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Marie-Pierre Gleizes
Andrea Omicini
Franco Zambonelli (Eds.)

Engineering Societies in the Agents World V

5th International Workshop, ESAW 2004
Toulouse, France, October 2004
Revised Selected and Invited Papers

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Marie-Pierre Gleizes
Université Paul Sabatier
IRIT, Institut de Recherche en Informatique de Toulouse
118, Route de Narbonne, 31062 Toulouse Cédex, France
E-mail: Marie-Pierre.Gleizes@irit.fr

Andrea Omicini
Università di Bologna a Cesena
DEIS, Dipartimento di Elettronica, Informatica e Sistemistica
Via Venezia 52, 47023 Cesena, Italy
E-mail: andrea.omicini@unibo.it

Franco Zambonelli
Università di Modena e Reggio Emilia
DISMI, Dipartimento di Scienze e Metodi dell'Ingegneria
Via Allegri 13, 42100 Reggio Emilia, Italy
E-mail: franco.zambonelli@unimore.it

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Preface

The first workshop "Engineering Societies in the Agents World" (ESAW) was held in August 2000, in conjunction with the 14th European Conference on Artificial Intelligence (ECAI 2000) in Berlin. It was launched by a group of researchers who thought that the design and development of MASs (multi-agent systems) not only needed adequate theoretical foundations but also a call for new techniques, methodologies and infrastructures to develop MASs as artificial societies. The second ESAW was co-located with the European Agent Summer School (ACAI 2001) in Prague, and mostly focused on logics and languages, middleware, infrastructures and applications. In Madrid, the third ESAW concentrated on models and methodologies and took place with the "Cooperative Information Agents" workshop (CIA 2002). The fourth ESAW in London was the first one that ran as a stand-alone event: apart from the usual works on methodologies and models, it also stressed the issues of applications and multidisciplinary models. Based on the success of previous ESAWs, and also given that the difficult challenges in the construction of artificial societies are not yet fully addressed, the fifth ESAW workshop was organized in the same spirit as its predecessors.

In particular, ESAW 2004 took place at the IRIT laboratory of the Université "Paul Sabatier" (Toulouse, France), at the end of October 2004. It was not co-located with any other scientific event, in the same way as ESAW 2003. ESAW 2004 remained committed to the use of the notion of MASs as the seeds for animated, constructive and highly interdisciplinary discussions about technologies, methodologies and tools for the engineering of complex distributed systems. The widespread interest in these topics, as well as the effectiveness of ESAW as a well-established research forum, are witnessed by both the high number of submissions received (46 papers from 20 countries) and by the good participation (46 researchers from 14 countries).

This fifth workshop mainly focused on effective and methodical development of complex software systems in terms of multi-agent societies, as well as on novel approaches to software modelling and engineering to support the successful deployment of software systems made up of massive numbers of autonomous components. While designers should be enabled to control and predict the behavior of their systems, we should also allow emergent global system properties and discovered functionality to become commonplace in the theory and practice of MASs. It is very likely that such innovations will exploit lessons from a variety of different scientific disciplines, such as sociology, economics, organization science, modern thermodynamics, and biology. This is the main reason why the presentations in this workshop covered a number of these domains.

The following different themes were addressed during the three-day meeting:

- *Agent-Oriented Software Engineering.* The presentations of this session concerned methodologies, and discussed requirements analysis, specification, design and deployment phases.
- *Negotiation.* This session covered different mechanisms to enable agents to negotiate and to solve conflicts. The different mechanisms presented were based on biological metaphors, social welfare, and Activity Theory.
- *Large-Scale Multi-agent Systems.* The papers of this session focused on communication in large systems, semantics, and physical accessibility.
- *Roles.* Presentations in this session concentrated on the notion of role in a MAS: in particular, on the notion of role as used in the context of the argumentation process, and during conversation protocols.
- *Organizations.* This is one of the main topics in societies of agents, and was discussed in the context of a normative framework and of virtual knowledge communities.
- *Social Aspects.* This session drew a parallel between human and artificial societies by studying on the one hand the social power theory and on the other hand the role of sanctions in a society.
- *Simulation.* This session elaborated on the issues of simulation by using MASs, focusing on challenges such as the development process and the calibration of parameters in a simulation system.
- *Cooperation.* This session covered one of the most traditional topics in MAS research, that is, cooperation.

Two invited presentations tried to bridge between artificial and natural societies, such as human or animal societies. The first invited talk was given by Vincent Chevrier, who is an assistant professor at the Université Henri Poincaré of Nancy (France) and a researcher at LORIA in the MAIA team. He proposed methodological principles for the design of MASs drawing from the mechanisms observed in natural systems such as stigmergy or resource access.

Pablo Noriega expounded the other invited presentation concerning e-institutions. He is a senior researcher at Anáhuac University, Mexico City (Mexico), as well as a visiting researcher at the Institut d'Investigació en Intelligència Artificial (IIIA) in Barcelona (Spain). He elaborated on how interaction conventions for agents — human or software agents — can be used to engineer complex open systems by using commitments.

Furthermore, discussions during the meeting emphasized the need for tools to design large-scale systems and open systems. From the debate, two main acceptations of the term "openness" clearly emerged: a MAS is open either when agents can be dynamically added or removed, or when the MAS can take into account the perturbations coming from the MAS environment.

The original contributions, the slides of the presentations, as well as more information about the workshop are available online at the ESAW 2004 website (`http://www.irit.fr/ESAW04`). This postproceedings (ESAW 2004: LNAI 3451) continues the series published by Springer (ESAW 2000: LNAI 1972, ESAW 2001: LNAI 2203, ESAW 2002: LNAI 2577, and ESAW 2003: LNAI 3071).

This volume contains revised, reworked and extended versions of selected papers from ESAW 2004, and also includes the contribution of one of the two invited speakers.

The ESAW 2004 organization would have not been possible without the financial help of:

- Agentlink III
- ARTAL Technologies, Labège, France
- ILOG, Paris, France
- IRIT, Toulouse, France
- Université Paul Sabatier, Toulouse, France
- Whitestein, Switzerland

as well as the scientific support of the Alma Mater Studiorum, Università di Bologna in Cesena, the Università di Modena e Reggio Emilia, and all the members of the Program Committee. Our thanks also go to Alfred Hofmann and all of his Springer crew for their essential role during the realization of the postproceedings. We also want to thank the local organizers who created a studious and convivial ambiance during the workshop.

The next ESAW workshop will take place in Turkey supported by the Ege University of Izmir during the fall of 2005, with Oguz Dikenelli, Marie-Pierre Gleizes and Alessandro Ricci as the chairs and organizers. We expect that the next ESAW workshop will keep up its tradition of innovation and stimulating scientific debate, and also that more applications and demonstrations of running systems will further prove the feasibility and usefulness of the mechanisms and methods recommended by agent researchers.

February 2005

Marie-Pierre Gleizes
Andrea Omicini
Franco Zambonelli

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Organizations as Socially Constructed Agents in the Agent Oriented Paradigm

Guido Boella[1] and Leendert van der Torre[2]

[1] Dipartimento di Informatica - Università di Torino - Italy
[2] CWI - Amsterdam and TU Delft The Netherlands

Abstract. In this paper we propose a new role for the agent metaphor in the definition of the organizational structure of multiagent systems. The agent metaphor is extended to consider as agents also social entities like organizations, groups and normative systems, so that mental attitudes can be attributed to them - beliefs, desires and goals - and also an autonomous and proactive behavior. We show how the metaphor can be applied also to structure organizations in functional areas and roles, which are described as agents too. Thus, the agent metaphor can play a role similar to the object oriented metaphor which allows structuring objects in component objects. Finally, we discuss how the agent metaphor addresses the problems of control and communication in such structured organizations.

1 Introduction

The role of software engineering is to provide models and techniques that make it easier to handle the complexity arising from the large number of interactions in a software system [1]. Models and techniques allow expressing knowledge and to support the analysis and reasoning about a system to be developed. As the context and needs of software change, advances are needed to respond to changes. For example, today's systems and their environments are more varied and dynamic, and accommodate more local freedom and initiative [2].

For these reasons, agent orientation emerged as a new paradigm for designing and constructing software systems [1, 2]. The agent oriented approach advocates decomposing problems in terms of autonomous agents that can engage in flexible, high-level interactions. In particular, this is a natural representation for complex systems that are - as many real systems are - invariably distributed [1]. Compared to the still dominant software paradigm, namely object orientation, agent orientation offers a higher level of abstraction for thinking about the characteristics and behaviors of software systems. It can be seen as part of an ongoing trend towards greater interactivity in conceptions of programming and software system design and construction. Much like the concepts of activity and object that have played pivotal roles in earlier modelling paradigms - Yu [2] argues - the agent concept can be instrumental in bringing about a shift to a much richer, socially-oriented ontology that is needed to characterize and analyze today's systems and environments.

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The shift from the object oriented perspective to the agent oriented one is not, however, without losses. Booch [3] identifies three tools which allow coping with complexity: "1) Decomposition: the most basic technique for tackling any large problem is to divide it into smaller, more manageable chunks each of which can then be dealt with in relative isolation. 2) Abstraction: the process of defining a simplified model of the system that emphasises some of the details or properties. 3) Organisation: the process of identifying and managing interrelationships between various problem solving components."

In the agent oriented approach, however, decomposition, abstraction and organization are not yet addressed with the same efficacy as in the object oriented approach, where an object can be composed of other objects, which can be ignored in the analysis at a certain level of abstraction. The agent metaphor is sometimes proposed as a specialization of the object metaphor [4]: agents do not only have - like objects - a behavior which can be invoked by the other agents, but they also autonomously act and react to changes in the environment following their own goals and beliefs. In contrast, the component view of objects in the object metaphor could to be lost. The property of agents, i.e., sociality, closest to the property allowing the aggregation of objects to form more complex objects is not enough to overcome the gap. In particular, multiagent systems offer as aggregation methods the notion of group or of organization. According to Zambonelli *et al.* [5] "a multiagent system can be conceived in terms of an organized society of individuals in which each agent plays specific roles and interacts with other agents". At the same time, they claim that "an organization is more than simply a collection of roles (as most methodologies assume) [...] further organization-oriented abstractions need to be devised and placed in the context of a methodology [...] As soon as the complexity increases, modularity and encapsulation principles suggest dividing the system into different suborganizations". According to Jennings [1], however, most current approaches "possess insufficient mechanisms for dealing with organisational structure". Moreover, what is the semantic principle which allows decomposing organizations into suborganizations must be still made precise.

The research question of this paper, thus, is: how can the agent oriented paradigm be extended with a decomposition structure similar to the one proposed by the object oriented paradigm? How can a multiagent system be designed and constructed as an organization using this structure?

The methodology we use in this paper is a normative multiagent framework we proposed in [6, 7, 8, 9]. The basic idea of this framework is: agents attribute mental attitudes, like beliefs, desires and goals, to the other agents they interact with and also to social entities like groups, normative systems, and organizations. Thus these social entities can be described as agents too, and at the same time, the components of organizations, namely, functional areas and roles, can be described as agents, as in the ontology we present in [7]. We call them *socially constructed agents.*

This paper is organized as follows. In Section 2 we discuss the progress from object orientation to agents and socially constructed agents. In Section 3 we present the formal model and in Section 4 we discuss the issue of control and communication in an multiagent system structured as an organization. A summary closes the paper.

2 From Objects to Socially Constructed Agents

The trend in software and requirements engineering and in programming languages paradigms has been from elements that represent abstract computations towards elements that represent the real world: from procedural to structured programming, from objects to agents. Agent systems have no central control authority, instead each agent is an independent locus of control, and the agent's task drives the control. Delegating control to autonomous components can be considered as an additional dimension of modularity and encapsulation. Intentional concepts such as goals, beliefs, abilities, commitments, *etc.*, provide a higher-level characterization of behavior. One can characterize an agent in terms of its intentional properties without having to know its specific actions in terms of processes and steps. Explicit representation of goals allows motivations and rationales to be expressed. The agent concept provides a local scope, for reconciling and making tradeoffs among competing intentionality, such as conflicting goals and inconsistent beliefs. By adopting intentional modelling, the networks of dependencies among the agents can be modelled and reasoned about at a high level of abstraction. Moreover, cooperation among agents cannot be taken for granted. Because agents are autonomous, the likelihood of successful cooperation is contingent upon many factors. However, an agent that exists within a social network of expectations and obligations has behaviors that are confined by them. The agent can still violate them, but will suffer the consequences. The behavior of a socially situated agent is therefore largely predictable, although not in a precise way.

Given that agents are nowadays conceived as useful abstractions for modelling and engineering large complex systems, the need for a disciplined organizational principle for agent systems emerges clearly in the same way as the formalizatoin of the object decomposition principle does in the case of object oriented systems.

One of the main features of the object perspective is that objects are composed by other objects and that objects can be replaced by other objects with the same properties (e.g., the same interface). This is not entirely true for agents. According to Jennings [1], "the agent oriented approach advocates decomposing problems in terms of autonomous agents", but no further decomposition seems possible. To overcome this flatness limitation, the organization metaphor has been proposed, e.g., by [10, 5]. Organizations are modelled as collections of agents, gathered in groups [10], playing roles [1, 11] or regulated by organizational rules [5]. What is lacking is a notion of organization as a first class abstraction which allows decomposing into subproblems the problem which a system wants to solve, using a recursive mechanism (as the object decomposition is) until autonomous agents composing a multiagent system are reached.