Pablo Noriega Javier Vázquez-Salceda
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Eric Matson (Eds.)

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Coordination, Organizations, Institutions, and Norms in Agent Systems II

AAMAS 2006 and ECAI 2006 International Workshops, COIN 2006
Hakodate, Japan, May 2006
Riva del Garda, Italy, August 2006, Revised Selected Papers

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Preface

In recent years, social and organizational aspects of agency have become major research topics in MAS. Recent applications of MAS on Web services, grid computing and ubiquitous computing highlight the need for using these aspects in order to ensure social order within such environments. Openness, heterogeneity, and scalability of MAS, in turn, pose new demands on traditional MAS interaction models and bring forward the need to look into the environment where agents interact and at different ways of constraining or regulating interactions. Consequently, the view of coordination and governance has been expanding to entertain not only an agent-centric perspective but societal and organization-centric views as well.

The overall problem of analyzing the social, legal, economic, and technological dimensions of agent organizations, and the co-evolution of agent interactions, provide theoretically demanding and interdisciplinary research questions at different levels of abstraction. The MAS research community has addressed these issues from different perspectives that have gradually become more cohesive around the four notions in the title to the workshop: coordination, organization, institutions, and norms. The COIN workshops are thus designed to consolidate the subject by providing focus events that reach researchers from diverse communities working in related topics and facilitate more systematic discussion of themes that have been treated from various perspectives.

This year, the COIN workshops were hosted during AAMAS 2006, (on June 9, in Hakodate, Japan) and ECAI 2006 (on August 28, in Riva del Garda, Italy). The papers contained in this volume are the revised versions of a selection of those that were presented in these workshops.

We want to express our gratitude to the Program Committee members, the additional reviewers, the participants of workshops, and most particularly to the authors for their respective contributions. We also want to thank the organizers of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems in Hakodate and of the 17th European Conference in Artificial Intelligence in Riva del Garda, for hosting and supporting the organization of the workshops, Finally, we would also like to acknowledge the encouragement and support from Springer, in the person of Alfred Hofmann, for the publication of this second volume of COIN workshops.

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Table of Contents

Part I
MODELLING AND ANALYZING ORGANIZATIONS

Structural Aspects of the Evaluation of Agent Organizations

Davide Grossi[1], Frank Dignum[1], Virginia Dignum[1], Mehdi Dastani[1], and Làmber Royakkers[2]

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Abstract. A multi-agent system can be analyzed and specified as an organization consisting of roles and their relations. The performance of an organization depends on many factors among which the type of its organizational structure, i.e., the set of relations holding between its roles. This work focuses on the structure of organizations and addresses the issue of the analysis, evaluation, and comparison of organizational structures which can contribute to develop general methods for the assessment of multi-agent systems' performance. Specifically, quantitative concepts from graph theory are used to provide numerical analyses of organizational structures. It is argued that these analyzes can be used for evaluating to what extent an organizational structure exhibits some characteristic properties such as robustness, flexibility and efficiency.

1 Introduction

A great deal of ongoing research in the field of organization-based multi-agent systems (MAS) is devoted to comparing and evaluating different types of organizations and their performance. Work on these issues varies from surveys comparing organizational paradigms [6], to frameworks for representing and verifying organizational designs [7,19], to studies concerning properties and performance of specific types of organizations [13,17].

The present paper aims at contributing to the establishment of a number of techniques for evaluating MAS organizations and their performance. The notion of organization plays an important role in multi-agent systems, which is also reflected in many agent-oriented software methodologies (cf. GAIA, TROPOS). The performance of different organizations depends on organizations' characteristics such as robustness, flexibility, and efficiency. For example, hierarchies are known not to perform well in rapidly changing environments because of their poor flexibility. The paper is based on the intuition that a connection can be drawn between some of these characteristics and graph-theoretical properties of the structure of organizations. For example, flexibility depends on how strongly the roles in the organization are connected with one another. The notion of flexibility, though complex and multi-faceted, can definitely be correlated

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with structural aspects of the organization. Intuitively, the more are the connections between the roles in the organization, the more flexible is the organization. The point is to relate the notion of flexibility to precise properties of the organizational structure. Given an organization, can we say it is flexible? And how flexible? Is it more flexible than another one as far as structure is concerned? How can a designer foster flexibility in a MAS just working on its structure? These types of questions constitute, in a nutshell, the target of the present work.

We claim that an investigation of this connection is important for the development of appropriate methods for comparing and evaluating different types of organizations and their performances. In order to tackle the evaluation problem, "the space of organizational options must be mapped, and their relative benefits and costs understood" [6], and to provide such a "map" a rigorous analysis of organizational structure plays a crucial role. The perspective chosen consists thus in addressing the evaluation issue from a structural perspective, that is to say, analyzing the organizational structure of MAS and providing a way to rigorously describe the pros and cons of them which lie in their structures.

We will proceed as follows. Firstly (Section 3), building on the results presented in [3] (briefly recapitulated in Section 2) we investigate a number of simple equations which can provide ways of measuring to what extent a given organizational structure enjoys some specific graph-theoretical properties. For instance, to what degree is the structure connected? These measures already provide a way to evaluate, in an exact fashion, the adherence of organizational structures to structural constraints a designer might take into consideration. Secondly (Section 4), the proposed measures are linked to commonly used criteria for the classification and evaluation of organizations. The criteria on which we focus are robustness, flexibility and efficiency. We show then (Section 5) how these criteria can conflict with each other, and how to ground a structural analysis of these conflicts as well. Conclusions follow in Section 6.

2 Organizational Structure

2.1 Some Terminology

Before getting started it is worth recollecting some standard graph theoretical notions which will be used in the proceeding of the paper. An R_k-path (of length n) is a sequence $\langle x_1, ..., x_{n+1} \rangle$ of distinct elements of $Roles$ s.t. $\forall x_i \ 1 \leq i \leq n$, $(x_i, x_{i+1}) \in R_k$. A R_k-semipath (of length n) is a sequence $\langle x_1, ..., x_{n+1} \rangle$ of distinct elements of $Roles$ s.t. $\forall x_i \ 1 \leq i \leq n$, $(x_i, x_{i+1}) \in R_k$ or $(x_{i+1}, x_i) \in R_k$. A *source* in $Roles$ is an element s s.t. $\forall d \in Roles$ with $d \neq s$ there exists a R_k-path from s to d. The *indegree* $id_k(d)$ of a point d in structure k is the number of elements d_1 s.t. $(d_1, d) \in R_k$. The *outdegree* $od_k(d)$ of a point d in structure k is the number of elements d_1 s.t. $(d, d_1) \in R_k$. We say a point d to be incident w.r.t. a k link if $id_k(d) \leq 1$, and it is said to have emanating k links if $od_k(d) \leq 1$.

2.2 Representing Organizational Structures

In [3] a view on organizational structure has been proposed, inspired by foundational work on the theory of organizations [11,15], which is based on the claim that

organizations do not exhibit only one structural dimension, but rather a multiplicity of interrelated dimensions, the dimensions of *power*, *coordination* and *control*. A natural way of modeling this notion of organizational structure is via directed graphs, which we represent here as systems of relations.

Definition 1. (Organizational structure)
An organizational structure OS is a tuple:

$$\langle Roles, R_{Pow}, R_{Coord}, R_{Contr} \rangle$$

where $Roles$ is the finite set of roles, and $R_{Pow}, R_{Coord}, R_{Contr}$ are three irreflexive binary relations on $Roles$ characterizing the Power, respectively, the Coordination and the Control structures.

For every R_k s.t. $k \in \{Pow, Coord, Contr\}$, we denote with $Roles_k$ the smallest subset of $Roles$ such that, if $(x, y) \in R_k$ then $x, y \in Roles_k$. In other words, sets $Roles_k$ denote the set of roles involved in the structural dimension k. Each digraph $\langle Roles_k, R_k \rangle$ in OS will be also referred to as the *structural dimension* k of OS.

Some observations are in order. First, it is worth noticing that in [3] the enactment relations between agents and roles are also included under the notion of organizational structure . In that work, it was necessary to include agents in the explicit representation of the structure in order to give an account of the effects that structural links bear on agents' performance. That study proposes also a formal analysis of the meaning of structural links in terms of the effects that they have on the activities of the agents playing roles in the organization. To briefly recapitulate it, the *power structure* defines the task delegation patterns possible within the organization. The *coordination structure* concerns the flow of knowledge within the organization, and the *control structure* has finally to do with the task recovery functions of the organization. In other words, the existence of a power link between role a and role b implies that every delegation of tasks from agent a (agent enacting role a) to agent b (agent enacting role b) ends up in the creation of an obligation directed to agent b. If a and b are connected via a coordination link, then every information act from a to b ends up in creating the corresponding knowledge in agent b. Finally, a control link between a and b implies that agent a has to monitor the activities of agent b, possibly taking over the tasks of agent b which have not been accomplished. In the present work however, such concern about the "semantics" of the structural links is left aside, and the main focus is settled only on the structural configurations linking the roles of the organization. This emphasizes also the generality of the method proposed here. In fact, the technical results that are going to be presented in Section 3 abstract from the meaning attached to the links, and can thus be applied to any kind of organizational structure representable in the fashion of Definition 1.

Second, we consider the roles on which the organizational structure ranges (i.e., the elements of set $Roles$) to be enacted by one and only one agent. The reason for this choice is illustrated by the following example. Suppose we need to model an organization for a soccer team implementing a 4-3-3 strategy. in such a way that the organizational structure inherent in the strategy is made explicit. Three roles can be defined in every team: 'attacker', 'defender' and 'midfielder', which are connected by appropriate power, control and coordination relations. An option would be to model the organization via imposing complex enactment constraints such as: "the role 'attacker' should be