PREFACE

Intelligent agents and multi-agent systems (MAS) represent the next big step in the development of next-generation software systems, especially when considering large scale distributed applications consisting of several sub-components with behavior that is increasingly difficult to predict. This is supported by important research and development results and reinforced by the increasing uptake of agent-based solutions and services for real-world industries. In fact, software agent technology successfully addresses a number of highly relevant issues, like efficient resource distribution, scalability, adaptability, maintainability, modularity, autonomy, self-sustainability, and decentralized control, by providing powerful concepts, metaphors and tools. The mentioned issues are often regarded as essential non-functional properties of emerging software architectures and systems.

The high importance of agent-related research and development can be seen from the fact that currently about 100 major projects are funded in Europe only - see http://www.agentlink.org/resources/agentprojects-db.php - and more than 100 academic and commercial software tools are publicly advertised - see http://www.agentlink.org/resources/agent-software.php. And these numbers are still growing. As a result of the enormous efforts the stage of maturation has reached a level, which encourages commercial players to increasingly adopt multi-agent systems concepts and technologies for the development of a variety of real-world applications in different domains such as logistics, e-commerce, and entertainment. In this perspective, concrete agent-driven research and development results (such as applications, platforms, and development kits) substantially contribute to promote the technology and increase its exploitation for industrial solutions.

This book provides a first and comprehensive overview of existing software agent development kits, environments, and applications. It is intended to be of particular use for those who want to assess the maturity and state-of-the-art of applied software agent technology. Both the software engineering and the user perspective are covered by a carefully selected set of contributions reporting on prominent examples of agent development environments, platforms, and toolkits and deployed agent-based applications from various different application areas. In particular, most of them have been either successfully demonstrated to the public at the agent technology exhibition of the first German conference for Multi-Agent system TEchnologieS (MATES 2004) in Erfurt, or won the prestigious system innovation award of the international workshop series on Cooperative Information Agents (CIA). Since this book concentrates on implemented systems most of them are available on the Internet. Thus, at the end of each paper you will find all relevant information about where to get the software on the Internet (if it is available) and whom you may contact in case of questions.

Contents

The book consists of seven chapters. The assignment of papers to chapters has been a hard choice, since many papers fall into several categories. However, we believe the final layout is the most reasonable one.

The first three chapters (with eight papers altogether) present toolkits for the development of multi-agent systems. The toolkits are subdivided into three categories: platforms, development environments, and frameworks. An *agent platform* is intended as the set of middleware components supporting the development of (distributed) multi-agent applications. It provides all basic services, like agent life-cycle management, communication, tasks scheduling, security, etc., to easily initialize and run multi-agent systems. A *development environment* usually supports all phases in multi-agent system engineering, which comprises requirements engineering, system design, development and deployment. *Agent frameworks* provide a high-level programming environment consisting of a multi-agent system skeleton that allows the programmer to easily extend it to a full-fledged MAS application. Toolkits can also be differentiated according to their focus of support. In general, it is possible to distinguish between middleware- and reasoning-oriented systems. In this latter case, one emphasizes rationality and goal-directedness support for agent development.

The first chapter focuses on agent platforms and starts with the paper *The JADE Platform and Experiences with Mobile MAS Applications* by Fabio Bellifemine, Giovanni Caire, Giosuè Vitaglione, Giovanni Rimassa, and Dominic Greenwood. JADE is a well-known and well-established Java-based and FIPA-compliant agent platform. The paper gives a comprehensive overview about the basic concepts of JADE. Furthermore, it shows how JADE can be used on mobile networks. Finally, it discusses possible application domains for JADE. The second paper *A-globe: Agent Development Platform with Inaccessibility and Mobility Support* by David Šišlák, Martin Rehák, Michal Pechoucek, Milan Rollo, and Dušan Pavlicek presents A-Globe, a streamlined lightweight platform for MAS development, which operates on normal PCs as well as on PDAs. After a comprehensive introduction into the basic features of A-Globe it is compared to some other agent platforms. The next section concentrates on simulation support since A-Globe provides a special infrastructure for environmental simulation. The third paper in this chapter *Supporting Agent Development in Erlang through the eXAT Platform* by Antonella Di Stefano and Corrado Santoro motivates and presents first the agent programming language Erlang. Then the agent programming platform eXAT that is based on Erlang is discussed. eXAT especially emphasizes the implementation of agent intelligence, behavior, and communication.

The second chapter is dedicated to development environments. The paper *Living Systems® Technology Suite* (LS/TS) by Giovanni Rimassa, Monique Calisti, and Martin E. Kernland describes the LS/TS set of components for the development and deployment of products and systems based on software agent technology and autonomic computing. The paper not only gives a comprehensive overview about the architecture and functionality of this package, but also discusses the challenges that were to be addressed in order to develop the proposed software methodology and infrastructure. The second paper by Vladimir Gorodetsky, Oleg Karsaev, Vladimir Samoylov, Victor Konushy, Evgeny Mankov, and Alexey Malyshev presents the *Multi-Agent System Development Kit* (MASDK), a comprehensive software tool kit for the development, implementation, and deployment of multi-agent systems. The paper mainly concentrates on the development process, which is heavily influenced by the Gaia methodology. It is conducted with the help of a number of integrated editors (e.g., for the model, protocol, ontology, behavior, and state transition development), which are de-

scribed in detail. The third paper *An Integrated Development Environment for Electronic Institutions* by Josep Lluís Arcos, Marc Esteva, Pablo Noriega, Juan Antonio Rodríıguez-Aguilar, and Carles Sierra presents a methodology and an integrated development environment for engineering multi agent systems as electronic institutions. The latter defines a set of artificial constraints that articulate agent interactions, defining what they are permitted and forbidden to do. It defines a normative environment where heterogeneous (human and software) agents can participate by playing different roles and can interact by means of speech acts. The integrated use of these tools is illustrated using as an example the double auction market.

The third chapter starts with the paper *Jadex: A BDI-Agent System Combining Middleware And Reasoning* by Lars Braubach, Alexander Pokahr, and Winfried Lamersdorf. The presented system Jadex relies on an arbitrary given agent platform, e.g. JADE, however, extends it by providing tools to model agent rationality and goal-directedness. Its reasoning engine supports cognitive agents by exploiting the BDI model. It permits to explicitly model such features as beliefs, plans, goals or capabilities. The CAFnE toolkit is presented in the paper *Component Agent Framework For Non-Experts (CAFnE) Toolkit* by Gaya Jayatilleke, Lin Padgham. and Michael Winikoff. The vision of the authors is not only to support developers in the initial application development but also to provide a framework that facilitates domain experts themselves in making modifications to a deployed system, in order for it to better fit needs which are identified as the system is used. The system is introduced and its functionality is explained with the help of an example system.

The forth chapter comprises two papers that show how Web-Services can be integrated into agent technology. The paper *The WSDL2Agent Tool* by László Zsolt Varga, Ákos Hajnal, and Zsolt Werner presents a bipartite tool for this purpose. The WSDL2Jade part of the tool generates code for a proxy agent that makes the Web service available in a multi-agent environment. The WSDL2Protégé part of the tool translates a WSDL description to a Protégé project in order to support its semantic enrichment. It generates a project file for the Protégé ontology engineering tool in which the ontology of the Web service can be visualized, edited, or exported to various formats. The second paper *WS2JADE: A Tool for Run-Time Deployment and Control of Web Services as JADE Agent Services* by Xuan Thang Nguyen, Ryszard Kowalczyk, Mohan Baruwal Chhetri, and Alasdair Grant presents the WS2JADE framework. It permits the easy integration of Web services into the JADE agent platform. In particular, the technical aspects of the run-time deployment and control of Web services as agent services are discussed. The Web service - agent integration capabilities of WS2JADE are demonstrated with simple examples of Web service management including service discovery, composition, and deployment with JADE agents.

Chapter five concentrates on *Tool Support for Agent Communication and Negotiation.* The paper by Tibor Bosse, Catholijn M. Jonker, Lourens van der Meij, Valentin Robu, and Jan Treur presents SAMIN, *A System for Analysis of Multi-Issue Negotiation*. The agents in this system conduct one-to-one negotiations, in which the values across multiple issues are negotiated on simultaneously. The paper shows how the system supports both automated and human negotiation. To analyze such negotiation processes, the user can enter every formal property deemed useful into the system and use the system to automatically check this property in given negotiation traces. The

paper also shows how to deal with incomplete information and presents some experimental results about human multi-issue negotiation. *FuzzyMAN: An Agent-Based E-Marketplace with a Voice and Mobile User Interface* by Frank Teuteberg and Iouri Loutchko focuses on the conceptual foundations and the architecture of an agent-based job e-Marketplace that supports mobile negotiations. The negotiation model is based on many negotiation issues, a fuzzy utility scoring method, and simultaneous negotiation with many negotiation partners in an environment of limited negotiation time. The paper discusses FuzzyMAN's architecture, agents, negotiation model, and mobile and voice user interfaces. Heikki Helin and Mikko Laukkanen deal in their paper with *Efficient Agent Communication in Wireless Environments.* They propose a layered model of agent communication in the context of the FIPA agent architecture. For each layer of this communication stack an efficient solution for wireless agent communication is presented. Furthermore, the paper thoroughly analyzes the performance of agent communication in slow wireless environments.

Chapter six contains two papers about tool kits for mobile agents. The paper *AMETAS - The Asynchronous Message Transfer Agent System* by Michael Zapf presents a development and runtime environment for creating and running mobile, autonomous agents under Java 2. AMETAS defines three kinds of application components: agents, user adapters, and services. Services are able to wrap system-dependent resource accesses and provide functional enhancements while user adapters integrate the human user into the agent environment. Techniques of mediation are used to realize open applications; i.e. applications with an ever-changing set of components. The discussed security system prevents illegal access between users and defines the access control to resources. The other paper *Tracy: An Extensible Plugin-Oriented Software Architecture for Mobile Agent Toolkits* by Peter Braun, Ingo Müller, Tino Schlegel, Steffen Kern, Volkmar Schau, and Wilhelm Rossak presents a kernel-based tool kit that only provides fundamental concepts and functions common to all toolkits and abstracts from all of their possible services. In particular, although Tracy was developed as a mobile agent toolkit, its kernel abstracts from all issues related to agent mobility, delegating this to an optional service implementation. This makes it possible to replace Tracy's migration service with another implementation and even to have two different migration services in parallel. Service implementations are developed as plug-ins that can be started and stopped during run-time. The paper first discusses the set of fundamental services. Then it is shown how they are realized in Tracy.

Chapter seven comprises three papers that are related to agent-based applications. Each of these papers also covers a research issue, however, discusses its solution on the basis of an application. *The Packet-World: A Test Bed for Investigating Situated Multi-Agent Systems* by Danny Weyns, Alexander Helleboogh, and Tom Holvoet presents as application area the packet world. The research aim of the paper is to discuss how to model a distributed application as a set of cooperating autonomous entities (agents), which are situated in an environment. The Packet-World is used as a test bed to explore and evaluate a broad range of fundamental concepts and mechanisms for situated MASs. The paper elaborates on the structure of the environment, agents' perception, flexible action selection, protocol-based communication, execution control and timing, simultaneous actions and several forms of stigmergy. *Decommitment in a Competitive Multi-Agent Transportation Setting* by Pieter Jan 't Hoen, Valentin Robu,

and Han La Poutre discusses the decommittment issue on the basis of a large-scale logistics setting (freight forwarding) with multiple, competing companies. It is shown in the paper that decommitment as the action of foregoing of a contract for another (superior) offer can reach higher utility levels in case of negotiations with uncertainty about future opportunities. The paper *Teamworker: An Agent-Based Support System for Mobile Task Execution* by Habin Lee, Patrik Mihailescu, and John Shepherdson shows how a multi-agent based computer cooperative support system known as TeamWorker can help to overcome the difficulties faced by mobile workers. Each mobile worker is assigned a personal agent that can assist her/him during the working day through appropriate service provision (based on current work context), and through monitoring work progress to anticipate and undertake required actions on the user's behalf. A detailed presentation of the TeamWorker system is given, including the benefits provided for a real life mobile business process.

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In summary, we hope that this book will be of substantial benefit for students, software engineers, computer scientists, researchers (both academic and industrial), and IT experts, who are keen to learn about the deployment of software agent technology for engineering complex solutions and systems.

Enjoy the reading!

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