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Internal pricing strategies design and simulation in virtual enterprise formation

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ABSTRACT

A virtual enterprise (VE) is an organization intended to cope with the rapidly changing manufacturing environment. Organization building is important in virtual domains because it has largely been affecting the success of VEs. However, the process of forming a VE is based on self-determination by the participants. This paper adopts a bargaining model under a scenario of incomplete information to formalize the formation process, considers the characteristics of the VE formation process, presents the pricing strategies for the corresponding bargaining, and verifies the correctness and validity of the pricing strategies using computer simulation. This paper breaks through the relative research that compares the formation process with partner selection from the core enterprise's perspective and also provides the basis for the intelligent information platform of VE, whose key part is pricing software.

1. Introduction

With the rapid globalization, agile manufacturing (AM) was proposed by Nagel and Dove (1991) to satisfy the diversified demands of consumers. In this scenario, the design, development, and manufacturing of products are distributed in geographically different sites, and they are carried out by a so-called virtual enterprise (VE) (Dove, 1995). As pointed out by Camarinha-Matos and Afsarmanesh (1999), a VE is a temporary alliance of enterprises for sharing skills or core competencies and resources to respond to business opportunities. The cooperation among these enterprises is supported by computer networks.

The life cycle of a VE has four stages: formation, operation, evolution, and dissolution (Dess, Rasheed, McLaughlin, & Priem, 1996). When an enterprise has a market opportunity, which is denoted as the core enterprise, it searches potential partners and negotiates with them through information infrastructure. After contracts are signed, a VE is created for the manufacturing of a product. The VE then manages the manufacturing process of a product. When the product is completed, and a new market opportunity is created, the VE can be reconfigured to meet resource requirements. When the mission of the VE is fulfilled, the VE is finally dissolved. In other words, a VE is characterized by frequent reconfigurations (Wu & Su, 2005). The formation process influences the stability of an alliance. Many research works have described the formation process based on partner selection. However, the perspective neglects self-determination during the organization-creating process. On the other hand, given that market mechanism can optimally allocate resource based on the pricing system, we believe in the same bargaining process to describe the formation process of VE to deal with the conflicting utility between the core enterprise and the partners. Designing the VE formation process based on internal bargaining is shown in Fig. 1

Based on Fig. 1 an enterprise has the market opportunity to become the core enterprise. First, the core enterprise decomposes the market opportunity to n task (n is a positive integer). Second, bargaining occurs between the core enterprise and one qualified potential partner for one task. If the two parts reach an agreement and sign the corresponding contract, the core enterprise starts bargaining with other candidates. The VE will be created until it successfully signs the contracts for each task.

This paper is a preliminary study on this direction. It is composed of four parts. In the first part, the paper formalizes the parameters and process of the bargaining for the formation of a VE. During the bargaining, both sides choose the pricing strategy to maximize utility. In the second part, the paper presents the pricing strategies for core enterprise (the same analysis could occur in the potential partner) under time limitation, with the opponent's reserved price unknown. In the third part, the paper simulates the internal bargaining process during which the players adopt the strategies presented in the paper and compare the outcome with the ones produced by linear pricing strategy. By analyzing the simulation consequence, the validity and advantage of the pricing strategies that the participants adopt may be verified. In the last part, the paper summarizes the research work and plans future work.

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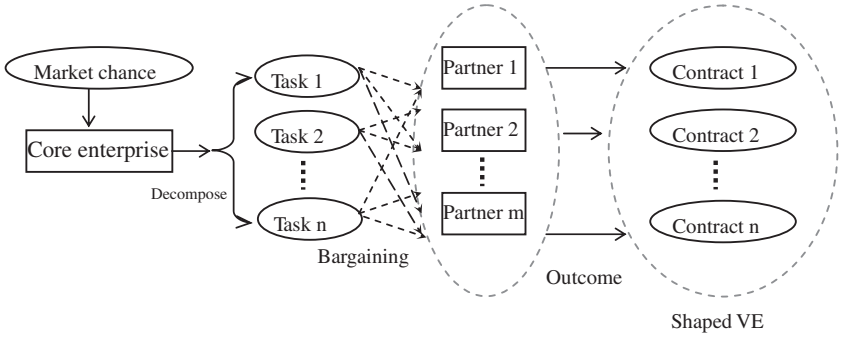

Fig. 1. VE formation process based on bargaining.

2. Related work

In this section, we will discuss the main method to optimize the process of forming a VE and analyze the reason for introducing bargaining to the VE formation. We will then discuss the relative research for bargaining.

2.1. How is a VE created?

As formation is a key stage that influences the following stages of a life cycle, many researchers focus on it. Most works compares the formation process with a partner selection problem, with the core enterprise choosing the partner from qualified ones. For example, Talluri and Baker (1996) proposed a two-phase mathematical programming approach to solve the partner-selection problem in the formation of a VE, where the factors of cost, time, and distance were considered. Wang, Ip, and Yung (2001) developed a fuzzy decision that embedded genetic algorithm to obtain the partner-selection solution with due date constraint in a VE, where the sub-projects form a precedence network. Ip, Huang, Yung, and Wang (2003) described and modeled a risk-based partner-selection problem, and a rule-based genetic algorithm was developed to solve the partner-selection problem. Zeng, Li, and Zhu (2006) proved that the partner-selection problem with a due date constraint in a VE is an NP-complete problem, and a nonlinear integer programming model for this partner selection problem was established. Cheng, Ye, & Yang, 2009 modeled the partner-selection process as a nonlinear integer programming problem, and an Ant Colony Optimization (ACO) algorithm embedded project scheduling was presented for solving the problem with the lead time, subproject cost, and risk-factor constraints in VEs. Genetic algorithm (GA) and enumeration algorithm were introduced for comparison to verify the effectiveness of the ACO algorithm. Sari, Sen, and Kilic (2008) proposed an analytic hierarchy process model to contribute to the selection of the partner companies in the virtual enterprises. A case example was also covered to validate the feasibility of the adoption of the model in virtual enterprise situations. Jarimo and Salo (2009) studied how the selection of partners in a virtual organization (VO) can be assisted through mixed-integer linear programming (MILP) models. In addition to the given fixed and variable costs, extensions that accommodate transportation costs, capacity risk measures, and inter-organizational dependencies, such as the success of past collaboration, were presented in this paper. However, the methods mentioned above supposed that the decision makers are generally sure of their preferences, which is not in accordance with the reality, as the information about the candidates and their performances is incomplete and uncertain during the partner-selection process. Given that some of the decision attributes are subjective and qualitative (Mikhailov, 2002; Wang and Chen, 2007) and that many factors, such as cost, quality, trust, credit, delivery time, reliability, and so on (Wu & Su, 2005) are considered, Ye and Lia (2009) proposed two multi-attribute decision model (MADM) methods for group decision making with interval values to solve the partner-selection problem under a scenario of incomplete information. The first method is a technique for order preference by similarity to ideal solution (TOPSIS) for group decision making based on deviation degree. The second method is a TOPSIS for group decision making based on a risk factor. An illustrative example showed that these two extended TOPSIS methods for group decision making with interval values could effectively deal with the partner-selection problem under a scenario of incomplete information.

The research works mentioned above have a potential hypothesis: the selected partner will join the VE without any hesitation, thus neglecting the self-determination of the potential partners. The neglect makes the coalition's performance unstable. As the matchmaking place is a kind of pure market in terms of structure, the idea of a VE being combined with a virtual market (VM) must be promising. Market mechanism can provide several advantages in the partnering process in VE. We introduced bargaining to the VE formation process, as the pricing process of bargaining can truthfully represent the preference of two sides. In the following sub-section, we will discuss the basic research about bargaining and focus on the work relative to the characteristics of a VE formation.

2.2. Research on bargaining

Bargaining is a process undergone by players to reach mutually beneficial agreements through communication and compromise (Harsanyi, 1956). Here, a player is the one taking part in the bargaining. In such situations, players have a common interest to cooperate but have conflicting interests over exactly how to cooperate. In this context, the main problem that confronts players is deciding on how to cooperate before they actually enact the cooperation and obtain the associated benefits. Each player would like to reach the agreement that is most favorable to it. The bargaining process has four components (Rosenschein & Zlotkin, 1994). (1) **Protocol** specifies the rules of encounter between the bargaining participants. (2) **Pricing strategies** are a specification of the sequence of actions that the player plans to make during bargaining. Many strategies are usually compatible with a particular protocol, each of which may produce a different outcome. (3) **The information state** of players describes the information it has about the bargaining game. (4) **The bargaining equilibrium** game theory prescribes the following main criteria (Osborne & Rubinstein, 1994) for evaluating the equilibrium outcome: *uniqueness*, *efficiency*, *symmetry*, *and distribution*.