AN ORDER ALLOCATION MODEL IN VIRTUAL ENTERPRISES BASED ON INDUSTRIAL CLUSTERS

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Abstract: To build virtual enterprise based on an industrial cluster is one of the most important ways to improve the agility and competitiveness of manufacturing enterprises. One of the key factors towards the success of virtual enterprises is the correct selection of cooperative partners. The approach proposed for order allocation and partner selection is composed of two stages: task-resource matching and quantitative evaluation. In the first stage the potential candidates are identified and in the second stage evolutionary programming is applied. The architecture for information evaluation and order allocation is studied for the proposed approach. The target function, in which the load rate of candidate enterprise is taken as the main variable, is developed, and a simplified example is used to verify the feasibility of the proposed approach. The result suggests that the proposed model and the algorithm obtain satisfactory solutions.

1 INTRODUCTIOIN

The manufacturing industry in the 21st century is faced with a rapidly changing market demands and global competition. Customers require that manufacturing companies make more products with high quality, low cost, quick delivery, short lead time, perfect service, as well as the personalization of the products. From the early 90s of last century, agile manufacturing has become a popular philosophy and an important enabling tool.

Partner selection and order allocation are very important problems in virtual enterprise. Early literatures on partner selection have been mainly qualitative and focused on methodological aspects. Then quantitative methods are employed to study partner selection problem. Tulluri and Baker (Talluri S and Baker R.C, 1996) proposed a two-phase mathematical programming approach for partner selection by designing a virtual enterprise where the factors of cost, time and distance were considered. Zhao Fuqing (Zhao Fuqing et al, 2005) proposed a multi-objective optimization model and took into account the factors of cost, due date, and the risk of failure at the same time. Order allocation problem in virtual enterprise is attracting increasing attention in recent years. A. Hammami proposed a method to calculate satisfying routes for customers' orders within manufacturing networks of small-medium enterprises (A. Hammami et al, 2003). Ruengsak Kawtummachai et al constructed an algorithm to deal with order allocation and minimize the total purchasing cost in a supply chain (Ruengsak Kawtummachai et al, 2005).

The above literatures studied partner selection and order allocation separately. However, order allocation is sometime coupled with partner selection in a virtual enterprise. Moreover, production load rate of each entity in virtual enterprise is one of most important factors for partner selection and order allocation problems.

Industrial clusters are generally defined as geographic concentration of interconnected companies and institutions in particular business field according to the relationship of specialization

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and collaboration. In China, there are many typical industrial clusters, such as plastics injection machine industry in Ningbo, shoe making companies in Wenzhou, Zhejiang province, and so on.

2 ORDER ALLOCATION

2.1 Problem Description

When one of the companies in an industrial cluster gains an order, and if it is too large for its own capacity, a good way for this company (dominant company) is to allocate order among a group of manufacturing companies in the cluster. The dominant company needs to review the core competencies and the production load of the candidates in the cluster and decide how to allocate the order. An order allocation oriented to the horizontal virtual enterprise model based on evolutionary programming is proposed according to the above two aspects of information in this paper.

This approach consists of two stages: task-resource matching and quantitative evaluation. In task-resource matching stage the dominant company search for the candidates according to the product's manufacturing features and the candidates' resources information. In the light of the parameters in the model, evolutionary programming is applied

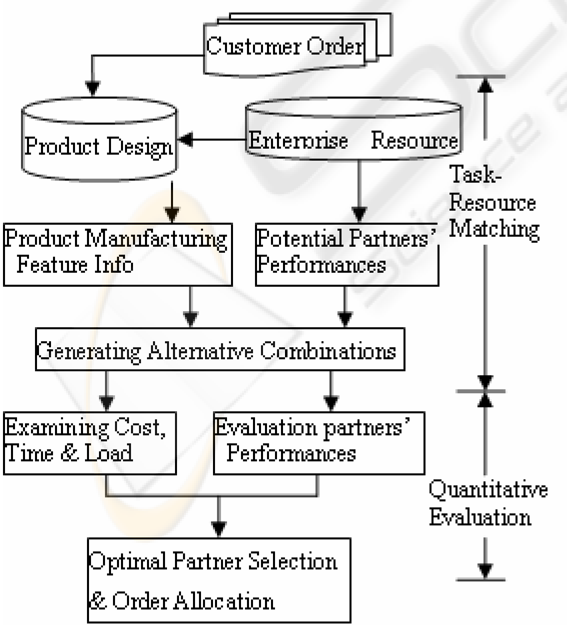

Figure 1: An outline of the approach for optimal model.

to optimize partner selection and order allocation in the second stage. Figure 1 illustrates the relationship of two stages.

2.2 Task-Resource Matching

Task-resource matching means that products' features should match companies' manufacturing capacities. By using definite search algorithm, all the potential companies that are qualified for the manufacturing tasks will be found. For achieving the above procedure, companies' manufacturing resources database should be built to improve the efficiency and effectiveness of the search and match. The requirements of search and match are that the manufacturing capacities of companies' combination cover the requirements of collaboration tasks.

2.3 Quantitative Evaluation

To identify the proper partners and assign corresponding volume of orders is the key task of the second stage. An evolutionary programming method is used to gain the results.

The problem can be described as follows. There are n candidates in an industrial cluster, and the target function and the constraints are modeled as follows:

$$M\inf = \max\{T_1, T_2, \cdots, T_n\} \bullet \sum_{i=1}^{n} num_i C_i \quad (1)$$

$$s.t. \quad \sum_{i=1}^{n} num_i x_i = 100 \quad (2)$$

$$T_i = num_i / (CP_i \bullet (1-\rho_i)) \quad (3)$$

Where: $i = 1, 2, \cdots, n$; T_i is the lead time of candidate i ; num_i is the volume of products corresponding candidate i ; C_i is the cost of each product in candidate i ; x_i is the candidate which is selected to combine into the virtual enterprise; CP_i is the competences of candidate i ; ρ_i is the production load rate of candidate i .

For the evolutionary programming, the natural number string is selected as the gene description. Let $w = \{w_1, w_2, \cdots, w_n\}$, where w_i is a natural number between 0 and m_i. That stands for the number of volume of orders corresponding candidate i.

2.4 System Architecture

Based on the order allocation oriented to the horizontal virtual enterprise model mentioned above, the system architecture was proposed for information evaluation and order allocation system (IEOAS) as shown in Figure 2, which contains five function modules, and a knowledge base and partners' databases.

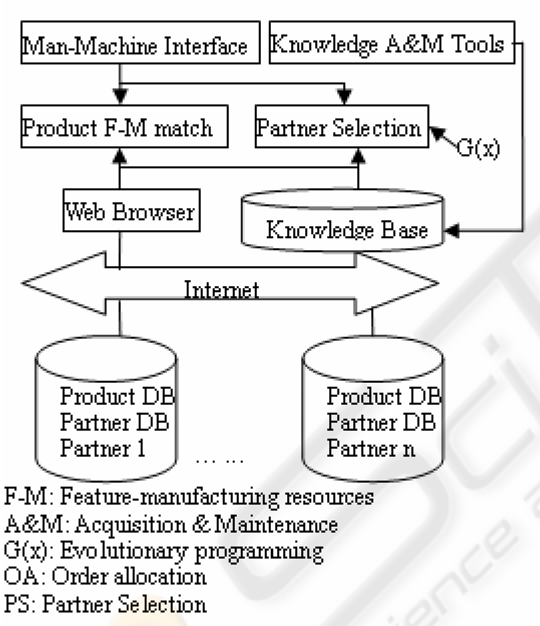

Figure 2: Architecture of IEOAS.

3 NUMERICAL EXAMPLE

To illustrate the approach presented in this paper, a simplified example by using evolutionary programming is described below.

There are the parameters of the numerical example. Six candidates and the corresponding parameters were given shown in Table 1.

Table 1: Performance index of each candidate.

Items \ CCN	1	2	3	4	5	6
C_i	0.75	0.35	0.98	1.05	2.00	1.56
CP_i	10	30	24	37	9	45
ρ_i	0.30	0.80	0.75	0.65	0.12	0.97

Note: CCN: candidates code number in Table 1.
The total number of orders is 100 units;
The population size is 20;
The condition to end iterative process is 10000.

The evolutionary programming can obtain the second-optimal solution and cost less time than many other programming methods such as integer or mixed integer programming if the size of problem is very large. The target function converges 0.8981 when the iterative number is 1930, and the quantum of each candidate is allocated. The result is shown in Figure 3.

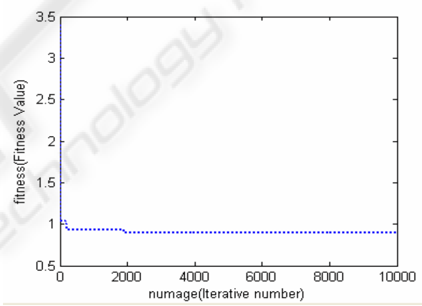

Figure 3: Target function value change curve.

Since our optimal target is the lead time and cost, the lead time of each enterprise is almost equal shown as Table 2. From comparing the lead time of each candidate, it is evident that the deviation among the candidates is very small. The biggest value is 2.57 and the smallest value is 2.02.

Table 2: The results of order & Time.

Items	1	2	3	4	5	6
ρ_i	0.30	0.80	0.75	0.65	0.12	0.97
num_i	18	15	15	33	16	3
T_i	2.57	2.50	2.50	2.55	2.02	2.22

4 CONCLUSIONS

In order to improve the agility and competitiveness of manufacturing companies with similar products in industrial clusters, horizontal virtual enterprises are suggested to be an effective enabler. During the development and operation of the virtual enterprises based on industrial clusters, a two-stage approach is employed, in which there are a task-resources matching and a quantitative evaluation stages. In the second stage, evolutionary programming is applied. Meanwhile, the architecture of network system is studied in relation with the algorithm. The study shows that production load rate should be considered as a very important factor in partner selection and order allocation to achieve the equilibrium of production load in all the involved enterprises. Then the overall improvement of agility and competitiveness can be obtained within the enterprises.

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