agent societies the object of concern is the introspective application of soft-wired local computations, with respect to physical rules, the environment, and conventional rules, in order to achieve intended and coordinated global outcomes. This conscious, deliberate, and targeted adaptation of conventional rules, i.e., rules agreed among the participants, which effectively defined their behaviors (what some philosophers of language would call *constitutive rules*), was the focus of what we called *organized adaptation*.

Two invited presentations underlined the interdisciplinary nature of research on organized adaptation by considering real-world applications of autonomic computing and the life-cycle of norms in agent societies. The first invited talk was given by Jeffrey Kephart of IBM Research, USA. Dr. Kephart described the efforts at IBM Research to apply multi-agent concepts and principles to the development of autonomic technologies that work coherently with one another,

in order to reduce energy consumption in data centers without unduly sacrificing performance. The second invited talk was given by Jan Broersen, a lecturer at the University of Utrecht. In his talk, the contents of which appear in this volume as an invited submission, Dr. Broersen discussed several issues concerning the design of logical models of norm change.

Apart from Dr. Broersen's invited contribution, two regular papers focus on the theme of norm change. Bou and colleagues, in the paper entitled "Adapting Autonomic Electronic Institutions to Heterogeneous Agent Societies," present case-based reasoning techniques in order to dynamically adapt the norms of an institution, given the changes in the agents' behaviors and the institutional goals. Carr and Pitt, in the paper entitled "Adaptation of Voting Rules in Agent Societies," present a logical framework for modifying at run-time the norms of a voting protocol.

Three papers present organizational models of adaptive MAS. Kota and colleagues, in their paper entitled "Decentralized Structural Adaptation in Agent Organizations," demonstrate a decentralized approach for adapting the structure of an organization in order to achieve an 'optimal' allocation of tasks. Renz and Sudeikat, also focusing on adaptive organizations, aim to address, in their article entitled "Modeling Feedback Within MAS: A Systemic Approach to Organizational Dynamics," the need for tools expressing the dynamics of multi-agent organizations. Keogh and colleagues, in their article entitled "Coordination in Adaptive Organizations: Extending Shared Plans with Knowledge Cultivation," study the requirements of coordination in complex 'unfolding scenarios,' where there is no fixed organizational structure, with the aim of developing a simulation framework as a part of a training system in the domain of emergency management.

The last part of the proceedings includes two papers on simulations of adaptive MAS. Bonnet and Tessier in their paper entitled "An Incremental Adaptive Organization for a Satellite Constellation," present their results on a simulated satellite constellation where a collaboration method, based on an incremental coalition formation algorithm, is used for achieving the objectives of a coalition. The paper of Roesli and colleagues, entitled "Modelling Actor Evolution in Agent-Based Simulations," presents an extension to the i* agent- and goal-oriented formalism used in requirements engineering, for modelling the knowledge about how an actor may evolve—a mapping to the ConGolog simulation environment is provided.

Following the tradition of associated workshops, all regular papers were reviewed once for the workshop pre-proceedings; and revised, re-submitted, and re-reviewed, for inclusion in this final proceedings volume.

During AAMAS 2008 it became clear that the issues addressed by organized adaptation in MAS were prime issues of concern to the Coordination, Organizations, Institutions and Norms (COIN) community, and had, perhaps, been under-represented in this workshop series to date. The quality of the submitted papers, the strong representation at the OAMAS workshop, and the lively contributions to the discussions suggested that the embryonic community

aggregating around the subject of organized adaptation was sufficiently well-founded to sustain an independent scientific event. However, the organizers are strongly of the opinion that the AAMAS workshops should be used to cohere the agents community, not to fragment it, and enhance the quality of scientific research, not to dilute it.

The OAMAS workshop organizers were therefore happy to entertain a discussion with the COIN Steering Committee, and since this is a now well-established workshop series with a good scientific reputation, we accepted their invitation to fuse the two organizing bodies and highlight *organized adaptation* as a key theme for any future COIN call for papers.

This, then, is the Final Proceedings of the First International Workshop on Organized Adaptation in Multi-Agent Systems. It is also the Final Proceedings of the Last International Workshop on Organized Adaptation in Multi-Agent Systems. For the authors contributing to this volume, we hope for their continued participation in the subject of organized adaptation, and look forward keenly to their constructive interaction with and within the COIN community. These authors can also reflect on the fact that their collective contributions have had a scientific impact on an established institution (the COIN workshop) which changed its membership, charter, and rules to accommodate this body of work. We believe this is an example of organized adaptation.

November 2008

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