Chapter XIII

Virtual Enterprise Coalition Strategy with Game Theoretic Multiagent Paradigm

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ABSTRACT

Nowadays, virtual enterprise (VE) is a crucial paradigm of business management in an agile environment. VE exists in both service and manufacturing organizations, although the complexity of each enterprise in a VE may vary greatly from industry to industry. Obviously, there is a need for a mechanism through which these different functions can be integrated together transparently. In this contribution, we focus on the negotiation process in VE formulation as a basic research to clarify its effective management in terms of partner search. Each enterprise in VE is defined as an agent with multiutilities, and a framework of multiagent programming with game theoretic approach is newly proposed as a negotiation algorithm among the agents. Each unit is defined as an agent in our VE model, and their decision making is formulated as a game theoretic methodology. We develop a computer simulation model to form VEs through multiple negotiations among several potential members in the negotiation domain, and finally clarify the formulation dynamism with the negotiation process.

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INTRODUCTION

Nowadays, VE is a crucial paradigm of business management in an agile environment. VE exists in both service and manufacturing organizations, although the complexity of each enterprise in VE may vary greatly from industry to industry. Realistic VE handles multiple end products with shared components, facilities, and capacities (Camarinha-Matos, 1999). Because the flow of materials in VE is not always along an arborescent network, various modes of transportation may be considered, and the bill of materials for the end items may be both deep and large (Ganeshan, 2004).

Traditionally, marketing, distribution, planning, manufacturing, and the purchasing organizations operated independently. These organizations have their own objectives, and these are often conflicting. Marketing’s objectives of high customer service and maximum sales conflict with manufacturing and distribution goals. Many manufacturing operations are designed to maximize throughput and lower costs with little consideration for the impact on inventory levels and distribution capabilities. Purchasing contracts are often negotiated with very little information beyond historical buying patterns. The result of these factors is that there is not a single, integrated plan for the organization — there were as many plans as businesses. Clearly, there is a need for a mechanism through which these different functions can be integrated. Although cooperation is the fundamental characteristic of the VE concept, due to its distributed environment and the autonomous and heterogeneous nature of the VE members, cooperation can only succeed if a proper management of dependencies between activities is in place, just like supply-chain management (Fisher, 1994; Goldratt, 1983).

We focus on the negotiation process in VE formulation as a basic research to clarify its effective management. Each enterprise in VE is defined as an agent with multiutilities, and a framework of multiagent programming with game theoretic approach (Von Neumann, 1947) is newly proposed as a negotiation algorithm among the agents. Although there are several researches about multiagent-based VE systems, most are mainly related to IT systems architecture rather than to negotiation algorithm (Rabelo, 2000; Dignum, 2002; Shen, 1999). Our approach is dedicated to the VE negotiation mechanism so as to facilitate effective VE partnering with rationality. Each unit is defined as agent in our VE model, and their decisions are formulated as a game theoretic methodology. We adopt the contract net protocol (CNP; Smith, 1980; Durfee, 1987) as the coordination and negotiation mechanism among the units. CNP models transfer control in a distributed system with the metaphor of negotiation among autonomous intelligent beings. CNP consists of a set of nodes that negotiate with one another through a set of messages (Kaihara, 2002a, 2002b, 2002c). Nodes generally represent the distributed computing resources to be managed, corresponding to “enterprises” in this chapter.

Additionally, we introduce an adaptive behavior (i.e., learning effects) into our VE model, by adopting a reinforcement learning algorithm (Sutton, 1998) into the node so as to attain the dynamic evaluations with time domain. We develop a computer simulation model to form VE through multiple negotiations among several potential members in the negotiation domain, and finally clarify the macro VE formulation dynamism with the micronegotiation process.