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A network approach to operate agile manufacturing systems

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Abstract

This paper presents and illustrates a strategic framework for designing and operating agile networked manufacturing systems. This framework allows to collaboratively plan, control and manage day-to-day operations and contingencies in a dynamic environment. The first section summarizes the NetMan organizational and collaboration strategy. It consists of a dynamic business method to organize and operate manufacturing activities through the configuration, activation and operation of a distributed network of inter-dependent and responsible manufacturing centers. Next, the concepts underlying this strategic framework as well as the technical implications of such an approach, are illustrated, using a detailed case study inspired by a motorcoach industrial partner. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

In this paper, the NetMan² project is presented. NetMan aims to develop an operation system designed to support operations in an agile manufacturing network. It provides a framework to design responsibility-based networked manufacturing systems. The NetMan project also illustrates a collaborative business framework designed to operate

agile manufacturing networks in a dynamic environment. This paper delves further into this aspect. In the first section, the main concepts of the NetMan strategic framework are summarized, building on previous studies that have influenced the development of this approach. Thus, the concepts of NetMan centers and NetMan networks are introduced and compared to other distributed manufacturing approaches such as bionic, fractal and holonic manufacturing systems. Then, the generic and specific aspects of collaboration underlying this approach as well as the multi-agent integration platform approach that is implemented in an agent-oriented prototype, are described. The next section introduces the NetMan Operation System principles through the intensive use of a case study, inspired by the project's industrial partner Prévost Car from the Volvo Group. The implementation of business collaboration mechanisms into an operating manufacturing network are then discussed.

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2. The NetMan strategic framework

The structure of network organizations is different from both the traditional integrated and hierarchical organizations and the pure market form. They are traditionally described as hybrid forms, lying between the previous two (e.g., [1–3]). This kind of organizations has been widely discussed in the management literature (e.g., [1,2,4–15]). Instead of dividing the organization into functional responsibilities and re-integrating them implementing hierarchical relationships between the different levels of responsibility, the network approach builds the organization in a different way. Forrester [16,17] suggested some new ideas for new types of organization design. These ideas are moving toward more “democratic” forms of organization, “moving away from authoritarian control”. Along the same line, organizational governance structures based on the internal market paradigm and describing the organizations as a set of distributed and autonomous business units have also been discussed (e.g., [18–20]).

In the manufacturing systems’ literature, many authors present their work on future manufacturing system approaches whose basic foundations also underlie the NetMan approach. These manufacturing systems, all based on the distribution of autonomous units, concern the bionic manufacturing (e.g., [21–23]), the fractal factory (e.g., [24,25]), and the holonic manufacturing (e.g., [26–30]). These manufacturing concepts are compared in a study carried out by Tharumarajah et al. [31]. This study is used in this paper as a reference to compare the NetMan concepts with these approaches.

The NetMan strategic approach extends these works. The next sections present the main concepts of the NetMan approach. However, the reader is referred to Montreuil et al. [32] and Frayret et al. [33,34] for more information on the NetMan strategic framework.

In the NetMan approach, from a design point of view, a manufacturing business dynamically organizes its operations through the configuration and activation of a distributed network of inter-dependent business entities, called NetMan centers, responsible for fulfilling their own mission and

maintaining business-oriented partnerships between themselves. Following, the nature and the behavior of the NetMan centers are summarized in the next section. Then, the dynamic modeling approach used to design the NetMan networks is described. Finally, the NetMan collaboration strategy is presented.

2.1. The NetMan centers

Each of the NetMan centers involved in a NetMan business network may be an external business, or an internal center. In both cases it is designed according to a business responsibility that specifies precisely its own precise mission agreed upon with the parent business. This mission is expressed in terms of a set of responsibilities, as proposed by Montreuil and Lefrancois [35]. Each responsibility is defined in terms of satisfying some specific set of needs of the center’s clients (in general from the center’s interactors). Within the scope of its responsibility, each NetMan center is self-managed and relies upon other NetMan center partners to fulfill its mission. To do so, it is responsible for making its own strategic, tactical and operational decisions, in interaction with its parent center(s), and especially for fulfilling its commitments. Thus, the NetMan centers constitute the fundamental components of the responsibility network and contribute to the overall business mission. The NetMan centers share key characteristics that are expressed in Table 1. In this context, a NetMan center may rely on different strategies to achieve its mission. According to its capacity and privileges, it may fulfill its mission using four distinct approaches (see Fig. 1). First, it may use its business relationships with actual internal or external partners, or adapt those relationships to new requirements due to environmental changes or new overall or local objectives. Second, it may define new business relationships with existing NetMan centers or new external businesses, and use them. Third, it may exploit its own internal set of resources (data processing capabilities and or physical assets). Then fourth, it may have the privilege of creating and own new NetMan centers and define business relationships with them, and use these relationships. These four approaches allow the partner

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