AGENT

多Agent
制造业供应链管理

蒋国瑞 等◎编著

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序一

供应链管理跨越业务单元或企业界限，从合作制造和伙伴关系的角度出发，在全局和整体上审视价值增值路径，包括产品的质量和市场竞争力。供应链管理的范围也涵盖运作与战略层面，关注点既涉及局部节点间的供需和契约，也会聚网络和链条上的协调和博弈。

信息技术的迅猛发展推动了全球化和网络经济的进程。现代企业（尤其是制造业企业）面临着越来越复杂的竞争环境和客户需求日趋多元化、个性化的挑战。在此背景下，如何加强供应链管理，通过信息分析和优化手段提升供应链效率和企业竞争优势，已成为亟待解决的理论与实践课题。

从市场需求预测、物料需求管理、库存控制策略、生产计划制订，乃至企业资源规划、客户关系管理、商务智能决策等管理方法，到 MRP、MRP Ⅱ、ERP、CRM、BI 等企业解决方案，信息技术的应用形式一直伴随着供应链管理模式的演化而脉动着。这种管理与技术的融合，一方面提高了管理的科学性和精益化品质，改变了许多传统的业务和流程，催生了新的经营理念和商机；另一方面提高了技术的可靠性和业务支撑能力，促进了许多现有技术升级和应用扩展，产生了新的方法创新和应用形态。

随着企业信息化和业务数字化应用的日益深入，特别是在线业务和网络经营范围的不断扩大，信息处理规模、关系网络的复杂性以及供需的动态特征等因素成为供应链管理的难点问题。这进一步引发了人们在供应链管理中运用智能化方法的研究和应用兴趣。基于多智能体（Multi-Agent）的供应链管理方法就是一个很有意义的尝试。一般来说，多智能体技术具有分布性、自治性、移动性、智能性和自学习性等特点，被认为适用于跨越企业边界的、处于复杂环境的供应链管理，进而满足企业间可整合、可扩展的需求，集成供应链上各节点企业的核心能力和价值创造能力，强化供应链的整体管理水平和竞争力。基于多智能体技术构建的供应链管理信息系统，旨在发挥其在链网式组织模式中的经营管理、辅助决策和协同优化功效。

该书作者长期从事信息系统、制造业供应链管理、协同优化，以及电子商务谈判等领域的研究工作，成果颇丰。在吸收国内外相关学科领域最新研究成果的基础上，作者对多智能体制造业供应链管理的理论和应用现状、发展前景，

以及企业实例进行了深入全面的探讨，取得了一批富有见地的成果，总结整理成该书。该书取材丰富，较好地结合前沿性、全面性和系统性等特点，同时叙述重点突出、实例分析针对性强。

相信通过阅读该书，读者可以理解如何有效地将多智能体技术和方法引入制造业供应链管理、商务谈判等领域中，以提升供应链管理的可整合、可扩展能力。该书不仅可以作为相关学科领域学者的学术读物和研究参考，也可以作为高等学校相关专业高年级本科生和研究生的教材，并为行业和企业管理者提供有益的启发。

清华大学经济管理学院教授、副院长

2012 年 2 月于清华园

管理信息系统是一个以人为主导的，利用计算机硬件、软件、网络通信设备以及其他办公设备，进行信息处理，以企业战略竞优、提高效益和效率为目的，支持企业高层决策、中层控制、基层运作的集成化的人—机系统。其主要任务是最大限度地利用现代计算机及网络通信技术加强企业的信息管理，以便进行正确的决策，不断提高企业的管理水平和经济效益。

随着计算机技术的快速发展，管理信息系统为了适应大环境的不断进步也逐步向网络化、对象化、智能化的方向发展。依托国际互联网的"大信息环境"背景，使企业由内部走向外部，对管理、组织产生了深刻的影响，引发了管理制度与管理模式的重大变革，出现了供应链信息系统（SCMS）、虚拟企业（VE）、电子商务（EB）以及各种有关电子商务的交易平台，促进了人工智能技术的进一步发展。这些新技术、新发展能够更为直接地反映客观世界中事物及其相互关系的本来面貌，提高决策支持水平，减轻人的体力劳动，实现智力放大，具有高效益和高竞争力。

近年来，在信息全球化和激烈市场竞争的压力下，商务智能成为了又一热点问题。实际上不仅是商务，而是所有的组织如企业、政府和教育部门等，都可以而且应该利用智能技术，提高智能化的水平。商务智能（BI）的出现是一个渐进的复杂演变过程，目前还处于发展之中。它可以看做在决策支持系统（DSS）、智能决策支持系统（IDSS）的基础上引入了材料需求计划（MRP）、制造资源计划（MRPⅡ）、企业资源规划（ERP）、客户关系管理（CRM）、供应链管理（SCM）、电子商务（E-Business）等先进的企业管理理论和方法后综合而成。

商业智能通常被理解为将企业中现有的数据转化为知识，帮助企业做出明智的业务经营决策的工具。为了将数据转化为知识，需要利用数据仓库（DW）、联机分析处理（OLAP）工具和数据挖掘（DM）等技术。因此，从技术层面上讲，它是数据仓库、在线分析处理和数据挖掘等技术的综合运用。它先后经历了决策支持系统（DSS）、经理信息系统（EIS）、智能决策支持系统（IDSS）等阶段，最终演变成今天正在发展中的商务智能系统（BIS）。

多 Agent 技术是人工智能领域里一种新兴技术，近年来得到了迅速发展。

多 Agent 系统是由分布在网络上的多个 Agent 松散耦合而成的大型复杂系统，这些 Agent 相互作用以解决由单一 Agent 的能力和知识所不能处理的复杂问题。其中的每个 Agent 是具有一定感知能力、能模拟人类行为，在其所在环境下自主运行来完成一定目标的服务程序。

在制造业供应链管理系统中，引入多 Agent 系统（MAS），生成多 Agent 制造业供应链管理系统。利用 Agent 的交互性和智能性，将供应链管理系统和商务智能融合起来，既能解决商务智能中交互上的不足，又能克服供应链管理上智能的缺陷，从而提高供应链管理的智能化程度。

该书作者多年利用多 Agent 技术进行预测预警、商务谈判、供应链协同优化研究，得到多项课题支持（其中包含两项国家自然科学基金），取得了系列成果。该书是在我们商务智能研究室取得的成果基础上，结合国内外同行相关的前沿成果，在基础理论、协同优化、协同谈判三个层面，围绕理论知识、常用方法、实现技术、构建模型、模拟仿真、实证分析进行撰写。对多 Agent 制造业供应链管理系统中的三个层面的产生、发展、现状和未来进行了较为全面、系统的归纳总结，旨在为国内外相关领域的研究人员提供支持，推动多 Agent 制造业供应链管理系统迅速形成、快速发展并广泛应用。

哈尔滨工业大学教授
北京工业大学双聘教授
2012 年 2 月于北京

前言

制造业供应链管理是针对制造业企业的有效性管理。它包括了对整个供应链系统进行计划、协调、操作、控制和优化的各种活动和过程的管理。通过改善上、下游供应链关系，整合和优化供应链中的信息流、物流、资金流，以获得企业的竞争优势，同时达到客户的满意度最大、总成本最低、效率最高等最优目标。将传统的供应链管理思想与先进的信息技术相结合，使智能化的技术与方法更好地融入管理的实践当中，增强管理的高效性、创新性、智能性及对复杂环境的适应性，无疑是信息时代制造业企业供应链管理行之有效的发展途径。

本书的创作目的就是通过对多 Agent 在制造业供应链管理中的应用研究的现状、发展前景、基础理论、应用实例和系统实现相结合的综合性阐述，使多 Agent 技术、供应链协同，以及电子商务自动谈判等相关领域的学者和研究人员，更充分地了解和掌握学科领域的前沿，为进一步深入的研究提供帮助。

本书的创作主要来源于作者负责的两项国家自然科学基金（71071005、70940005）阶段性成果、两项北京市自然科学基金（9042001、9072001）部分成果、北京市哲学社会科学规划办公室重点项目（08ABJa236）以及北京市教委科技创新平台项目（54K3001）的研究成果。课题研究组成员主要依托北京现代制造业发展研究基地和北京工业大学商务智能研究室的平台，经过几年的时间，不断地进行相关领域资料的系统整理和分析，并在此基础上进行了大量的拓展与创新研究，最终将成果整理完成了本书。本书从基础知识、供应链协同优化和协同谈判角度将主要内容分为三大部分。

第一章至第四章为基础知识篇。第一章介绍 Agent 和 Agent 系统的基本概念，以及多 Agent 供应链系统在供应链管理中的具体应用。第二章提出了现代制造业供应链管理系统的设计思想、原则及其信息技术支撑体系架构，并对 SCM 中各种信息系统的应用进行系统阐述。第三章介绍关系质量的基本维度信任的概念、典型的信任模型、信任体系的构建方法，目的在于明确完善多 Agent 的信誉保障体系和运行机制。第四章介绍计算机仿真在制造业供应链中的具体应用与最新的虚拟现实和敏捷制造的相关知识。
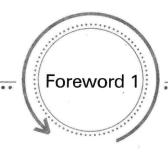
第五章至第七章为供应链协同优化篇。第五章主要从供应链整个流程上的

协同优化方面阐述协同优化的基本理论方法及其在供应链领域的基本应用模式，并列举了几个经典模型实例。第六章主要对供应链的上游的供应商与生产商的协同生产进行理论阐述，并举例介绍了典型的协同生产计划方法与模型。第七章主要对供应链下游的生产-分销环节进行理论阐述，说明其发展现状，并举例介绍生产-分销协同计划应用的主要方法、模型与流程。

第八章至第十一章为协同谈判篇。第八章主要介绍供应链协同谈判协议的基本概念、描述方法等相关知识，列举了几种常见的谈判协议并进行详细阐述。第九章主要介绍协同谈判学习机制的研究意义、研究现状，以及发展展望，并详细介绍了几种常用的学习方法的基本原理和应用，举例说明了谈判学习系统的设计思想。第十章主要针对供应链协同谈判策略的相关理论及研究成果进行详细阐述，并举例说明谈判策略在供应链谈判系统中的应用。第十一章主要介绍供应链协同谈判模型的相关理论和设计思想，并举例加以详细阐述。

本书系统、全面地对多 Agent 理论技术在制造业供应链领域的应用进行了深入的研究和总结，从制造业供应链管理的先进思想深入到供应链的协同计划、协同谈判领域，涵盖了管理科学与工程专业领域的多个研究热点，为相关领域人员进行深入研究提供重要的参考。同时引入大量典型案例分析与系统设计，使理论更具实践性和指导性。

由于时间紧迫，水平有限，书中错误、不妥之处在所难免，恳请读者批评指导！

教授，副院长
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2012 年 3 月

Supply Chain Management crosses over the boundaries of business unit or enterprise, starts from the perspective of co-manufacturing and partnership, then examines the value added path globally and overall, which includes quality and market competitiveness of the product. Supply Chain Management covers operation and strategic levels as well which does not only concern about supply/demand and contract between partial nodes, but also assemble the coordination and game playing of networks and chains.

The rapid development of information technology has pushed forward the process of globalization and network economic. Modern enterprises (especially manufacturing enterprises) are facing with the challenge that competition environment is becoming increasingly complex and customer demands are more diversified and personalized. In this context, how to enhance Supply Chain Management of enterprise and improve supply chain efficiency and competition advantage through information and optimization tools has become a theoretical and practical subject, and needs to be solved immediately.

The application form of IT has been changing with the evolution of Supply Chain Management, from management methods such as Market Demand Forecast, Material Demand Management, Inventory Control Strategies, Production Planning as well as Enterprise Resource Planning, Customer Relationship Management, Business Intelligence Decision-making to enterprise solution programs such as MRP, MRPII, ERP, CRM, BI and so on. On one hand, the combination of management and technology improves the scientific nature and lean quality of management. It changes many traditional businesses and processes, and also creates new business ideas and opportunities. On the other hand, the combination improves reliability and business support capacity of technology, upgrades many existing technologies and expands their applications. Moreover, it gener-

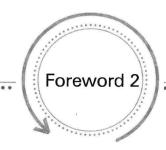ates new method innovation and application form as well.

  With the in-depth development of the application of enterprise informatization and business digitization, especially the expanding range of on-line service and Internet business, some factors, such as information processing scale, relation network complexity, the dynamic features of supply/demand and so on have become difficult problems in Supply Chain Management. This will further attract people to use intelligent methods in Supply Chain Management while doing research. The Supply Chain Management method based on Multi-agent is a worthy attempt. In general, Multi-agent technology has such characters like distribution, autonomy, mobility, intelligence and self-learning. It is regarded as appropriate tool for Supply Chain Management to cross boundaries of enterprises and locate in complex environment. And thus it can satisfy the need of integration and scalability between enterprises, integrate the core ability and value added ability of each node enterprises on the supply chain and strengthen the overall management level and competitiveness of supply chain. The Multi-agent technology based Supply Chain Management information system is designed to play the function of management, decision-making assistance and collaborative optimization in chain network organization.

  The author has been doing research in the field of information system, manufacturing Supply Chain Management, collaborative optimization, E-commerce and so on for years, and he has obtained many achievements. He absorbs essence from latest research of both domestic and international scholars and on this basis, he has made an in-depth and comprehensive discussion on theory, application status, prospects and enterprise cases of Multi-agent Manufacturing Supply Chain Management. He has achieved plenty of insightful results, and summarized them into this book. This book seeks to combine such characters like frontier, comprehensiveness and systemic together through abundant materials, meanwhile this book is narrative focused and case analysis targeted.

  I believe that after reading this book, readers can understand how to introduce Multi-agent technology and method into Manufacturing Supply Chain Management and business negotiation effectively, in order to improve the ability of integration and expansion of Supply Chain Management. The book can be regarded not only as academic book and research reference for scholars in related fields, but also as teaching material for senior undergradu-

ates and graduates in related majors. It can also enlighten managers in related industries and businesses.

Chen Guoqing
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February 2012 in Tsinghua University

MIS (Management Information System) is a people-oriented system, which combines computer hardware, software, network communication equipments and some other office equipments to process information. It aims at choosing the best business strategy, and improving effectiveness and efficiency. It can support high-level decisions, mid controls and integrate man-machine system of primary operation of the enterprise. Its main task is to maximize the use of modern computer and network communication technologies to enhance the enterprise's information management, so that the enterprise can make right decisions, constantly improve management level and obtain more economic benefits.

With the rapid development of computer technology, MIS has gradually become more diverse and intelligent in order to adapt to the continuously changing environment. Relying on the "Great information environment" background of Internet, MIS makes enterprises change from internal form to external form, which has a profound impact on management and organization, and causes a major change in management system and management itself. Moreover, MIS develops Supply Chain Information System (SCMS)、Virtual Enterprise (VE)、E-Business (EB) and various kinds of E-Business transaction platforms, and these new platforms have promoted the further development of artificial intelligence technology. New technologies and development can reflect the original appearance of things and their relations in the objective world more directly. They can improve the supportive decision-making level, reduce the physical work, and achieve intelligence amplification, in order to have high efficiency and high competitiveness.

In recent years, under the pressure of information globalization and fierce market competition, Business Intelligence (BI) has become another hot issue. In fact, not only business, but all organizations such as enterprise, government and education department should use intelligence technology to improve intelligence

level. The appearance of BI is a gradual process of complex evolution, and BI is still in progress. BI can be seen as that, on the basis of Decision Support System (DSS) and Intelligent Decision Support System (IDSS), integrate Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP II), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM), E-Business and other advanced business management theories and methods together.

BI is usually understood as a tool that helps enterprises to make wise business decisions by translating their existing data into knowledge. For the purpose of turning data into knowledge, these technologies such as Data Warehouse, Online Analytical Processing (OLAP) tools, Data Mining and so on are needed. Therefore, from a technical perspective, BI is the integrated use the technologies mentioned above. It has gone through such phases as Decision Support System (DSS), Executive Information System (EIS), Intelligent Decision Support System (IDSS), and at last it has evolved into Business Intelligence System (BIS), which is still in progress.
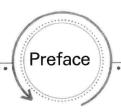
Multi-agent technology is a new technology in artificial intelligence field. It has been developing rapidly in recent years. Multi-agent system is a large and complex system, which is loosely coupled by many agents that are distributed on the network. These agents can interact with each other to solve complex issues which couldn't be handled with the ability and knowledge of a single agent. Each agent is a service program, which has certain perception, simulates human behavior, and automatically runs operations to accomplish certain goals in certain environment.

In Manufacturing Supply Chain Management System, the introduction of Multi-agent System (MAS), generates Multi-agent Manufacturing Supply Chain Management System. This system uses interactivity and intelligence character of agent to combine Supply Chain Management System and Business Intelligence together. Also, it can solve the problem of lack of interaction in BI. It can also overcome the default of intelligence in Supply Chain Management. The system aims at improving the intelligent level of Supply Chain Management.

The author has been doing research on forecast and early warning, business negotiation and supply chain collaborative optimization using Multi-agent technology for many years. He has got support from many subjects (including two national natural science funds), and gained a series of achievements. This book

is based on the research results of our Business Intelligence Research Center, and written with the forefront of research achievements of domestic and international researchers. The book focuses on three levels, which are basic theories, collaborative optimization and collaborative negotiation, and it includes theories, common methods, implementation techniques, construction models, simulation and empirical analysis and so on. This book has a comprehensive and systematic summary on generation, development, present and future of three levels in Multi-agent Manufacturing Supply Chain Management System. It aims at providing support to domestic and international related researchers, and promoting the rapid formation, development and wide application of Multi-agent Manufacturing Supply Chain Management System.

Huang Tiyun
Professor of Harbin University of Technology
Dual Professor of Beijing University of Technology
February 2011 in Beijing

Preface

Manufacturing Supply Chain Management is effective for manufacturing enterprises, which include the management of every activity and process of the whole supply chain system, such as planning, coordination, operation, control and optimization. By improving the relationship between upstream and downstream of supply chain, integrating and optimizing the information flow, logistics, capital flow of supply chain, the enterprise can gain competitive advantage. Meanwhile the enterprise can achieve maximum customer satisfaction, lowest total cost, highest efficiency and other optimal goals. The combination of traditional Supply Chain Management ideas and advanced information technology can integrate intelligent technologies and methods into management practice. In this way we can enhance management efficiency, innovation, intelligence and the adaptability to complex environment. Undoubtedly, it is an effective development path for Supply Chain Management of manufacturing enterprises in information era.

This book gives a comprehensive illustration of the combination of the research status, prospects, basic theories, application cases and system implementation of Multi-agent in manufacturing Supply Chain Management. This can help scholars and researchers in related fields of Multi-agent technology, supply chain collaboration and E-commerce automatic negotiation to catch up with the forefront of research, and it can also help them to do further in-depth research.

The sources of the book mainly come from initial results of two National Natural Science Funds (71071005、70940005), partial results of two Beijing Natural Science Funds (9042001、9072001), the research results of the key project of Beijing Philosophy and Social Sciences planning office (08ABJa236) and Beijing Education Committee Science and Technology Innovation Platform Project (54K3001), which are the author responsible for. The team members have done their research relying on the platform of Beijing modern manufacturing development research base and Business Intelligence Research Center of Beijing. University of Technology. The members have collected and analyzed related infor-

mation systematically for several years, and have done a large amount of expansion and innovation research on the basis of the above work, and eventually we organize these results into this book. The book can be divided into three parts: basic knowledge, supply chain collaborative planning and collaborative negotiation.

Part One: Basic knowledge. This part includes four chapters (from Chapter One to Chapter Four). Chapter One introduces the basic concept and prospects of Agent and Agent system, and explains the specific application of Multi-agent Supply Chain System in Supply Chain Management. Chapter Two proposes the design thoughts, principles and the framework of information technology supportive system of modern Manufacturing Supply Chain Management System and describes the application of each information system in SCM systematically. Chapter Three introduces the concept of basic dimension trust of relationship quality, typical trust model and the construction method of trust system whose purpose is to improve the credit security system and operation mechanism of Multi-agent specifically. Chapter Four introduces the knowledge about the specific application of computer simulation in manufacturing supply chain, latest virtual reality and flexible manufacturing.

Part Two: Supply Chain collaborative optimization. This part includes three chapters (from Chapter Five to Chapter Seven). Chapter Five mainly illustrates the basic theories and methods and its basic application form in supply chain field of collaborative optimization from the aspect of collaborative optimization in the entire supply chain process and lists some classic model cases. Chapter Six focuses on illustrating theories of collaborative production of suppliers and manufacturers in the upstream of supply chain and gives examples to introduce the typical collaborative production planning method and model as well. Chapter Seven mainly illustrates the theories of production-distribution process in downstream of supply chain, explains the development status, and gives examples to introduce the main methods, models and processes of the application of production-distribution collaborative planning.

Part Three: Collaborative Negotiation. This part includes four chapters (from Chapter Eight to Chapter Eleven). Chapter Eight focuses on introducing the basic concept of supply chain collaborative negotiation agreement, description methods and so on. It also illustrates some common negotiation agreements in details. Chapter Nine focuses on the research meaning, research status and pros-