

A strategic framework for networked manufacturing

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Abstract

This paper introduces a strategic framework for designing and operating agile manufacturing networks, enabling to collaboratively plan, control and manage day-to-day contingencies in a dynamic environment. It is based on a distributed collaborative vision of manufacturing systems. We first introduce a network-oriented organizational strategy according to which a manufacturing business dynamically organizes its operations through the configuration and activation of a distributed network of interdependent responsible manufacturing centers. Then, we present a collaborative relationships strategy as a contractual approach to implement operational networks. Finally, we introduce an operational strategy, showing how this networked collaborative approach can be used to manage day-to-day activities and contingencies in a close-to-reality manner. The concepts underlying the strategic framework are illustrated using a simplified case inspired by our manufacturing partner, a world-class motorcoach manufacturer. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Networked manufacturing; Distributed manufacturing; Collaborative planning; Flexible manufacturing systems; Planning and control strategy; Contingency management; NetMan concepts

1. Introduction

This paper presents the NetMan¹ strategic framework for enabling networked manufacturing. NetMan aims at providing both a framework for the design of responsibility-oriented manufacturing net-

works and a collaborative business methodological framework to operate agile manufacturing networks in a dynamic environment. In the first part, we present some of the main studies influencing the development of our approach. In the second part, we introduce our open-network organization strategy. We present two fundamental aspects in the NetMan organizational framework: the *NetMan centers*, which are the elementary business entities that constitute the manufacturing network organization, and the NetMan networks. We describe the essence of such manufacturing networks and illustrate their application through three network alternatives for a simple case inspired by our manufacturing partner, the world-class bus manufacturer *Prévost Car* from the Volvo group. This enables us to introduce how the NetMan methodology could be used to design hierarchical networks of business entities and to

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¹ The NetMan project is being funded by the Manufacturing and Processing Technology Strategic Grant Program of the Natural Sciences and Engineering Research Council (NSERC) of Canada, and supported by the companies Prévost Car from the Volvo Group and APG Solution et Technologies.

operate such networks. The third part of the paper presents the collaborative relationship strategy. We describe an approach to elaborate collaborative mechanisms between business entities. Finally, the fourth part describes the operational strategy used by the manufacturing entities to realize day-to-day business operations. We use the illustrative applications mentioned above to present the fundamental operational mechanisms.

2. Literature review

Networked manufacturing, and our introduction of the NetMan strategic framework, aim to help manufacturing businesses thrive in the dynamic and open business context emerging with the entry into the 21st century. Browne et al. [2] emphasize, among the current pressures on manufacturing enterprises, the stress caused by the mutations of the business and organizational structures. Critical to these mutations are the roles played by information technology [21,65] and market place volatility. Moreover, globalization forces organizations to recognize that performance is not the feature of a single firm, but the complex output of a network of interconnected individual firm performances. In order to cope with uncertainties within supply chains [69], highlights that organizations have to rethink their business processes, emphasizing on their flexibility [9] and their agility [10,23,49]. Dealing with volatility and uncertainty has become a central theme in manufacturing research (e.g., Refs. [1,6,37,38,44,67]).

These new manufacturing pressures drive the emergence of new manufacturing organizations [70] involving concepts such as decentralization and internal market systems [25,26]. New forms of organization, such as network organizations [40,48,53], extended organizations [2,30,64] and virtual organizations [3,12,41,50,58,61] are explored in this new manufacturing context.

Collaboration and partnership are new leitmotifs in organizations and supply chain management [56], with emphasis on collaborative design and planning. Several major research projects emphasize on the manufacturing and logistic aspects of the collaboration, addressing the problem of enterprise and enterprise-wide modeling and integration [45,66]. Exam-

ples are the CIMOSA project [71] and the TOVE project [18].

Distributed manufacturing is also a strongly emerging research field. In order to implement information system enabling such distributed manufacturing [29], highlight the requirements on manufacturing software applications. Teuwe and Wortmann (1997) and Valckenaers et al. [62] address the new planning system requirements. Collaborative information system application and integration is recognized as a key success factor. Thus, Lin and Solberg [34] present an integrated shop floor control framework. Sikora and Shaw [52] present a multiagent approach for the integration and coordination of computer-based machines in a shop floor. Eberts and Nof [14] present a distributed planning approach for collaborative production. Tsukada and Shin [60] address the problem of distributed tool sharing in flexible manufacturing systems. Duffie and Prabhu [13], Maturana and Norrie [36] and Tharumarajah and Wells [59] address the scheduling and control problem in distributed manufacturing systems. Sikora and Shaw [51] present multiagent coordination mechanisms for the integration of manufacturing scheduling tasks. We can also cite the works related to the Holonic Manufacturing Systems [22,55,63] and to the AARIA project [47]. With the same preoccupations, Gyires and Muthuswamy [24] and Pan and Tenenbaum [46] propose two multiagent frameworks for the integration of widely dispersed enterprises. Finally, Camarinha-Matos and Lima [4] and Song and Nagi [54] present different approaches for the management of virtual enterprises.

Building on this emerging research and our earlier work (e.g., Refs. [19,20]), we introduce in this paper the NetMan strategic framework for enabling the design and operation of agile manufacturing networks. Our introduction is structured around sections devoted to three main strategic issues: the network organization, the collaborative relationships, and the operational processes.

3. NetMan network organization strategy

According to the NetMan organization strategy, a manufacturing business dynamically organizes its

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