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MARINA - METHOD OF ANALYSIS, RECONFIGURATION, AND INTEGRATED NETWORK ADAPTATION

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Abstract: Subject of this contribution is to elaborate a framework of integrated analysis and (re)-synthesis under the terms of uncertainty for collaborative networks (CN). The elaborated concept MARINA (Method of Analysis, Reconfiguration and Integrated Network Adaptation) aims at developing a comprehensive modelling approach for business continuity supporting and continuous adjustment of collaborative networks in accordance with permanent changes of project execution environment. It makes it possible to increase quality of decision-making about the CN reconfiguration based on reflections of synthesis and analysis as well as planning and execution phases of the CN control on the adaptation principles. It also allows comprehensive taking into account three main types of uncertainty regarding a decision maker: factors known to a planning moment, factors unknown to a planning moment, and uncertainty factors emerging while CN execution.

Keywords: adaptive planning and control, collaborative networks, analysis, reconfiguration, adjustment, modelling methodology,

1. INTRODUCTION

The current challenges for manufacturing and logistics arising from advancing collaborative organisational strategies and information technologies have profound effect on management practices. The main advantages of collaborative networks (CN) lie in a faster and more flexible reaction to market changes as well as in cutting of time-to-market through operative distribution and coordination of resources (competencies) in all phases of product life cycle. Participation in enterprise networks is a one of the key factors of the enterprise competitiveness.

The CN must be configured according to project goals and reconfigured in dynamics according to a current execution environment (Ivanov et al., 2007). Recent research to the CN (Teich, 2003, Camarihna-Matos et al., 2005) has been mostly conducted in the area of CN configuration. Various models and algorithms have been proposed to find optimal CN plans, supplier structures etc. However, the CN plans must be also proofed and analyzed regarding their feasibility to ensure *CN stability* (Ivanov et al., 2006). Besides, CN execution is accomplished by permanent changes of internal network properties and external environment. In practise, we also come across deviations from plan and necessity of CN reconfiguration. It requires *CN adaptation* in accordance with the current execution environment and the goals and decisions of the configuration phase. So, reflections of *synthesis and analysis as well as planning and execution* models are needed. The other issue of CN modeling is interlinking of conceptual and mathematical models in order to achieve accurate models (adequate, scaleable, representative) and provides application independence, then the insights gained from analysis of CN model can be used to obtain similar results in real world. To ensure generating stable plans as well as timely and efficient decision making about the CN reconfiguration taking into account above described challenges, a systematic approach is needed.

Subject of this contribution is to elaborate methodological basics of integrated analysis and reconfiguration for collaborative networks (CN), which are characterized by high structure and process dynamics due to flexible customer-oriented networking of core competencies. Typical examples of such CN are networks of small and medium enterprises, supply chains with not-fixed supplier structures, and virtual enterprises. Findings suggest that presented concept MARINA (Method of Analysis, Reconfiguration, and Integrated Network Adaptation) allows comprehensive decision-making supporting in distributed large-scale business systems with decentralized decision making and control. It makes it possible to increase the quality of decision-making about the CN analysis and reconfiguration under the terms of uncertainty to ensure business continuity in the CN.

2. LITERATURE REVIEW

The CN management is composed of network planning (configuration) and control (execution). At each of these stages, problems of CN synthesis and analysis can be distinguished. Although the problem of the CN configuration was presented in details widely in recent research, the research on CN analysis under the terms of uncertainty and CN reconfiguration is still very limited.

CN analysis can be divided into two stages: CN design analysis (planning side) and CN execution analysis or monitoring (control side). CN design analysis is usually performed regarding uncertainty. Uncertainty is a category which is mostly used in relation to risk management. Risk management is a methodological approach to the management of outcome uncertainty. The research (Ivanov, 2007) classified the following types of uncertainty: environmental uncertainty, behaviour uncertainty, uncertainty of goals, (multi-criteria task), and logic uncertainties. Few studies have integrated uncertainty into models of networking (Hallikas et. al., 2004, Ivanov 2007). These conceptual researches try to classify types of risk and uncertainty, and to develop frameworks how to plan and control the networks taking into account uncertainty. (Sorensen 2004) provides an overview of main streams of such a research.

Another research stream deals with mathematical formulation of the CN execution under the terms of risk. As a rule, two uncertainty drivers – demand and behaviour of participants – were considered. There were elaborated valuable approaches using deterministic or stochastic models and game theory. However, these models do not provide any support for decision making in the situations, which do not allow producing deterministic or stochastic models (and we come across these situation more and more in practise)

The risk management can help only with a part of uncertainty factors, which can be estimated by means of stochastic models. It means, this part of uncertainty is something like "certain". We know certainly, which factors may appear. Uncertain is only, whether their will appear or not. In many cases, we do not have enough information to forecast the system functioning by means of stochastic models. This requires *amplifying the risk management concept.*

Research on the *CN execution analysis* and reconfiguration is still very limited. (Fox et al. 2006) contrast *plan repair* and *replanning* in terms of plan stability. By *plan repair* they mean the work of adapting an existing plan to a new context whilst perturbing the original plan as little as possible. By contrast, *replanning* is the work of generating a new plan from scratch without considering stability. Strategies vary from attempting to reuse the structure of an existing plan by constructing bridges that link together fragments of the plan that fail in the face of new initial conditions (Hanks and Weld 1995) to more dynamic plan modification approaches that use a series of plan modification operators to attempt to repair a plan (van der Krogt and de Weerdt 2005). (Fox et al. 2006) identify a new metric, *plan stability*, which they claim to be important in situations, where the safety of the executive, or of equipment deployed by the executive, is a major consideration in evaluating a plan. (Ivanov et al., 2006) define basics of stability analysis and its challenges in the CN settings and present a conceptual model of CN stability analysis and its dynamical interpretation.

(Proth 2006) refers to real-time scheduling. Depending on the kind of problem, two different types of real-time scheduling may be required. The first type consists in assigning tasks to resources without changing the previous schedule. He refers to this kind of scheduling as online assignment using idle periods. The second type of scheduling allows limited changing in the existing schedule. This kind of scheduling is called online assignment with *partial rescheduling*.

(Kopfer and Schoenberger, 2006) consider the online-optimization of problems with several multi-layered objectives, which cannot be integrated in a multi-criteria optimization problem, because they are situated on different decision levels. The authors present an approach for the extension of computer-aided decision systems so that they are capable to make a self-adaptation to a given superordinated objective and apply it to a problem of dynamic vehicle routing and scheduling.

Adaptation is a category, which is directly linked to the reconfiguration. A widely used approach for modeling adaptation processes are complex adaptive systems (CAS). The term *complex adaptive system was* coined by John H. Holland, Murray Gell-Mann and others (Holland, 1995,