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Series Editors
Professor Lakhmi Jain
Lakhmi.jain@unisa.edu.au

Professor Xindong Wu
xwu@cs.uvm.edu

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Maria Chli • Philippe de Wilde

Convergence and Knowledge Processing in Multi-Agent Systems

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Maria Chli
Aston University
Birmingham
United Kingdom B4 7ET

Philippe de Wilde
Heriot Watt University
Edinburgh
United Kingdom EH14 4AS

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Preface

Agent systems are being used to model complex systems like societies, markets and biological systems. Our broader interest lies in understanding the dynamics as well as in analysing the properties which emerge from the interactions that occur in such systems. More specifically, in this work we investigate issues of agent systems related to convergence and interactivity. We have been using techniques from agent-based modelling to simulate complex systems. The work described in this book makes four main contributions to the fields of convergence and knowledge processing in agent systems.

First, we propose a definition for the stability of multi-agent systems. The system is perceived as a discrete time Markov chain with a potentially unknown transition probability distribution. It is considered to be stable when its state has converged to an equilibrium distribution. The definition proposed is the only one which takes into account the game nature of multi-agent systems, is relevant to systems with a varying number of agents and is supported by the mathematical framework of stochastic systems. Several artificial ecosystems have been implemented and used to verify the proposed definition and carry out an analysis of the stability of multi-agent systems.

Second, we investigate knowledge exchange among agents in a market scenario. The forces that drive it are identified as well as its effects on the overall behaviour, and especially the convergence of the system. Knowledge exchange is known to be beneficial for industry, but in order to explain it, authors have used high-level concepts like network effects, reputation and trust. Even though the model we present does not include any such concepts, information exchange naturally emerges as a successful, profitable behaviour. This behaviour is shown to increase the efficiency of the market.

Third, we show how information provided through interaction of users in a scenario can be used to optimise the queries submitted. The proposed algorithm is based on the observation that documents are often found to contain terms with high information content which can summarise their subject matter. Experiments carried out demonstrate that our approach significantly shortens the web search sessions as well as the number of documents viewed.

Fourth, we describe a pricing strategy for a realistic large-scale distributed system. This system consists of automatic personal assistants (PAs) that can book time slots in each other's diaries, and that have to pay for doing so. Stability of strategies is first studied in an evolutionary context early in this book. We call the strategy stable if it prevents deadlock in the network, when none of the PAs buys or sells resources anymore. A stable strategy is robust if substantial noise on the parameters and the initial conditions maintains stability.

Empirical results validate all four contributions within a number of domains. The generality of the contributions is verified by applying them to simulations of complex market, social and biological systems. Ultimately, this book sheds light upon the complex interrelation between interactivity/exchange of knowledge and convergence in multi-agent systems.

We would like to thank all our collaborators in the EEII (Appendix A) and DBE (Section 4.2) projects for the inspiration and the useful discussions. The second author would like to thank Drs. Nader Azarmi, Ben Azvine, and Lyndon Lee at British Telecom (BT) for a collaboration that spanned several years, and for suggesting many inspiring problems. Their promotion of multi-agent systems and the need for analysis of such systems has been forward-looking.

Birmingham and Edinburgh, UK, *Maria Chli*
March 2009 *Philippe De Wilde*

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Acronyms

ACE	Agent-based computational economics
DBE	Digital business ecosystem; more details are available in Section 4.2.
DoF	Degrees of freedom
EEII	Evolution and ecology of interacting infohabitants; more details are available in Appendix A.
GA	Genetic algorithm
GPS	Global positioning system
MAS	Multi-agent system
PA	Personal assistant
R&D	Research and development
SME	Small and medium enterprises