Preface

This volume gathers the peer-reviewed papers which were presented at the fourth edition of the International Workshop "Service Orientation in Holonic and Multi-agent Manufacturing—SOHOMA'14" organized on November 5–6, 2014 by the University of Lorraine, France in collaboration with the CIMR Research Centre in Computer Integrated Manufacturing and Robotics of the University Politehnica of Bucharest and the TEMPO Laboratory of the University of Valenciennes and Hainaut-Cambrésis.

SOHOMA scientific events have been organised since 2011 in the framework of the European project no. 264207 ERRIC, managed by the faculty of Automatic Control and Computer Science within the University Politehnica of Bucharest.

The book is structured in six parts, each one grouping a number of chapters covering a specific research line which represents a trend in future manufacturing control: Part I: *Holonic and Agent-based Industrial Automation Systems*, Part II: *Service-oriented Management and Control of Manufacturing Systems*, Part III: *Distributed Modelling for Safety and Security in Industrial Systems*, Part IV: *Complexity, Big Data and Virtualization in Computing-oriented Manufacturing*, Part V: *Adaptive, Bio-inspired and Self-organizing Multi-Agent Systems for Manufacturing* and Part VI: *Physical Internet Simulation, Modelling and Control*.

These six evolution lines have in common concepts related to *service orientation* and *enterprise integration*, with *distributed intelligence* for activities planning and control in *holonic* and *agent-based* industrial environment; today it is generally recognized that the Service-Oriented Enterprise Architecture paradigm has been looked upon as a suitable and effective approach for industrial automation and manufacturing management and control.

Manufacturing systems are amongst the most complex and demanding artefacts in modern society but also amongst the most valuable ones. The challenges include coping with their heterogeneous nature and their online interactive nature in combination with competitive pressures. Offline plans are known to become invalid soon after arriving in the shop floor. Therefore, researchers are looking into matching technologies which are able to answer these challenges. *Holonic systems* are, actually by definition, targeting such challenges. *Agent technologies* focus on interactive and decentralized aspects. In particular, developments aim to deliver open systems and system components, as well as infrastructure and infrastructural components rather than closed systems.

Technological advances in wireless sensor networks are enabling new levels of distributed intelligence in several forms such as active products that interact with the working environment and smart metering for monitoring the history of products over their entire life cycle and the status and performances of resources. These distributed intelligences offer new opportunities for reducing myopic decision-making in manufacturing control systems, thereby potentially enhancing their sustainability. Control architectures switch their modes of operation to adapt to severe disruptions. *Manufacturing sustainability* is addressed in this special issue with respect to: fault-tolerance to resource and communication breakdown; energy efficiency at resource and shop floor level; balancing resource usage; cost efficiency and inline quality control of products. Innovative services will be growth enablers and drivers of next generation manufacturing enterprises that are competitive and sustainable.

Several frameworks are proposed for classifying, analysing initiatives and potentially developing distributed intelligent automation systems. These frameworks will be referred to in the book as *Distributed Intelligent Automation Systems*. In particular, there is interest in systems in which the planning or execution of tasks normally associated with a centralized operational level are reassigned to be carried out instead by a number of units cooperating at various levels. Or conversely, a task traditionally using information from a single source should be able, in a distributed information system, to make use of data spread across a range of operations—and potentially a range of organizations (the case of networked, virtual enterprises).

The book defines and explains ways to implement intelligent products by putting intelligence at the object (Intelligent Embedded Systems) or through the computing network (using Automatic Identification and Data Capture technology at the product to allow it to be identified and tracked, and take decisions in a computing architecture). These technologies enable the automated identification of objects, the collection of data about them and the storage of that data directly into computer systems.

The service-oriented multi-agent systems (SoMAS) approach discussed in the book is characterized by the use of a set of distributed autonomous and cooperative agents (embedded in smart control components) that use the SOA principles, i.e. oriented by the offer and request of services, in order to fulfil industrial and production system goals. This approach is different from the traditional Multi-agent Systems (MAS) mainly because agents are service-oriented, i.e. individual goals of agents may be complemented by services provided by other agents, and the internal functionalities of agents can be offered as services to other agents (these service-oriented agents not only share services as their major form of communication, but also complement their own goals with different types of external provided services).

Special attention is paid in the book to the framework for manufacturing integration, which matches plant floor solutions with business systems and suppliers.

This solution focuses on achieving flexibility by enabling a low coupling design of the entire enterprise system through leveraging of Service-Oriented Architecture (SOA), Cloud computing and Manufacturing Service Bus (MSB) as best practices.

The *Manufacturing Service Bus* (MSB) integration model described in some papers is an adaptation of ESB for manufacturing enterprises and introduces the concept of bus communication for the manufacturing systems. The MSB acts as an intermediary for the data flows, assuring loose coupling between modules at shop floor level.

The book offers a new integrated vision combining complementary emergent technologies which allow reaching control structures with distributed intelligence supporting enterprise integration (vertically and horizontally) and running in truly distributed and ubiquitous environments. Additionally, the enrichment of distributed systems with biology-inspired mechanisms supports dynamic structure reconfiguration, thus handling more effectively condition changes and unexpected disturbances, and minimizing their effects. As an example, the integration of service-oriented principles with multi-agent frameworks allows combining the best of the two worlds, and to overcome some limitations associated to MAS, such as interoperability.

A brief description of the book chapters follows.

Part I reports recent advances and ongoing research in *Holonic and Agent-based Industrial Automation Systems*. Nowadays, industries are seeking for models and methods that are not only able to provide efficient overall production performance, but also reactive, facing a growing set of unpredicted events. One important research activity in the field focuses on holonic/multi-agent control systems that integrate predictive/proactive and reactive mechanisms into agents/holons. The demand for large-scale systems running in complex and even chaotic environments requires the consideration of new paradigms and technologies that provide flexibility, robustness, agility and responsiveness. Holonic systems are, actually by definition, targeting challenges that include coping with the heterogeneous nature of industrial systems and their online interactive nature in combination with competitive pressures. Multi-agent systems is a suitable approach to address these challenges by offering an alternative way to design control systems, based on the decentralization of control functions over distributed autonomous and cooperative entities. Some chapters discuss the concept of *Intelligent Product* and related techniques for *Product-driven Automation*.

Part II groups papers analysing *Service-oriented Management and Control of Manufacturing Systems*. Service orientation is emerging at multiple organizational levels in enterprise business, and leverages technology in response to the growing need for greater business integration, flexibility and agility of manufacturing enterprises. Closely related to the IT infrastructure of Web services, the service-oriented enterprise architecture represents a technical architecture, a business modelling concept, an integration source and a new way of viewing units of control within the enterprise. Business and process information systems' integration and interoperability are feasible by considering the customized product as "active controller" of the enterprise resources—thus providing consistency between material and informational flows. The areas of service-oriented computing and multi-agent systems are getting closer, trying to deal with the same kind of environments formed by loosely coupled, flexible, persistent and distributed tasks. An example is the new approach of Service-Oriented Multi-agent Systems (SoMAS). The unifying approach of the contributions for this second part relies on the methodology and practice of disaggregating siloed, tightly coupled business and MES processes into loosely coupled services and mapping them to IT services, sequencing, synchronizing and orchestrating their execution.

Part III treats *Distributed Modelling for Safety and Security in Industrial Systems*. Risk and Hazard Control (RH Control) models are proposed as a basis for developing adequate strategies to avoid the effect of extreme, unexpected events in production systems. Chapters in this section present the state of the art and solutions in risk assessment and industrial safety, dynamic reconfigurability and prevention in manufacturing.

Part IV is devoted to *Complexity, Big Data and Virtualization in Computing-oriented Manufacturing*, which represents major trends in modern manufacturing. Virtualization of manufacturing execution system workloads offers a set of design and operational advantages to enterprises, the most visible being improved resource utilization and flexibility. At the manufacturing execution system level, cloud computing adoption refers mainly to virtualization of MES workloads. While MES implementations are different and usually depend directly on the actual physical shop floor layout, general MES functions are aligned with the functions set defined by ISA-95.03 specification. To achieve high levels of productivity growth and agility to market changes, manufacturers will need to leverage Big Data sets to drive efficiency across the networked enterprise. There is need for a framework allowing the development of manufacturing cyber physical systems that include capabilities for complex event processing and Big Data analytics, which are expected to move the manufacturing domain closer towards digital- and cloud manufacturing within contextual enterprises.

Part V discusses *Adaptive, Bio-inspired and Self-organizing Multi-Agent Systems for Manufacturing*. The dynamic change of the client's needs, leading to higher exigency, may require a smart and flexible automatic composition of more elementary services. Several bio-inspired approaches have been proposed; some are based on stigmergy like the ant colony optimization or the Fiery Algorithm; others are based on Particle Swarm Optimization: Bee-based Algorithm, Bat Algorithm, Shuffled Frog Algorithm and Roach Infestation Optimization. Such approaches provide intelligent decision-making capabilities of agents to dynamically and autonomously change services selection on the fly, towards more trustworthy services with better quality when unexpected events occur. Competitive self-interested agents providing services best suited for clients through dynamic service composition are also described.

Part VI is devoted to *Physical Internet Simulation, Modelling and Control*. The availability of individual information in open loop supply chains enables new organizations like Physical Internet (PI). The aim of the innovative PI concept is to solve the unsustainability existing in current supply chains and logistics systems.

The papers discuss adaptive storing, warehouse management systems, product intelligence, open tracing container or rail-road allocation problems.

If SOA is the conceptual framework for service orientation of enterprise processes, **Service-Oriented Computing** represents the paradigm and implementing framework for embedded monitoring and control systems with distributed intelligence in *Service-Oriented Enterprise Architectures* (SOEA).

All these aspects are treated in the present book, which we hope you will find useful reading.

Nancy, November 2014

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