

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Friedemann Mattern

ETH Zurich, Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

University of Dortmund, Germany

Madhu Sudan

Massachusetts Institute of Technology, MA, USA

Demetri Terzopoulos

New York University, NY, USA

Doug Tygar

University of California, Berkeley, CA, USA

Moshe Y. Vardi

Rice University, Houston, TX, USA

Gerhard Weikum

Max-Planck Institute of Computer Science, Saarbruecken, Germany

Ozalp Babaoglu Márk Jelasity
Alberto Montresor Christof Fetzer
Stefano Leonardi Aad van Moorsel
Maarten van Steen (Eds.)

Self-star Properties in Complex Information Systems

Conceptual and Practical Foundations



Springer

Volume Editors

Ozalp Babaoglu
Márk Jelasity
Alberto Montresor
Università di Bologna
Dipartimento di Scienze dell'Informazione
40126 Bologna, Italy
E-mail: {babaoglu,jelasity,montresor}@cs.unibo.it

Christof Fetzer
Technische Universität Dresden
Fakultät Informatik
01062 Dresden, Germany
E-mail: christof.fetzer@inf.tu-dresden.de

Stefano Leonardi
Università di Roma "La Sapienza"
Dipartimento di Informatica e Sistemistica
00198 Rome, Italy
E-mail: leon@dis.uniroma1.it

Aad van Moorsel
University of Newcastle upon Tyne
School of Computing
Newcastle upon Tyne, NE1 7RU, UK
E-mail: aad.vanmoorsel@newcastle.ac.uk

Maarten van Steen
Vrije Universiteit Amsterdam
Department of Computer Science
1081 HV, Amsterdam, The Netherlands
E-mail: steen@cs.vu.nl

Library of Congress Control Number: 2005925758

CR Subject Classification (1998): C.2.4, C.2, D.2, F.1, F.2, I.2.11, H.4

ISSN	0302-9743
ISBN-10	3-540-26009-9 Springer Berlin Heidelberg New York
ISBN-13	978-3-540-26009-7 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

Springer is a part of Springer Science+Business Media
springeronline.com

© Springer-Verlag Berlin Heidelberg 2005
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11428589 06/3142 5 4 3 2 1 0

Preface

Information systems can be complex due to numerous factors including scale, decentralization, heterogeneity, mobility, dynamism, bugs and failures. Deploying, operating and maintaining such systems can be not only very difficult, but also very costly. A flurry of recent activity has been directed at this problem, and future information systems are envisioned as self-configuring, self-organizing, self-managing and self-repairing. Collectively, we call these properties self-★ properties.

This book is a “spin-off” of a by-invitation-only Bertinoro workshop on self-★ properties in complex systems which was held in summer 2004 in Bertinoro, Italy. The Self-star workshop brought together researchers and practitioners from different disciplines and with different backgrounds to discuss complex information systems. The theme of the workshop was to identify the conceptual and practical foundations for modeling, analyzing and achieving self-★ properties in distributed and networked systems. Partly based on these discussions, we solicited papers from the workshop participants and a set of invitees for this book.

We sought original contributions in which authors explicitly take a position concerning requirements, usefulness, potential and limitations of technologies for self-★ properties of complex systems. This position needed to be founded on research results that were put clearly in context with respect to the position statement. We strongly encouraged visionary statements, thought-provoking ideas, and exploratory results that will help the reader form her or his own opinions on the importance of self-★ properties in current and future complex information systems.

We structured the book according to our goal of having such visionary statements. The first part of this book contains a set of separate 1-page summaries of the positions taken by the various authors. This gives the reader a chance to get a quick overview of the various positions. The second part of the book contains the full papers that explain in more detail the positions taken by the different authors.

Without further ado, we wish you a pleasant and stimulating read.

Bologna, Dresden, Rome,
Newcastle upon Tyne, Amsterdam
February 2005

Ozalp Babaoglu
Márk Jelasity
Alberto Montresor
Christof Fetzer
Stefano Leonardi
Aad van Moorsel
Maarten van Steen

Organization

Organizing Committee

Ozalp Babaoglu	University of Bologna, Italy
Márk Jelasity	University of Bologna, Italy
Alberto Montresor	University of Bologna, Italy
Christof Fetzer	Technical University of Dresden, Germany
Stefano Leonardi	University of Rome “La Sapienza,” Italy
Aad van Moorsel	University of Newcastle upon Tyne, UK
Maarten van Steen	Free University of Amsterdam, The Netherlands

Referees

Vinay Aggarwal	Márk Jelasity	Aad van Moorsel
Ozalp Babaoglu	Zbigniew Jerzak	Maarten van Steen
Luca Becchetti	Stefano Leonardi	Andrea Vitaletti
Christof Fetzer	Alberto Montresor	Berthold Vöcking

Special Thanks

We would like to thank the sponsors of Self-star 2004 for making the Workshop possible:

FET Open Project BISON

FET Integrated Project DELIS

FET Open Project COSIN

BICI: Bertinoro International Center for Informatics

UNESCO Office Venice, Regional Bureau for Science in Europe (ROSTE)

We are grateful to Dr. Dum of the European Commission for his enthusiasm and support of research in “Complex Systems” through the projects BISON, COSIN and DELIS. We would also like to thank the University Residential Centre of Bertinoro for hosting the Workshop.

Table of Contents

The Self-star Vision	1
----------------------------	---

Self-organization

Evolving Fractal Gene Regulatory Networks for Graceful Degradation of Software <i>Peter J. Bentley</i>	21
Evolutionary Computing and Autonomic Computing: Shared Problems, Shared Solutions? <i>A.E. Eiben</i>	36
Self-★ Topology Control in Wireless Multihop Ad Hoc Communication Networks <i>Wolfram Krause, Rudolf Sollacher, Martin Greiner</i>	49
Emergent Consensus in Decentralised Systems Using Collaborative Reinforcement Learning <i>Jim Dowling, Raymond Cunningham, Anthony Harrington, Eoin Curran, Vinny Cahill</i>	63
The Biologically Inspired Distributed File System: An Emergent Thinker Instantiation <i>Sergio Camorlinga, Ken Barker</i>	81
Evolutionary Games: An Algorithmic View <i>Spyros Kontogiannis, Paul Spirakis</i>	97

Self-awareness

Model Based Diagnosis and Contexts in Self Adaptive Software <i>Paul Robertson, Robert Laddaga</i>	112
On the Use of Online Analytic Performance Models in Self-managing and Self-organizing Computer Systems <i>Daniel A. Menascé, Mohamed N. Bennani, Honglei Ruan</i>	128
Prediction-Based Software Availability Enhancement <i>Felix Salfner, Günther Hoffmann, Mirosław Malek</i>	143

Making Self-adaptation an Engineering Reality <i>Shang-Wen Cheng, David Garlan, Bradley Schmerl</i>	158
An Online Control Framework for Designing Self-optimizing Computing Systems: Application to Power Management <i>Nagarajan Kandasamy, Sherif Abdelwahed, Gregory C. Sharp, John P. Hayes</i>	174
Self-management of Systems Through Automatic Restart <i>Katinka Wolter</i>	189
Fundamentals of Dynamic Decentralized Optimization in Autonomic Computing Systems <i>Tomasz Nowicki, Mark S. Squillante, Chai Wah Wu</i>	204
Self-awareness vs. Self-organization	
The Conflict Between Self-* Capabilities and Predictability <i>Rogério de Lemos</i>	219
Self-aware Software – Will It Become a Reality? <i>Peter Andras, Bruce G Charlton</i>	229
Supporting Self-★	
A Case for Design Methodology Research in Self-* Distributed Systems <i>Indranil Gupta, Steven Ko, Nathanael Thompson, Mahvesh Nagda, Chris Devaraj, Ramsés Morales, Jay A. Patel</i>	260
Enabling Autonomic Grid Applications: Requirements, Models and Infrastructure <i>M. Parashar, Z. Li, H. Liu, V. Matossian, C. Schmidt</i>	273
Pandora: An Efficient Platform for the Construction of Autonomic Applications <i>Simon Patarin, Mesaac Makpangou</i>	291
Spatial Computing: The TOTA Approach <i>Marco Mamei, Franco Zambonelli</i>	307
Towards Self-managing QoS-Enabled Peer-to-Peer Systems <i>Vana Kalogeraki, Fang Chen, Thomas Repantis, Demetris Zeinalipour-Yazti</i>	325

Peer-to-Peer Algorithms

Cooperative Content Distribution: Scalability Through
Self-organization

Pascal Felber, Ernst W. Biersack 343

Design and Analysis of a Bio-inspired Search Algorithm for Peer to
Peer Networks

Niloy Ganguly, Lutz Brusch, Andreas Deutsch 358

Multifaceted Simultaneous Load Balancing in DHT-Based P2P
Systems: A New Game with Old Balls and Bins

Karl Aberer, Anwitaman Datta, Manfred Hauswirth 373

Robust Locality-Aware Lookup Networks

Ittai Abraham, Dahlia Malkhi 392

Power-Aware Distributed Protocol for a Connectivity Problem in
Wireless Sensor Networks

Roberto Montemanni, Luca M. Gambardella 403

Self-management of Virtual Paths in Dynamic Networks

Poul E. Heegaard, Otto Wittner, Bjarne E. Helvik 417

Sociologically Inspired Approaches for Self-^{*}: Examples and Prospects

David Hales 433

Author Index 447