

Preface

The main topic of this book is agent organization. Organizations in Multi-Agent Systems (MAS) can be understood as complex entities where a multitude of agents interact, within a structured environment aiming at some global purpose. Agent organizations are often associated with the idea of openness and heterogeneity in MAS. Open and heterogeneous environments pose new demands on MAS design and implementation including the integration of global and individual perspectives and the dynamic adaptation of systems to environmental changes. As systems grow to include hundreds or thousands of agents, there is a need to move from an agent-centric view of coordination and control to an organization-centric one to cope with the complexity of interaction in an environment. The view of coordination and control central to MAS needs to be expanded to enable a societal-centric focus. MAS design languages provide structures for developing organizational models, but can also enable the analysis of how natural organizations may be augmented or enhanced. That is, the tools needed for modeling, simulating agent organizations will provide new insights into organization theory.

The term agent organization, of multi-agent organization, has become common-place within the Multi-Agent Systems (MAS) community, but is used to mean different, often incompatible, issues. On the one side, organization is taken as the process of organizing a set of individuals, whereas the other side sees organization as an entity in itself, with its own requirements and objectives. As it is often the case in such situations, this leads to a fragile sense of understanding causing interpretation and integration problems when trying to compare, merge, or analyze different models and frameworks. Practical applications of agent organizations and of agent principles for organizational modeling are being widely developed; however, formal theories are needed to describe interaction and organizational structure. Furthermore, it is necessary to understand the relation between organizational roles and the agents that fulfill them. Without attempting to merge different views into one general whole, this book presents a comprehensive overview of the different perspectives, such that the reader will be able to better understand and judge the differences.

The intent of this book is simple – to provide an overview of current work in agent organizations, from several perspectives, and focus on different aspects of the organizational spectrum. It is the hope that the work presented here will provoke additional thought, research attention and concern, for the concept of organization in and for multi-agent systems.

The book is divided in 6 sections, each focusing on a different aspect of multi-agent organizations. The first section “*Methodologies and Frameworks for Agent Organizations*” sets the tone of the book by presenting state-of-the-art developments on integrated models for MAS where the notion of organization is central.

Chapter I, “*The Role of Organization in Agent Systems*” provides an introduction to the volume, focusing on the use of organization concepts in MAS and discusses the differences between organizing MAS and MAS for organizations.

Chapter II, “*Modelling Dimensions for Agent Organizations*” by Coutinho, Sichman, and Boissier, discusses how to classify diverse aspects, or modelling dimensions, of agent organizations currently captured by different organizational models. Four basic dimensions are proposed: the structural dimension, mainly composed of roles and groups; the interactive dimension, characterized by dialogical interaction structures; the functional dimension, formed by goal/task decomposition; and, the normative dimension, defining norms, rights, rules, and so forth. Apart from the basic dimensions, four complementary dimensions are discussed: environment, evaluation, evolution, and ontology. These are related to the aspects of situatedness, measurement, adaptation, and domain specific semantics of agent organizations.

Chapter III, “*Towards an Integral Approach of Organizations in Multi-Agent Systems*” by Ferber, Stratulat, and Tranier, posit that a genuine organizational approach has to take into account both the environment and the institutional part of MAS societies. As in Chapter I, they also stress the importance of integrating different dimensions (agents, environment, interactions, organizations, and institutions) into an integral vision. A meta-model, MASQ (Multi-Agent System based on Quadrants), is proposed and constitutes an abstraction of the various aspects of an organization centred MAS, extending the well known AGR (Agent/Group/Role) model.

Chapter IV, “*OMACS: A Framework for Adaptive, Complex Systems*”, DeLoach introduces a suite of technologies for building complex, adaptive systems that includes a set of methodologies, techniques, and architectures that allow it to be implemented effectively on a wide variety of systems. It uses the organization model for adaptive computational systems (OMACS) to define the knowledge needed about a system’s structure and capabilities to allow it to reorganize at runtime in the face of a changing environment and its agent’s capabilities.

Another concrete example of an organization-oriented methodology for MAS is given in **Chapter V**, “*Hermes: Designing Flexible and Robust Agent Interactions*” by Cheong and Winikoff. Hermes is a goal-oriented design methodology for agent interactions which is aimed at being pragmatic for practicing software engineers. Hermes focuses on interaction goals, such as goals of the interaction which the agents are attempting to achieve, and results in interactions that are more flexible and robust than message-centric approaches.

Section II is about formalisms for agent organizations. In **Chapter VI**, “*A Formal Framework for Organization Modeling and Analysis*” by Popova and Sharpankykh is a formal framework for modeling and analyzing organizations is proposed and allows representing and reasoning about all important aspects of artificial and human organizations structured in a number of views, including performance-oriented, process-oriented, power- and interaction-related aspects.

Chapter VII, “*Describing Agent Societies: A Declarative Semantics*” by Tsvetovat, proposes a declarative language designed specifically for describing in an expressive way a variety of social interactions.

Chapter VIII, “*Structural Aspects of Organizations*” by Grossi and F. Dignum, investigates how organizations can be represented as graphs endowed with formal semantics. They distinguish different dimensions of organizations leading to different graph structures. By giving the graphs a formal semantics using Description Logic, the chapter shows that it is possible to formalize the effect of the organization on the activities of the agents playing the roles of the organization.

Chapter IX, “*A Logic for Agent Organizations*” by Virginia and Frank Dignum, posits that in order to develop a theory on the relation between organizational structures, organizational actions, and actions of agents performing roles in the organization, a theoretical framework to describe and reason about organizations is needed. The Language for Agent Organization (LAO) proposed in this chapter is sufficiently generic to enable the comparison of different existing organizational approaches to Multi-Agent Systems (MAS), while having enough descriptive power to describe realistic organizations.

In **Section III** the individual agent and their interactions in organizations are central. In **Chapter X**, “*Grounding Organizations in the Minds of the Agents*”, by Castelfranchi, presents organizations as a macro-micro notion and device. Organizations presuppose autonomous proactive entities (agents) playing the organizational roles. However, agents may have their own powers, goals, and relationships (of dependence, trust, etc.), which opens up important issues to be discussed. In order to model human organizations, and designing effective artificial organizations, models that exhibit a high degree of flexibility, exploiting autonomy and pro-activity, intelligence, and decentralized knowledge of role-players are needed; allowing for functional violations of requests and even of rules.

Chapter XI, “*Modelling Interactions via Commitments and Expectations*” by Torroni, Yolum, Singh, Alberti, Chesani, Gavaneli, Lamma, and Mello, presents and discusses two declarative, social semantic approaches for modeling interaction. The first one takes a state-oriented perspective, and models interaction in terms of commitments. The second one adopts a rule-oriented perspective, and models interaction in terms of logical formulae, expressing expectations about agent interaction.

Chapter XII, “*Communications for Agent-Based Human Team Support*”, by Sukthankar, Sycara, Giampapa, and Burnett, discusses the problem of agent aiding of ad-hoc, decentralized human teams so as to improve team performance on time-stressed group tasks. To see how human teams rise to the challenge, communication patterns of teams performing a collaborative search task are analyzed using empirical experiments.

The focus of **Chapter XIII**, “*Autonomous Agents Adopting Organizational Rules*”, by Van der Vecht, F. Dignum, and Meyer is agent autonomy. In particular, it discusses the adoption of organizational rules into the reasoning process of autonomous agents. It proposes a modular reasoning model that explicitly includes organizational rules and shows that this stimulates bottom-up dynamics in organization models.

Section IV presents the institutional view on organizations in which they are taken as highly regulated environments governed by norms. In **Chapter XIV**, “*Specifying Artificial Institutions in the Event Calculus*”, by Fornara and Colombetti, communication in open interaction systems is central. An approach to the standardization of communication is formally defined in the Event Calculus, which consists in modeling open interaction systems as a set of artificial institutions.

Chapter XV, “*Verifying Organizations Regulated by Institutions*”, by Viganò and Colombetti, proposes institutions to explicitly represent norms in open multi-agent systems, where agents may not follow them and which therefore require mechanisms to detect violations. A framework to verify organizations regulated by institutions is presented, which is characterized by a precise formalization of institutional concepts, a language to describe institutions, and a tool to model-check them.

In **Chapter XVI**, “*A Programming Language for Normative Multi-Agent Systems*”, by Dastani, Tinnemeier, and Meyer, views MAS as consisting of individual agents whose behaviors are regulated by an organizational artifact. The chapter presents a programming language that aims at facilitating the implementation of norm-based organizational artifacts for MAS.

Section V introduces several approaches to organizational dynamics and adaptation. In **Chapter XVII**, “*A Minimal Dynamical MAS Organization Model*”, by Rocha Costa and Pereira Dimuro, the Population-Organization model is presented as formal tool for studying the organization of open multi-agent systems and its functional and structural dynamics. The model is minimal in two senses: it comprises a minimal set of extensional concepts capable of adequately accounting for the notion of dynamic organization; and, it is a core organization model upon which a certain kind of dynamical rules can be defined to account for the action of intensional organizational elements like prestige, power, morality, and so forth.

Chapter XVIII, “*A Framework for Dynamic Agent Organizations*”, by Fatima and Wooldridge, presents an adaptive organizational policy for multi-agent systems called TRACE. TRACE allows a

collection of multi-agent organizations to dynamically allocate tasks and resources between themselves in order to efficiently process an incoming stream of tasks.

Chapter XIX, “*Dynamic Specifications for Norm-Governed Systems*”, by Artikis, Kaponis, and Pitt, a framework for executable specification of norm-governed multi-agent systems, is extended to allow for “dynamic specifications”, that is, specifications that may be modified at run-time by the members of a system. The framework extension is motivated by Brewka’s “dynamic argument systems”—an argument systems in which the rules of order may become the topic of the debate.

Chapter XX, “*Interactions Between Formal and Informal Organizational Networks*”, by Lamieri and Mangalagiu, presents a model of organization aimed to understand the effect of formal and informal structures on the organization’s performance. The model considers the interplay between the formal hierarchical structure and the social network connecting informally the agents emerging while the organization performs a task-set.

Finally, in **Section VI**, practical applications of MAS organizations are presented. **Chapter XXI**, “*Personal Assistants for Human Organizations*” by Okamoto, Sycara, and Scerri, focus on intelligent software personal assistants. The chapter describes the development of a computational model of organization to evaluate the impact that different proposed assistant abilities have on the behavior and performance of the organization. By varying the organizational structures under consideration, is possible to identify which abilities are most beneficial, as well as explore how organizations may adapt to best leverage the new technology.

Chapter XXII, “*Organizational Self-Design in Worth-Oriented Domains*”, by Kamboj and Decker, presents an approach to Organizational-Self Design (OSD), a method of designing organizations at run-time in which the agents are responsible for generating their own organizational structures. OSD is applied to worth-oriented domains – that is, domains in which problems are represented using TÆMS-based task structures.

Chapter XXIII, the final chapter, “*A Formal Petri Net-Based Model for Team Monitoring*” by Bonnet-Torrès, and Tessier, focuses on a Petri Net-based model for team organization and monitoring. The applications considered are missions performed by several robots that cooperate in different ways according to the goals to be achieved. The model allows several failure propagation ways within the team to be highlighted and local plan repair to be considered.

We have attempted to provide a comprehensive view of current developments in agent organizations as a paradigm for both the modeling of human organizations, and for designing effective artificial organizations. This book is intended to inspire and stimulate further research in the topic.

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