Marina V. Sokolova and Antonio Fernández-Caballero

Decision Making in Complex Systems

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Decision Making in Complex Systems, 2012
ISBN 978-3-642-25543-4

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Decision Making in Complex Systems

The DeciMaS Agent-Based Interdisciplinary Framework Approach

Springer

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ISBN 978-3-642-25543-4 e-ISBN 978-3-642-25544-1

DOI 10.1007/978-3-642-25544-1

Intelligent Systems Reference Library ISSN 1868-4394

Library of Congress Control Number: 2011942877

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Typeset by Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

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This book is dedicated to our families and friends, supporting us all around the world.

Preface

From the definition that "a system is a set of elements which interact with each other and the environment", one can note how the number of elements of a system and the number and nature of interactions that occur therein provide the information needed to estimate the degree of difficulty involved to accurately describe it. Clearly, when a system consists of numerous elements, knowledge of the relationships between them is crucial. The mere identification of these elements is not enough to understand its operation, and could lead to form a misconception or insufficient idea of the system as a whole.

Therefore, the study of complex systems attracts the attention of many researchers in all fields. Decision making for complex systems has traditionally been a complicated task that can be complied using an interdisciplinary approach. It has numerous outcomes and can be applied to manifold domains. Complex systems models highlight the dynamics of change. These complex systems are characterized by a high number of component entities and a high degree of interactions. One of the most important features is that it does not involve a central organizing authority, but the various elements that make up the system are self-organized. Some complex systems possess an emergency priority: climate change and sustainable development research, studies of public health, ecosystem habitats, epidemiology, and medicine, among others.

A great number of overlapping approaches that exist nowadays fail to meet the needs of decision makers when managing complex domains. The design of complex systems often requires the integration of a number of artificial intelligence tools and techniques. The problem can be viewed in terms of goals, states, and actions, choosing the best action to move the system toward its desired state or behavior. Agent-based approaches are increasingly being used to model complex systems as they have the advantage of being easy to describe and appear more realistic.

The main objective of this book is to bring together existing methods for decision support systems creation within a coherent framework and to provide an interdisciplinary and flexible methodology for modeling complex and systemic domains and policies. It is obvious that it is impossible to create an overall tool that would play the role of a magic wand to study any complex adaptive problem. But what can be

done, and what is absolutely necessary, is a framework for decision support systems design.

This book consists of six chapters. Chapter 1 is dedicated to making a brief introduction into complex system analysis with a particular emphasis on the problem of decision making for such systems. The chapter provides a review on challenges and approaches of modern decision support systems and shows that it is necessary to work out a new agent-based framework for decision support system creation for the case of complex domains. Next, the chapter gives a general overview of the problem at hand, the motivation and some highlights for this study.

Chapter 2 is devoted to related research and introduces an overview of current state-of-the-art in areas of complex system analysis and decision making by means of intelligent tools, including those that are agent-based. It also compares existing agent-oriented methodologies and frameworks for decision support. Furthermore, the chapter makes conclusions about the necessity of a general framework, which would combine characteristics of the former and the latter.

Chapter 3 is a description of the proposed DeciMaS framework. The chapter introduces components of the DeciMaS framework and the way in which they are organized. Design and implementation of the system are discussed as well. The chapter demonstrates how information is transformed into knowledge and illustrates the transformations made throughout each stage of the DeciMaS framework. Furthermore, the information about data mining methods, that are used in the DeciMaS framework, are introduced and depicted in detail.

Chapter 4 provides a case study of an agent-based decision support system developed in an effort to demonstrate the practical aspects of developing systems using the DeciMaS framework. This chapter presents an example of using the DeciMaS framework with the aim of developing a decision support system for environmental impact assessment upon human health. Meta-ontology of the domain of interest, the system itself and its mapping are presented in the chapter. In addition, a multi-agent architecture for a decision support system is shown. The sequence of the steps for the DeciMaS framework design with Prometheus Development Kit and its implementation with Jack Development Environment are presented as well.

Chapter 5 is dedicated to the discussion of the results obtained from the experiment for the case of environmental impact for some selected regions. Data and experiment results of data modeling, simulation, sensitivity analysis, impact assessment and decision generation are discussed.

Chapter 6 contains the conclusions of the proposed work and provides a list of activities for the near future.

Albacete, Spain, *Marina V. Sokolova*
September 2011 *Antonio Fernández-Caballero*

Acknowledgements

Completing a book is truly a marathon event, and we would not have been able to complete this journey without the help and support of countless people over the past four years. Al these anonymous supporters know of our everlasting gratitude.

Marina is especially grateful to all her friends and colleagues from the Kursk State Technical University for their assistance with all kind of help and for their faith in her. During years 2006 to 2008 she enjoyed the aid of a MAEC Scholarship from the Spanish Ministry of Foreign Affairs, which supported her while she started her PhD in the Advanced Informatics Program of the University of Castilla-La Mancha, Albacete, Spain.

We are very grateful to all our friends and colleagues from the Department of Computing Systems at University of Castilla-La Mancha and colleagues from the Albacete Research Institute of Informatics. Let us also say "thank you" to the members of the n&aIS (natural and artificial Interactions Systems) research laboratory for helping us at every time.

Finally, we are forever indebted to our families for their understanding, endless patience and encouragement when it was most required.

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Acronyms

AA	ANN agent
ACL	Agent Communication Language
ADSS	Agent-based decision support system
ANN	Artificial neural network
AOR	Agent-Object-Relationship
AOS	Agent-oriented software
AOSD	Agent-oriented software development
AUML	Agent-based Unified Modeling Language
BOD	Biochemical oxygen demand
BP	Backpropagation
COD	Chemical oxygen demand
CS	Complex system
DM	Data mining
DOA	Domain Ontology agent
BDI	Belief-desire-intention
CM	Committee machine
CMA	Committee Machine agent
CORMAS	COmmon pool Resources and Multi-Agents Systems
CSV	Comma-separated values
DA	Decomposition agent
DBMS	Database management system
DeciMaS	Decision Making in Complex Systems
DGMS	Dialog generation and management system
DPA	Data Preprocessing agent
DSA	Data Smoothing agent
DSS	Decision support system
EA	Evaluation agent
EIA	Environmental impact assessment
EIS	Environmental information system
ES	Expert system
FIPA	Foundation for Intelligent Physical Agents

GA Genetic algorithm
GAA Gaps and Artifacts Check agent
GMDH Group Method of Data Handling
GMDHA Group Method of Data Handling agent
GOPRR Graph-Object-Property-Role-Relationship
ICD International Statistical Classification of Diseases and Related Health Problems
ICIDH International Classification of Functioning and Disability
IDSS Intelligent decision support system
IDK INGENIAS Development Kit
IQR Interquartile range
ISA Integrated sustainability assessment
JADE Java Agent DEvelopment framework
JVM Java Virtual Machine
LCA Life cycle assessment
LGPL Lesser General Public License
MAS Multi-agent system
MASDK Multi-agent System Development Kit
MBMS Model-based management system
MiFA Mining Data Fusion agent
MoFA Morbidity Data Fusion agent
NA Normalization agent
OMT Object Modeling Technique
OO Object-oriented
PFA Petroleum Data Fusion agent
PDT Prometheus Design Tool
RA Regression agent
RPROP Resilient propagation
RUP Rational Unified Process
TFA Traffic Pollution Fusion agent
UML Unified Modeling Language
WDFA Waste Data Fusion agent
WFA Water Data Fusion agent
WWTP Waste water treatment plant
XML Extensible Markup Language
XSLT XSL Transformations