

Preface

The global economy and the recent developments in information and communication technologies have significantly modified the business organization of enterprises and the way that they do business. New forms of organizations such as extended enterprises and networked enterprises (also called supply chain networks) appear and they are quickly adopted by most leading enterprises. It is well known that “competition in the future will not be between individual organizations but between competing supply chains” (Simchi-Levi *et al.*, 2003). Thus, business opportunities are captured by groups of enterprises in the same network. The main reason for this change is the global competition that forces enterprises to focus on their core competences (i.e., to do what you do the best and let others do the rest). According to a visionary report of Manufacturing Challenges 2020 conducted in the USA (National Research Council, 1998), this trend will continue and one of the six grand challenges of this report is the ability to *reconfigure networked enterprises rapidly in response to changing needs and opportunities*. Although the resulting networked enterprises are more competitive, the tasks for planning, managing and optimizing are much more difficult and complex.

While alliance-like enterprise networks with the underlying supply network represent tremendous business opportunities, they also make the involved enterprises face greater uncertainties and risks. Firstly, networks or supply chains have to be modified or dissolved once the business opportunities evolve or disappear. Secondly, changes or major perturbations at one enterprise may propagate through the whole network to other enterprises and hence influence their performance. The evolution from single enterprise with a high vertical range of manufacture towards enterprise networks offers new business opportunities especially for small and medium enterprises that are usually more flexible than larger companies. However, in order to be successful, performance and expected benefits have to be carefully evaluated and balanced in order to become a partner of the right network of enterprises for the right task. All these issues have to be taken into account in order to find an efficient, flexible and sustainable solution. A promising approach

for that purpose is to combine analytical methods and knowledge-based approaches, in a distributed context.

Artificial intelligence (AI) techniques have been used in multiple segments of the networked enterprises. They have taken a prominent role to integrate people, information and products across dynamic networked enterprise boundaries including management of various manufacturing, logistics and retailing operations such as purchasing, manufacturing, warehousing and distribution of goods. Decisions involving customer profiling, new product development, retail marketing, and sales patterns are immensely refined using business intelligence tools. Further, as such decisions have an impact on the overall network enterprise processes, it is important that business intelligence tools should also be linked to networked enterprise management applications.

This book aims to align latest practice, innovation and case studies with academic frameworks and theories. It will include the latest research results and efforts at different levels including quick-response system, theoretical performance analysis, and performance and capability demonstration, hoping to cover the role of emerging AI technologies in modeling, evaluating and optimizing networked manufacturing enterprises activities at different levels.

Sixteen chapters were selected after a peer review process. They were revised in accordance with the suggestions and recommendations from the reviewers. They address prominent concepts and applications of AI technologies in managing networked manufacturing enterprises.

Chapter 1, by E. Oztemel, provides information on intelligent manufacturing systems. It also includes an analysis on historical progress of manufacturing systems as well as a brief review of traditional manufacturing systems. Fundamental technologies of AI are reviewed in order to establish the baseline for intelligent manufacturing systems. Moreover, basic characteristics of intelligent manufacturing and respective architectures are provided. Some examples of the applications of intelligent manufacturing systems are also highlighted in this chapter.

Chapter 2, by A.J. Soroka, describes a networked system developed for automating the gathering, processing and management of product fault knowledge. Such a system can remove the need for manual processing of fault reports and the associated problems. A reactive agent architecture based upon the concept of finite state automata (FSA) is implemented using the Java programming language. It also shows that the FSA-based agent architecture is suitable for application in this particular problem domain, due to the reactive nature of an FSA.

Chapter 3, by H. Ding *et al.*, presents a multi-agent-based simulation tool with descriptions of the overall architecture, modeling elements, operational policies, etc. The tool has been used in a commercial project with a leading high-tech manufacturer. The complex relationships between service levels, inventory cost, transportation cost, and forecasting accuracy are well studied. The project results show that networked enterprises can really get better insight from such a quantitative analysis and would be able to identify solid opportunities for cost saving and performance improvement.

Chapter 4, by Ouzrout *et al.*, focuses on unexpected swings in demand and on unexpected exceptions (problem of production, problem of transportation, etc.), which are important coordination and communication issues in supply chain management. The chapter analyses some of the existing approaches and work and describes an agent-based distributed architecture for the decision-making process. The agents in this architecture use a set of negotiation protocols (such as firm heuristic, recursive heuristic, collaborative planning and forecasting replenishment negotiation protocol) to collectively make decisions in a short time. The architecture is validated on an industrial case study.

Chapter 5, by Keshari *et al.*, presents a conceptual framework of a web-services-based e-collaborative system to establish a real-time information-sharing platform for enabling collaboration among similar types of manufacturing firms. The main idea of the chapter is to integrate the process planning and scheduling activities with the proposed system considering outsourcing as a viable technique of enhancing machine utilization and system's performance. An illustrative example is considered that demonstrate the working mechanism of the proposed framework.

Chapter 6, by Ounnar and Pujo, proposes a new approach for customer-supplier relationship control, in which the partnership is considered in the context of an association of potential suppliers within a network: an isoarchic control model for a supply chain network based on a holonic architecture. The decision-making mechanism is produced using an autonomous control entity. An implementation of the simulation of such a system is done via a distributed simulation environment high level architecture. A case study is presented.

Chapter 7, by A. Dolgui *et al.*, discusses the problems of lot-sizing and sequencing under uncertainties for a single machine or a flow-shop. The core of the chapter is a case study for multi-product lot-sizing and sequencing of flow-shop lines under uncertainties. Two main types of uncertainties are considered: breakdowns (random lead time) and rejects (random yield). The objective is to maximize the probability that customer demands will be satisfied at the given due date. A mathematical model of the problem and some heuristic and meta-heuristic approaches are discussed.

Chapter 8, by M. Souier *et al.*, presents a comparative study of a group of meta-heuristics, including taboo search, ant colony optimization, genetic algorithms, particle swarm optimization, electromagnetic meta-heuristic, and simulated annealing, against the modified dissimilarity maximization method for a job-shop routing problem picked from literature. Five criteria are selected for performance evaluation and comparison, namely: production rate, machine utilization rate, material handling utilization rate, work in process, and cycle time. The numerical results demonstrate that PSO and GA generate the best results practically in all cases.

Chapter 9, by D. Sánchez *et al.*, proposes the hybridization of evolutionary algorithms, well known for their multi-objective capabilities, with a supply chain simulation module in order to determine the inventory policy (order-point or or-

der-level) of a single product supply chain, taking into account two conflicting objectives: maximizing customer service level and minimizing total inventory cost. Four algorithms (SPEA-II, SPEA-IIb, MOPSO and NSGA-II) are evaluated on five different supply chain configurations to determine which algorithm gives the best results and makes the best use of the simulator. The results indicate that SPEA-2 favors a rapid convergence and that modifying its crossover or its archive truncation rule (variant SPEA-IIb) may improve the results even further.

Chapter 10, by D. D'Addona and R. Teti, considers the development and implementation of a multi-agent tool management system (MATMAS) for automatic tool procurement. The design, functioning, and performance of diverse flexible tool management strategies (FTMS) integrated in the MATMS are illustrated. The MATMS operates in the frame of a negotiation-based multiple-supplier network where a turbine blade producer (customer) requires dressing of worn-out cubic boron nitride grinding wheels from the external tool manufacturer. The diverse FTMS paradigms, configured as domain-specific problem-solving functions operating within the MATMS intelligent agent and holding the responsibility for optimum tool inventory sizing and control, are tested by tool inventory management simulations and compared with real industrial cases.

Chapter 11, by N. Rezg and S. Dellagi, presents two studies investigating new intelligent integrated maintenance and production or service strategies, which deal with complex reliability problems. The first study describes a sequential constrained linear-quadratic stochastic production-planning problem in which a random demand must be satisfied and the single machine is subject to random failure. A minimal repair is performed at every failure, with preventive maintenance actions scheduled according to the manufacturing system history so as to reduce the failure frequency. The second study proposes a failure law that can vary over time, not only with respect to the preventive maintenance actions, but also as a function of changes in operating and/or environmental conditions. The goal is to determine intelligently the number of preventive maintenance actions, which must be performed in order to minimize the cost under a threshold availability constraint.

Chapter 12, by T. Yoo *et al.*, combines global random search using nested partitions (NP) with statistical selection using optimal computing budget allocation (OCBA) to design an innovative algorithm called NP+OCBA. As a non-trivial illustration, the developed NP+OCBA algorithm is applied to the multi-pass scheduling problem. A new multi-pass scheduling framework is presented that minimizes the number of rules to be evaluated by using an NP method, and minimizes the total number of simulation replications by using OCBA method. The efficiency and effectiveness of the proposed NP+OCBA are demonstrated by comparing its performance with that of three methods, respectively equal allocation, stand alone OCBA and COMPASS.

Chapter 13, by B. Desmet *et al.*, discusses some intelligent solution approaches used to optimize safety stocks in networked manufacturing systems. These approaches are based on normal approximation models for the involved critical safety stock parameters. The proposed approximation models are first tested on

small example systems like distribution systems and assembly systems, and then in generic networked manufacturing systems. Moreover, they are benchmarked with results obtained from discrete-event simulation. As the various simulations show, the proposed approximations prove to be rather conservative and provide good upper bounds on the required system safety stocks.

Chapter 14, by S. Karnouskos *et al.*, considers the problem of how to deploy web services on shop-floor devices to connect them to enterprise systems. More specifically, it considers the case of a centrally managed population of devices that are located at different sites, dynamic discovery of devices and the services they offer, near real-time cross-site interaction, their interaction with business processes and distributed system management. The results show that the dynamic nature of the shop-floor can be utilized efficiently to plan further production orders and even implement last-minute changes on the production line using real-time data (real-time reconfiguration based on the application needs).

Chapter 15, by A.W. Colombo *et al.*, illustrates an overview of the engineering approaches, methods and tools that have been specified and developed within the European Research and Development project SOCRADES (www.socrades.eu). The results of the first set of successful applications in the area of electromechanical assembly systems, extending the concepts to geographically distributed service-oriented production sites are demonstrated.

Chapter 16, by J. Barata *et al.*, addresses the problem of shop-floor agility presenting as fundamental cornerstone for true agility and responsiveness of an enterprise willing to participate in highly dynamic collaborative organizations and supply chains. The feasibility of the architecture proposed is demonstrated in a pilot implementation in a near-real shop-floor. Emerging web standards such as DPWS are used to guarantee cross-layer/abstraction interoperability ensuring that the shop-floor reacts positively to adjustments in the supply chain.

We hope you will enjoy the result of these efforts.

References

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