PORTFOLIO SELECTION BASED ON ANALYTIC HIERARCHY PROCESS AND EVOLUTIONARY COMPUTATION

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Abstract: This paper refers to the supplier and product evaluation and selection process in business sphere. This problem is more and more emphasized, because suppliers' rating is an important part of strategic decision making. This paper proposes information system for selection of optimized portfolio based on the analytic hierarchy process supported by genetic algorithm. The proposed combination of methods helps to select a suitable supplier/product and a comprehensive portfolio of products meeting the requirements of customer, which are mostly cost and quality of products.

Keywords: supplier selection, portfolio selection, analytic hierarchy process, genetic algorithm

1 INTRODUCTION

With the increasing globalization of markets and the increasing competition, companies are under an endless pressure, which forces them to find new ways to reduce material and production costs, improve quality of services and increase an added value for end customers. This problem is closely related to finding a qualified supplier and to selection of suitable products which will be offered to the end customer. The process of evaluation and selection of suppliers/products (see Fig. 1) is a typical multi-criteria problem that includes both qualitative and quantitative criteria [1].

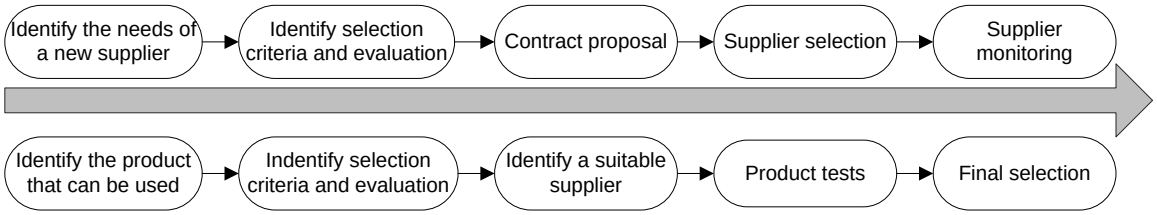

Figure 1: The selection process of supplier and product.

The main contribution of this paper is to design an information system for evaluating suppliers/products and for automatic optimization of product mix meeting the customers' requirements. The main goal is to demonstrate solvability of this problem by genetic algorithm. The optimization method is based on an analytic hierarchy process and genetic algorithm. The proposed system supports the quality management of services offered to customers and supports shopping process from choosing the suitable supplier, individual product, and comprehensive proposition of product portfolio created by automatic combination of different options which could be done by human operator only in a very difficult and time consuming way [1]. This paper presents a practical application of the information system in a commercial sphere. The system can be applied in many various areas of production and sales to save costs and comprehensively promote the purchase process.

The rest of the paper is structured as follows. The second chapter briefly mentions current approaches used in the evaluation and selection process of suppliers/products. The third chapter describes the model of the system. The fourth chapter demonstrates practical results. The fifth chapter summarizes results and possibilities of future work.

2 RELATED WORK

Over the past few years a large number of approaches based on different methods have been tested. The literature dealing with the approaches to evaluating suppliers and products includes the publications [3], [4], [5], and [6], which map the commonly used methods and the newly proposed methods. The methods can be divided into two groups, the individual methods using just one approach and the integrated methods which combine the individual methods.

Data envelopment analysis (DEA), which was used in 18% of publications [5], is a very popular method. Other methods which deserve attention are methods of mathematical programming, which includes linear and nonlinear programming, goal programming, and multi-criterial programming. These methods have been used in almost 12% of publications. Very popular method in practice based on fuzzy logic was used just in 4% of publications. Another large group, with 22% in total, are analytical processes - hierarchical and network process and their derivations. Analytic hierarchy process (AHP) is a very popular method. About 17% of the total number of all methods, not just integrated methods, are based on the AHP. The paper [5] describes other methods which are negligible in terms of use.

The AHP is one of the methods of multi-criteria decision making and was developed by Prof. Thomas L. Saaty [7]. The method provides a comprehensive and logical approach to structuring of a problem, in order to qualify the elements associated with the objectives and for evaluating alternative solutions.

3 PROPOSED SYSTEM

First, the system operator has to select the criteria for selection process which are the input for the whole calculation process. These criteria are chosen from 23 criteria defined by Dickson [2] in 1966. After the criteria selection, the operator must make a pairwise comparison of criteria, which will determine their priority. Weights of criteria that are later involved in the evaluation calculation of the supplier and product are calculated on the basis of pairwise comparison.

The next step is to select suppliers and products which will participate in evaluation process. If it is needed to add new data, an information dialog with the relevant data about the supplier/product must be filled in and values must be assigned to all criteria. These criteria are rated from 1 to 10, where 10 is the best suitability of criterion. This value indicates how well the criterion is met based on a scale defined by shopping department. After the selection process, the supplier/product score is calculated. Based on this score itself it is possible to select a suitable supplier or product. The calculation of the score S is based on a simple formula:

$$S = \sum_{i=0}^{m} w_i \cdot c_i \tag{1}$$

where m stands for a number of criteria which are involved in evaluation process, w stands for a weight of criterion calculated by analytic hierarchy process, and c stands for a criterion evaluation according to its suitability to scale defined by shopping department. Based on equation (1) the whole product portfolio is evaluated:

$$F = \sum_{i=0}^{n} s_i \cdot p_i \tag{2}$$

where n stands for a number of items in product portfolio, s stands for an evaluated value of supplier, and p stands for an evaluated value of product. Based on the computed value of product portfolio F is a working genetic algorithm that tries to maximize the value, therefore the value F is called a fitness value. The whole process of finding a suitable product portfolio is depicted in Fig. 2.

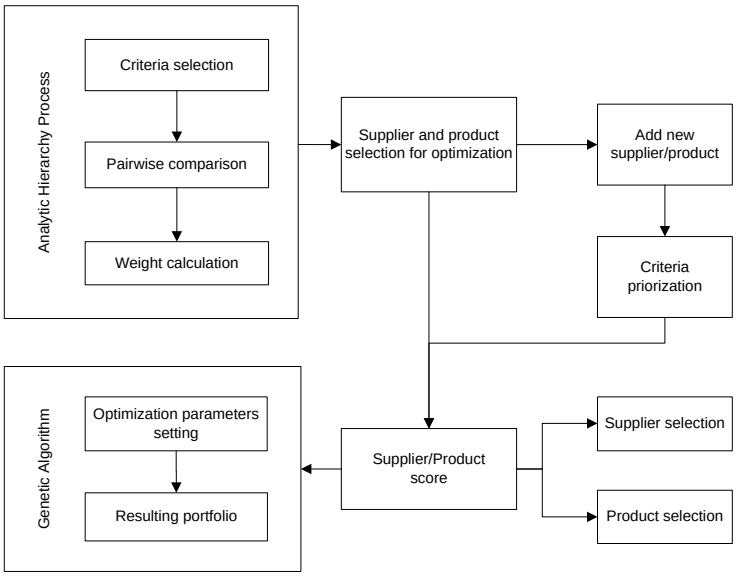

Figure 2: The proposed system for suppliers/product evaluation and portfolio optimization

4 USE-CASE EXAMPLE

The implementation of the proposed information system was tested in practice for an advertising company which deals with embroidering of different types of textiles [1]. In this case it was necessary to select a suitable choice of suppliers and textiles, because each of the suppliers provides several variants of textiles, differing in textile weight, color, packing, etc. For each property of textile the shopping department has created a scale to determine the score of each textile. Based on this assessment, an evaluation of products and the actual portfolio, which consisted of different products from different suppliers, was calculated.

The evolutionary optimization proceeded with the following settings. Experimental calculations (see Fig. 3 and Fig. 4) have verified that the sufficient number of evolutionary steps to achieve optimum results is 5. In every generation 10 individuals were involved. The calculation was performed relative to this rate of genetic operators: 80% of population was recombined by crossover and 20% of population was mutated. These parameters were selected based on the size of a testing set of data. The testing set included 6 suppliers, 8 groups of products and every supplier was represented by at least one product in each group of products. That is minimally 48 products in total.

The system operator has selected the criteria depicted in Tab. 1. Weights of those criteria were calculated by an AHP on the basis of pairwise comparison made by operator. Weights of the criteria are depicted in Tab. 1. As it can be seen, the largest claims in the process of supplier selection were

given on the quality and price of delivery. In terms of product the largest claim was given to its price per unit.

Criterion for supplier	Weight	Criterion for product	Weight
Quality	0.3761	Price per unit	0.6318
Price	0.3638	Quality	0.2655
Delivery	0.1536	Package	0.0964
Communication system	0.0519		
Repair service	0.0547		

Table 1: Criteria for supplier and product selection

Fig. 3 shows the progression of the whole population in evolution process and Fig. 4 presents the progression of the best individual in each population during the evolution process. The average time of evolution process was 35.4s (simulated on CPU Intel C2D E8400). The lowest price for order was CZK 1162.00 (see Fig. 4, 8th measurement), the highest price was CZK 1552.00. As it can be seen, the saving is CZK 390.00. That is not too much, but for an end customer it can be a significant saving.

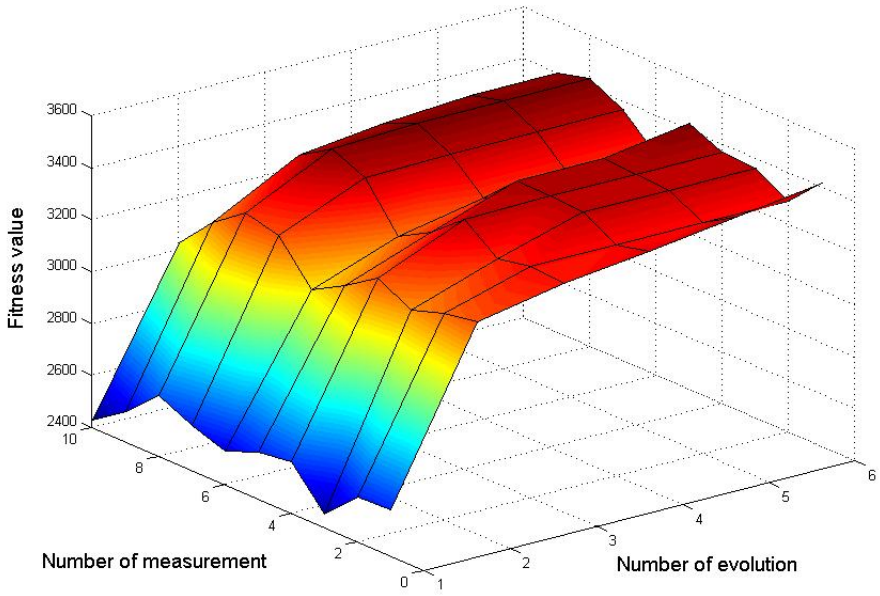

Figure 3: The evolution of whole population

5 CONCLUSION

The implementation of the proposed information system for evaluation of suppliers, products and for optimizing the shopping process will enable the company to introduce greater efficiency and transparency of the supplier selection process, to control easily the quality and price of product portfolio for the final customer, thereby increasing the competitiveness of firms on the market.

The paper demonstrated a basic application of the proposed information system. Much more interesting results in terms of savings could be seen with a much larger number of data and prices differing in thousands, ten thousands or more.

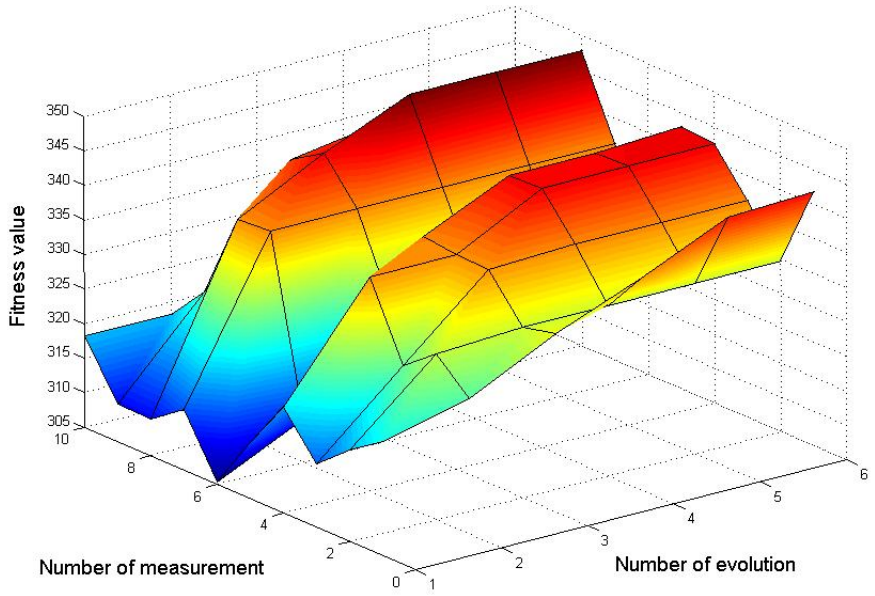

Figure 4: The evolution of the best individuals in each population

The proposed system can be incorporated into well-known information systems or used as a standalone product. Possible further extensions could include the implementation of the analytic network process, which allows to address the links between the criteria.

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