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COMBINED ALGORTIHMS FOR COLLABORATIVE NETWORKS ADAPTATION

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Abstract: This paper focuses on the adaptation modelling methodology for enterprise networks designed as temporary customer-oriented operational networking of manufacturing small and medium enterprises with no focal participant. The paper outlines an integrated approach for modelling and optimisation of the collaborative networks, and lays the special focus on the structural and parametric adaptation of models describing structure-dynamics control processes in the supply networks as well as on the formal statement of structural and parametric adaptation problems for collaborative networks models.

Keywords: adaptive control, manufacturing systems, process control, system synthesis, modelling methodology

1. INTRODUCTION

The current challenges for manufacturing industry arising from advancing collaborative organisational strategies and information technologies are having profound effect on production management practices. In many industries the conventional vertically integrated business models have been replaced by cooperative relationships the partners in supply chains. This forces the "global players" as well as the small and medium-sized enterprises (SME) to outsource certain activities and to specialize on the key competencies. The specialization forces the SME to ongoing of cooperation strategy. Therefore, the cooperation of SME in supply networks gains significance.

Former approaches and realisations of the integral management of the value chains or the Supply Chain Management (SCM) are predominantly oriented towards hierarchical cooperation and value chains (e.g. Chandra and Kamrani, 2004, Kuhn and Hellingrath, 2002, Tayur et al., 1999). In these approaches the cooperation of the self-responsible enterprises often has a long-term character and is forced by focal enterprises. Those include their suppliers and their distribution network in their own information system and influence and determine the production processes of their partners.

The other form of enterprise collaboration is a concept of Virtual Enterprises (VE) (Camarihna-Matos et al., 2004, 2005). The design of supply chains in a VE is based on dynamic selection of partners from a pool of available suppliers. The special feature of the SCM in VE lies in flexible configurable supply chains, conditioned by an enlargement of alternatives to search suitable partners for the cooperation. In literature, there is a number of various classifications of networked industrial and logistics organizations (Teich, 2003, Camarihna-Matos et al., 2005). In this paper, the term Collaborative Network (CN) is used as general definition for this type of networks.

This paper focuses on the problem of dynamical adaptation of the supply networks designed as temporary customer-oriented operational networking of manufacturing small and medium enterprises with no focal participant. Section 2 outlines study addressing problems of formal representation and mathematical modelling of collaborative production and logistics networks. Section 3 presents the basic principles of the integrated approach for modelling and optimisation of the collaborative networks. Sections 4 and 5 lay the special focus on the structural and parametric adaptation of models describing structure-dynamics control processes in the supply networks as well as on the formal statement of structural and parametric adaptation problems for supply networks models

2. RELATED WORKS

The study addressing problems of formal representation and mathematical modelling of collaborative production and logistics networks is still limited. Most of the literature analyses the traditional supply chains, which have stable structures and determined interactions, and deals relatively little with comprehensive modelling of supply chains design and control in virtual enterprises (Villa and Cassarino, 2005, Boucher and Lebureau, 2005, Ivanov et al., 2004, 2005, Zschorn et al., 2005). The SCM has been a very visible and influential topic in the field of operation research (Tayur et al., 1999, de Kok and Graves, 2004). The books provide a systematic summary of operation research on quantitative models of SCM, especially for inventory management, tactical planning and supply contracts. A closely related topic to the problem addressing in this paper is a research on vendor evaluation and selection (Abdel-Malek and Areeratchakul, 2004). Few studies have integrated risk management into models of networking (Sorensen, 2005, Zschorn et al., 2005). The researches try to classify types of risk and uncertainty, and to develop some suggestions how to plan and control the networks taking into account risk factors. One of the highlights of past researches has been the application of *multi-agent approach* to SCM and VE (Fox et al., 2000, Shen et al., 2001, Swaminathan et al., 1998). A number of researchers have attempted to apply agent technology to manufacturing enterprise integration, supply chain management, manufacturing planning, scheduling and control, materials handling, etc.

Some recent research papers emphasise, that the proper methods of formal representation and mathematical modelling of production networks have to combine elements drawn from various theories such as *Systems Science, Control Theory, Operation Research, Distributed Artificial Intelligence*. However, the disadvantage of the researches grounded in modern systems and control theories regarding complex business systems is that the system elements are being controlled from a centre and cannot change their states and interactions of their own free will (the system elements are passive. In complex business systems the elements are *active* (their can compete and have contradictive aims, interests etc.) The classic methods do not allow developing of practicable complex quantitative models taking into account the goal-oriented (active) behaviour of enterprises. That is why it seems to be sensible to draw the elements from the multi agent theory.

Because the issues on mathematical modeling of collaborative networks are mostly caused by *complexity and uncertainty of the CN,* we start next section with a complex consideration of complexity and uncertainty within the framework of the CN. Then it outlines an integrated approach for modeling and optimization of the CN.

3. INTEGRATED COLLABORATIVE NETWORK MODELING

In the terms of the system theory *a complex system* is characterized by uncertain interactions of the elements, distributed goals, and is described by a number of different model classes. A collaborative supply network can be defined as a complex open system with active independent elements. Complexity and uncertainty of the CN are caused by *interactions of active elements (enterprises), high dynamics* as well as *external and internal disturbances.*

The *uncertain interactions* of partner are the primary cause of the CN complexity. Moreover, additional uncertainty and requirements on models arise from the *activity of network elements* and their free-will interactions. The CN as complex object are described by *various models* (static and dynamic, stochastic and deterministic, analytical and simulation, etc), which have to be interconnected to each other. The CN is also characterized by a set of structures (*multi-level structure*), which are formed while supply chain synthesis (organizational, informational, topological, technological structures etc.). The *dynamic network operation* models are to describe the functioning of the supply chains (changing of order's states, changing of enterprise states with each operation to reflect the consumption of resources, as well as external operations to supply these resources from outside, etc.). By the