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A distributed decision making model for risk management of virtual enterprise

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ABSTRACT

Risk management in a Virtual Enterprise (VE) is an important issue due to its agility and diversity of its members and its distributed characteristics. In this paper, we develop a risk management model for the VE. More specifically, we introduce a Distributed Decision Making (DDM) model for risk management of the VE. The model has two levels, namely, the top model and the base model, which describe the decision processes of the owner and the partners of the VE, respectively. It can be regarded as a combination of both the top–down and bottom–up approaches for risk management of the VE. Here we focus on the case of symmetry information between the owner and the partners. A Particle Swarm Optimization (PSO) algorithm is then designed to solve the resulting optimization problem. The result shows that the proposed algorithm is effective and the two-level model can help improve the description of the relationship between the owner and the partners, which is helpful to reduce the risk of the VE.

1. Introduction

A Virtual Enterprise (VE) is a temporary organization which is created when there is a business opportunity and is dissolved when the business opportunity no longer exists. The VE is designed for multiple purposes, such as enhancing competitiveness, optimizing resource utilization and allocation, expanding scale of the business and taking advantages of the complementary capabilities of the business partners. However, in the paradigm of the VE, there are various sources of risks that may threaten the security of the VE, such as market risk, credit risk, operational risk, liquidity risk and others (Kliem & Ludin, 1997; Wang, Yung, & Ip, 2001). Risk measurement and management of a VE have received considerable interest among researchers and managers of enterprises. Various models and algorithms are developed to provide a more scientific and effective way for managing the risk of a VE. He (1995) proposes a risk assessment method which combines the risk probability analysis with the risk impact assessment. The method incorporates various sources of risks attributed to overseas construction projects. Das and Teng (1998) suggest two basic types of risk in strategic alliances: relational risk and performance risk. The alliance making process is examined in terms of the interactive effects of resource and risk on the orientations and objectives of the prospective alliance partners. This type of alliance is similar to the VE. Grabowski and Roberts (1999) identify four processes which are important to risk mitigation in virtual organizations. These processes are organizational structure and design, communication, culture and trust. They then suggest how these processes may enhance the reliability of the virtual organizations and discuss how thoughtful management of those attributes can mitigate the risk. Ip, Huang, Yung, and Wang (2003) consider minimizing the risk in selecting partners and ensuring the due date of a project in a VE. They propose a risk-based partner selection model. By exploring the characteristics of the problem considered and the knowledge of project scheduling, a Rule-based Genetic Algorithm (R-GA) with embedded project scheduling is developed to solve the problem. Karjalainen, Haahtela, Malinen, and Salminen (2004) use a case study approach to explore the implementation of profit-and risk-sharing mechanisms in a VE. Lack of a shared vision may have been the most important cause for the early decomposition of the VE. Therefore, the trust did not start to accumulate during the cooperation. This would have been imperative for the implementation of profit sharing mechanisms, because risk attitudes seemed to favor hierarchical rewarding mechanisms. Huang, Ip, Yang, Wang, and Lau (2008) focus on two main features of the VE, project mode and uncertain factors. They establish the fuzzy synthetic evaluation embedded nonlinear integer programming model of risk programming for the VE and present a tabu search algorithm with an embedded fuzzy synthetic evaluation for the model. Wei, Lu, and Yanchun (2008) introduce the theory of Fuzzy Cognitive Time Maps (FCTMs) into modeling and evaluating trust relationships and show how relevant is the inter-organizational trust based on trust sources and their credibility. They also propose a methodology by

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taking dynamic nature of trust into account to analyze the evolution of trust in the VEs setting. The established cognitive map illustrates the changes of different factors and their effects on the final trusts.

Much of the existing literature focus on identifying risk, providing risk evaluation method and developing risk management models. Many models proposed in the literature only discuss the risk management issues in a centralized structure and ignore the diversity of the members and the distribution characteristics of the VE. Here, we articulate this problem by introducing a two-level DDM model for the VE based on the DDM theory (Schneeweiss, 2003a, 2003b, 2003c). Our goal is to keep the risk taken by the VE at a reasonably low level by minimizing the aggregate risk level of the VE. We design a Particle Swarm Optimization (PSO) to solve the resulting optimization problem (Kennedy & Eberhart, 1995; Qi, Ruan, Shi, An, & Tan, 2008). We also demonstrate the effectiveness of the proposed algorithm by some numerical examples.

The rest of this paper is structured as follows. In Section 2, we describe the DDM theory and the two-level risk management model for the VE. The PSO is then presented in Section 3. Numerical examples are presented in Section 4. Concluding remarks are given in the final section.

2. The two-level DDM model

In this section, we first present the main idea of Distributed Decision Making (DDM) theory. We then present the two-level risk management model.

2.1. Distributed Decision Making (DDM) theory

Distributed Decision Making (DDM) addresses an important and rapidly developing field in general decision theory. It comprises diverse areas including (1) hierarchical optimization, (2) multistage deterministic programming, (3) multi-level stochastic programming, (4) distributed artificial intelligence (DAI), (5) principal agent theory, (6) contract theory, (7) auction theory, (8) negotiations, (9) group decision making, and many other fields (Schneeweiss, 2003a).

First one observes that in all the aforementioned fields one has more than just one decision. These decisions may support each other trying to arrive at an overall optimum, or they compete with each other resulting in some kind of equilibrium. Of particular importance appears to be the state of information. In case of symmetric information, i.e., in case no private information being present, one occasionally encounters the term 'decentralized decision making' which points to the fact that in principle a central decision might be achievable. Moreover, it indicates that in finding a solution to a complex problem it has to be 'decentralized' into more manageable subsystems. On the other hand, in case of asymmetric information, usually more than one decision maker is involved and one may often reach only some equilibrium state between the various decision making units (DMUs) (Schneeweiss, 2003a, 2003b).

Most of our investigation will be restricted to two levels, like the first and second levels in stochastic programming, or principal and agent in principal agent theory. We therefore use the general notation 'top-level' and 'base-level' which, in view of Fig. 1, is following the notation of a hierarchical setting.

The DDM systems can be divided into those involving only one DMU and those which have to do with more than one DMU. The one-party setting leads, per definition, to conflict-free planning situations. For the multi-party case, on the other hand, one has to distinguish between team and non-team based decision situations. Apart from communication aspects, team based DDM systems resemble one-party systems (Schneeweiss, 2003c).

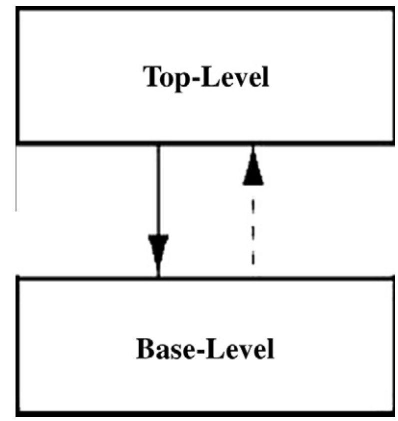

Fig. 1. The framework of two-level DDM.

In what follows, we concentrate on the four main DDM systems, which may be characterized as follows (Schneeweiss, 2003a, 2003b, 2003c):

(1) Constructional DDM (CDDM) systems: team and information symmetry,
(2) Organizational DDM systems: team and information asymmetry,
(3) Antagonistic hierarchical DDM systems: nonteam and information symmetry,
(4) Principal agent DDM systems: non-team and information asymmetry.

In this paper, we mainly focus on the Constructional DDM systems, which is embedded with the VE to separate a complex model into simpler submodels.

2.2. The two-level model

A virtual enterprise (VE) consists of one owner and several partners. Firstly the owner invests on a business opportunity and then invites several partners to join this opportunity. They form a team to work together to finish this business project. In the team, the owner is the dominating decision maker. The partners have to work according to the owner's decision. In the process of risk management, firstly the owner allocates budget among members of VE within the given total budget to minimize the risk level of VE. Then the partners select optimal risk control actions to minimize its risk level under the allocated budget. For the partners, there are various risk factors that affect its risk level and there are various risk actions that can be selected for each risk factor. The risk level is an overall result of all risk factors. In order to get a better decision, the owner has to anticipate the situation of the partners before making decision. In addition, to keep a low risk level of VE, every partner's risk level must be no more than a given level.

Obviously, VE has a typical DDM situation, since the two reasons:

(1) The multi-level feature of design decisions and multiple decision makers,
(2) The coordination problems within the risk management of VE.

For the CDDM systems, the information is symmetry between owner and partners, the owner can anticipate the accurate situation of partners. The decision process of risk management is described by a two-level DDM model, which is demonstrated below.