Editorial: production planning for distributed manufacturing

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Biographical notes: Dr. Lihui Wang is a Senior Research Officer of Integrated Manufacturing Technologies Institute at National Research Council of Canada. He received his PhD and MESc from the Kobe University, Japan in 1993 and 1990, respectively and his BSc from China in 1982. He has worked for two years at the Kobe University and two years at the TUT, another national university in Japan, as an Assistant Professor prior to joining NRC. He has published over 120 papers in scientific journals and conferences and edited seven proceedings and journal special issues. His research interests are currently focused on manufacturing process planning, planning and scheduling integration, agent technology, real-time monitoring, Java control and web-based systems. He is currently a registered Professional Engineer, a Senior Member of SME, a Member of ASME and an Adjunct Professor at the University of Western Ontario.

Manufacturing processes in today's distributed manufacturing environment are rather complex from shop floors to every level along supply chains, where highly mixed products in small batch sizes are handled simultaneously. In addition to the fluctuating shop floor operations, unpredictable issues such as job delay, urgent order insertion, fixture shortage, missing tools and even machine breakdown are regularly challenging manufacturing companies. Targeting the unpredictable issues, in recent years, manufacturing research has been focusing on improving flexibility, dynamism, agility and productivity for distributed manufacturing. Various web- and AI-based tools have been developed to deal with issues in process simulation, production planning, resource scheduling and supply chain management. Understanding the current status and mastering available technologies become crucial for the engineers and researchers to effectively solve problems and tackle uncertainties in distributed manufacturing.

The purpose of this special issue is to provide a forum for researchers and practitioners to review the past development and to identify the possible research directions in distributed manufacturing. Eleven papers have been carefully selected for inclusion in this special issue. It is hoped that this special issue is stimulating more interests in R&D of production planning to solve problems in distributed manufacturing.

The first paper is provided by the Guest Editor and his co-workers as the extended editorial of the special issue. This paper gives an overview of process planning, scheduling and their integration. A detailed state-of-the-art literature survey is to help readers to understand existing methodologies and applications in the area, particularly on process planning and scheduling integration. A Distributed Process Planning (DPP) approach is introduced as a new way of process planning and its integration with scheduling, using the function blocks and intelligent agents, so as to significantly improve the flexibility and dynamism of manufacturing shop floors.

The second paper reports on authors' experience on the development of a holonic job shop scheduling system based on object-oriented and multiagent systems approaches. In particular, this paper focuses on the holonic architecture (created primarily for the system analysis purposes), the multiagent architecture (created primarily for the system design purposes) and the agent platform (FIPA-OS). On the basis of their experience with this development project, the authors reflect on the approach and provide suggestions for the developers of holonic systems.

The third paper presents the comparative use of Simulated Annealing and Genetic Algorithm in a scheduling problem of unrelated parallel machines considering set-up times. The objective of this problem is to minimise the total weighted tardiness for the unrelated parallel machine scheduling. The performance of proposed heuristics is compared through computational experiments with real data from dicing operations of a compound semiconductor manufacturing facility.

The fourth paper is concerned with the production scheduling problems that can be solved using the advanced model checking. This method makes use of timed automata to model the complex production scheduling problems such as those encountered in the job shop and open shop scheduling. Several algorithms and heuristics are proposed for finding the shortest paths in timed automata. An advanced model checking tool, UPPAAL, is used to implement and test the method on different models and to show the effectiveness in terms of finding optimal or near to optimal, schedules in polynomial time, even for the large-scale problems.

To make a process plan adaptable to computer numerical controllers, the fifth paper introduces a framework for reconciling STEP-compliant manufacturing information to a CNC machine. The STEP-compliant manufacturing information is represented in STEP-NC-format containing information, such as 'Workplans', 'Workingsteps' and 'Machining Features', which are generic and machine-independent. Also discussed in this paper includes the three components of the framework, a native CNC system database, an adaptor and a human–computer interface.

Along the line of STEP-NC research, the sixth paper combines STEP-NC with eXtensible Markup Language (XML) so as to connect distributed shop floors to an enterprise-wide information network for collaborative e-manufacturing. This paper documents how to map the STEP-NC data to XML format for cross-platform information sharing and how to realise a STEP-NC-enabled e-manufacturing framework for the web applications.

The seventh paper presents a method for finding optimal collision-free inspection sequences for coordinate measuring machines. The sequencing problem is formulated as a standard Travelling Salesperson Problem (TSP). During the network construction, collision detection is performed for each pair of measurement points using an image-based collision detection method. The effectiveness of the methods is verified by simulations to demonstrate the collision-free path generation of parts with complex geometry. A comparison of TSP solutions with and without the collision penalties is also presented.

The goal of the eighth paper is to develop a 'clean interface' between the design and fabrication facilities for the production of custom-machined parts. It introduces a new data exchange format – Numerically Controlled Markup Language (NCML) for the internet-based distributed machining. A prototype system is developed to illustrate how NCML can be effectively used to conduct e-commerce for the custom-machined parts, followed by the testing of the methodology with a number of parts obtained from different sources.

To deal with variations in the request for manufacturing capacity between cells, the ninth paper introduces the two types of cooperation between the distributed manufacturing cells. Load-oriented cooperation concerns the reallocation of jobs to different cells. Resource-oriented cooperation refers to movements of workers between the cells. It is concluded that the maximal effect of load-oriented cooperation is higher than the maximal effect of resource-oriented cooperation.

A constraint-based product configurator is reported in the tenth paper for the mass customisation. This paper proposes a constraint model for n-ary numeric constraints and effective search algorithms for solving such constraints. It highlights a system design approach on modelling domain-specific product knowledge, integrating domain-specific product models into generic search algorithms and presenting configuration results to the end users. A software tool is developed that can automatically generate customised product designs based on the customer requirements and design constraints.

The last paper presents a framework for modelling and realisation of a multiagent system aimed at process planning. Within the framework, the communication of knowledge as well as the subsequent achievement of subtasks are illustrated by the two intelligent agents, a *part agent* and an *operation agent*. Both the internal dynamics of the intelligent agents and the conversation model are presented as Petri nets. The effectiveness of the framework is demonstrated by a multiagent system in connection with a rule-based system.

These papers cover a broad area ranging from the process planning to mass customisation that are typical in the distributed manufacturing. As the guest editor, I would like to take this opportunity to thank all the authors for the time and effort they spent in writing their papers and for complying with referees' comments in revising their manuscripts. I would also like to express my hearty gratitude to the referees, who reviewed the papers and made valuable comments for improving the quality of the manuscripts. I hope this special issue is timely in delivering the latest R&D contributions to the research community.

Finally, I would like to gratefully acknowledge the trust and support provided by Dr. Mohammed Dorgham, Editor-in-Chief of the IJCAT journal, in the process of collating this special issue on Production Planning for Distributed Manufacturing.