Partner Trust Evaluation Method of Virtual Enterprise

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Abstract: Post-crisis era, the trust and reputation problems in the cooperative enterprises have highlighted the risk of virtual enterprise, Virtual Enterprise trust evaluation model is presented based on QFD method, trust evaluation set and trust evaluation grades at first. Then, project schedule optimal model base on reputation is given integrating push and pull inventory mechanism which reflects that reputation is the center of modern management concepts according to the principle of maximizing long-term interests. Finally, the relative optimal algorithm is discussed for implement during partner selection and profits distribution of virtual enterprise. Furthermore, decision-making model is given by Reputation-based incentive mechanisms.

Key words: Virtual enterprise, evaluation method, trust, QFD

INTRODUCTION

During the second half of 20th century, the rapid development of information technology promotes the globalization of markets. The users have diversified and personalized demands so that the product life cycle has become shorter and shorter. In order to adapt to the flexible market, virtual enterprise emerged and has been considered to be the main form of enterprise organization in 21th century (Bishr and Mantelas, 2008). Based on the mutual trust, it establishes a long-term alliance whose members include manufacturers, suppliers, distributors and customers (Porter, 1990). “Mutual trust” is not only the basis of cooperation and mutual success but also the precondition of the realization of the agility of virtual enterprise. The “long-term alliance” is aimed to accumulate the credibility and reputation of enterprises which is the important factor for partner selection. Therefore, trust and reputation plays an important role in the operation of the virtual enterprises. With the American financial crisis, the European debt crisis and international trade protectionism, the loss of credits between countries spread to the enterprises. The increase of uncertain factors led to the worse situation of losing credibility in global manufacturing industry. Trust crisis and credit deterioration in the cooperative enterprises have highlighted the risk of virtual enterprise.

TRUST EVALUATION MODEL USING QFD METHOD

QFD is applied in a wide variety of services, consumer products, military needs and emerging technology products. The technique is also used to identify and document competitive marketing strategies and tactics. We use QFD to trust evaluation of partner in virtual enterprise as shown in Fig. 1. In this hypothesis, where is:

- $S_i$ (i = 1, 2, ..., m) stands for the Trust improvement demands and $w_i$ is the weight of $S_i$ (Pan, 2001)
- $Q$ is the autocorrelation matrix of $S$, $q_{ij}$ (i, j $\epsilon$ [1, m]) is the correlation coefficient of $S_i$ and $S_j$
- $P$ is autocorrelation matrix of improvement measures $e_i$, $j$ $\epsilon$ [1, n], $p_{ij}$ is the correlation coefficient of $S_i$ and $S_j$ as shown in Table 1, i, j $\epsilon$ [1, n]
- $R$ is relationship matrix of $S_i$ and $e_i$, $r_{ij}$ is the correlation coefficient of $S_i$ and $e_j$, i, j $\epsilon$ [1, n]
- $D$ is the column vector of $d_i$ (i = 1, 2, ..., m) which is the current trust improvement
- $D^*$ is the column vector of $d^*_i$ (i $\epsilon$ [1, m]), target trust improvement value whose grades shown in Table 2
- $C$ is the factors affecting on trust, $c_i$, (i = 1, 2, ..., n) is the correlation coefficient of $e_i$ and $c_i$
- $H_i$ is the trust improvement rate, $H_i = (\lambda_i - \mu)/\mu$, $\mu$ is the current value, $\lambda_i$ is the improved trust value

PROJECT SCHEDULE OPTIMAL MODEL BASE ON REPUTATION

We regard reputation as a positive incentive of partner selection and profits distribution of virtual enterprise, so that increase and decrease the credibility would have incentives and penalties to business interests. Based on the above ideas, project schedule model of virtual enterprise can be setup according to the principle of maximizing long-term interests which reflects the reputation as the center of modern management concepts.

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Suppose virtual enterprises should complete m tasks to produce n products within the planning period [1, T]. $d_i(t)$ is the order quantity of product i in day t. It is known the $w_i$ stands for unit production capacity of product i needs the resources $c_i$, $z_i$ is cost to keep a contract , $p_i$ is the cost to break a contract, $i = 1, 2, ..., n$. The enterprise available capacity of day t is $C_i(t), j = 1, 2, ..., m, t = 1, 2, ..., T$. The initial storage capacity of product i in $I_i$, $i < 0$ indicates less production, $i = 1, 2, ..., n$. Establishment of incentive mechanisms based on $I_i$ will play a positive role for the maintenance of enterprise credit. Assuming a dynamic credit of enterprise $V_i$ is with proportional to $I_i$, there are: $V_i = K \cdot I_i + N$ (Shi-Hua and Yong-Lin, 2000).

Storage capacity can be expressed as $I_i = (V_i-N)/K, K>0$. $K$ is the proportionality constant, $N$ is fixed constant.

$$\min F(P) = \sum_{t=1}^{T} \sum_{i=1}^{n} w_i (V_i - N)/K + \sum_{i=1}^{n} p_i(k) - \sum_{t=1}^{T} d_i(t)(k)^+ + \beta_i \sum_{t=1}^{T} d_i(t) - \sum_{t=1}^{T} p_i(k) - (V_i - N)/K)^+$$

subject to \( \sum_{i=1}^{m} w_i \rho_i(t) \leq C_i(t), t = 1, 2, ..., T, j = 1, 2, ..., m \)

\( p_i(t) \geq 0, i = 1, 2, ..., n, t = 1, 2, ..., T \)

\((x)^+ \) stands for max(0,x)

The planned production capacity of product i in day t is $p_i(t), i = 1, 2, ..., n, t = 1, 2, ..., T$, then keep or break contract plan model (PO) as follows, namely, how full use of the effective resources to breach the minimum amount of punishment during planning period.

Since, the objective function of the above plan (PO) is nonlinear, cannot use ordinary mathematical programming method for solving. Let $x_i(t)$ and $y_i(t)$ were
the more or less on the production of product i, taking into account the role of credit rating maintained, there:

$$x_i(t) = \frac{(V_i - N)}{K} + \sum_{i \in I} p_i(k) - \sum_{i \in I} d_i(k), \quad y_i(t) = \sum_{i \in I} d_i(k) - \sum_{i \in I} p_i(k) - \frac{(V_i - N)}{K}, \quad i = 1, 2, ..., n, t = 1, 2, ..., T$$

(2)

**Definition:** $x_i(0), y_i(0)$ are yield or less production of product i at end of the last plan period, apparently $I = x_i(0) - y_i(0)$, according to the significance of each variable, the following recurrence formula:

$$x_i(t) = y_i(t) - x_i(t - 1) + y_i(t - 1) + p_i(t) - d_i(t), \quad i = 1, 2, ..., n, t = 1, 2, ..., T$$

(3)

Take $x$, $y$ as variables, the P0 can be transformed into the following standard form linear program (P):

$$\min \text{F}(P) = \sum_{i \in I} \sum_{t \in T} [x(t) + \beta y(t)]$$

$$\text{st.} \sum_{i \in I} \sum_{t \in T} [x_i(t) - y_i(t) - x_i(t - 1) + y_i(t - 1)] \leq C(t) - \sum_{i \in I} \sum_{t \in T} d_i(t), \quad t = 1, 2, ..., T$$

$$x_i(t) - y_i(t) - x_i(t - 1) + y_i(t - 1) \geq 0, \quad i = 1, 2, ..., n, t = 1, 2, ..., T$$

$$x_i(t) \geq 0, y_i(t) \geq 0, \quad i = 1, 2, ..., n, t = 1, 2, ..., T$$

(4)

Solving the linear problem, the production of i in the day t, namely $F(t)$, can be determined by the formula:

$$p_i(t) = d_i(t) + x_i(t) - y_i(t) - x_i(t - 1) + y_i(t - 1), \quad i = 1, 2, ..., n, t = 1, 2, ..., T$$

(5)

The key to solving the problem is as follows:

**Step 1:** Determination of $\alpha_i$ and $\beta$, the business factors affecting on keeping or breaking contract of Virtual Enterprise are shown as Table 1. Let $\alpha_i$ is the j kind of cost to keep contract of product i, $W_i$ is the weight of stock cost in advance which can be given by AHP method or empirical formula. The calculation of the cost to break contract is similar to keep it, there are:

$$\alpha_i = \sum_{m \in M} w_i \times \alpha_i, \quad \beta_i = \sum_{m \in M} w_i \times \phi_i$$

(6)

In general, $\alpha_i$ and $\beta_i$ are respectively for early and tardiness factor, $\alpha_i$ and $\beta_i$ can be solved using the following formula:

$$\alpha_i = \alpha \times p_i, \beta_i = \beta \times p_i$$

(7)

**Step 2:** The constraint number of original problem (P0) is $m \times T$, when $m$ is large, the scale of the problem becomes too large to solve.

With the increasing of uncertainties in the world, whether keeping contract or not depends not only on the task of capacity constraints but also on exchange rates, raw material costs. Removing the force majeure, such as trade regulation, trade protection, only the real capacity constraints of those "bottleneck task" determine whether a company keep contract or not. The "bottleneck task" refers to the task with longer completion time on the critical path, it can be pointed by setting a time threshold. The task whose occupied time longer than the threshold is the "bottleneck task" (Pan, 2004).

Suppose $I_j$ is the "bottleneck task" located at time $t$ which constituted by tasks taking the j kind of resource to produce the i products, $i = 1, 2, ..., n, t = 1, 2, ..., T$. RP is a plan with relaxation and constrained only by $I_j$.

Based on the above analysis, we give the following virtual enterprise project schedule algorithm:

- According to the nature of virtual enterprise, manufacturing process framework and its subclassification process are setup
- Taken the centralized control tasks in the framework to compose a directed graph G for task network
- Identify the critical path in the directed graph
- Identify the "bottleneck task" on the critical path, namely $\{I_j\}$
- Solving RP only constrained by $\{I_j\}$ and get the optimal solution $x^*, y^*$ and $p^*$
- Check all constraints on the feasibility of $p^*$, if all constraints can be satisfied, then $p^*$ is the optimal solution, stop. Otherwise, all the constraints not meet are added to the Relaxed Plan (RP) and will turn (Table 3)
CONCLUSION

In this study, we presented our experience on optimizing project schedule of virtual enterprise. The trust evaluation applied QFD analysis to analyze the factors of trust crisis and credit deterioration in the countries, then cooperative enterprises and afterwards inside their own enterprise. We obtained preliminary results on trust crisis in virtual enterprise is of the increase of uncertain factors. Our results based on trust evaluation indicate that decision-making model should be based on reputation and trust incentive mechanisms should be built ASAP to avoid the risk of partner selection in virtual enterprise.

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