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Design of a Customer's Type Based Algorithm for Partner Selection Problem of Virtual Enterprise

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Abstract

Virtual Enterprise (VE) is a temporary platform for individual enterprises to collaborate with each other, sharing their core competencies to fulfill a customer demand. In order to improve the customer satisfaction, the most successful VEs select their consortium's members based on customer's preferences. There is quite extensive literature in the field of partner selection in VE, each proposing a new approach to evaluate and select the most appropriate partners among pool of enterprises. However, none of the studies in literature recommend which partner selection methodology should be used in each project with a particular customer attitude. In this study an algorithm is proposed which classifies the customers into three categories; passive, standard and assertive. Three different approaches; Fuzzy Logic- FAHP TOPSIS and Goal programming are used for each customer type respectively. This classification is beneficial since the problem's characteristics; such as vagueness of data, change as the customer's attitude varies. The results certify that, adopting this algorithm not only helps the VE to select the most appropriate partners based on customer preferences, but also the model adapts itself to each customer's attitude. As a result, the overall system flexibility is significantly improved.

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1. Introduction

Today's global market leads to an ever increasing competitive environment for manufacturers. In this respect, manufacturing enterprises are under continuous pressure to produce high quality products with competitive prices

through efficient operations. Furthermore, vast improvements in communication technologies made international markets, rapidly changing environment that requires quick response to each arising demand. Therefore, an enterprise needs variety of resources to remain in the market which is, surely, would be costly for a Small and Medium sized Enterprises (SME). On the other hand, even the large enterprises are not completely advantageous because their complex structure are not flexible enough to adapt to frequently changing demand. These issues inspire organizations to work within cooperation based platforms; so that, they can participate in demanding projects while taking just partial responsibilities of a large scale project.

Virtual Enterprise is a successful example of this concept. By definition, VE is a temporary alliance of independent enterprises that collaborate with each other to share their core competencies and respond to a certain demand of the customer and once the goal is accomplished the consortium dissolves (Camarinha-Matos & Afsarmanesh, 2009). Via VE framework, each partner of VE brings its expertise to accomplishing the main project. Therefore this cooperation results in high quality products based on customer's specific requirements while maintaining the agility of the whole structure.

Generally, the first step in forming VE is triggered by a request from a customer. Fulfilling the requirements of this demand would be defined as the upcoming project for VE. Based on the project's manufacturing requirements and design specifications, VE project is divided into its subprojects. The responsibilities of each subproject would be given to each partner of VE. Not surprisingly, the success of VE highly depends on the performance of its partners. Hence, it is crucial to select the most appropriate enterprises while there might be tens of enterprises volunteering to take role in the project. Traditionally partner selection problem was based on price only. Most of the researchers treated the problem as a cost optimization model (Hsieh & Lin, 2012), (Zeng, et al., 2006) (Jarimo & Salo, 2009). But this approach may result in low quality products with low service and low reliability. Subsequently, it was argued that, partner selection problem is not a simple optimization problem (Camarinha-Matos & Afsarmanesh, 2007). Recently, researchers have classified the partner selection problem as a Multiple Criteria Decision making (MCDM) problem since the decision maker aims to choose the best possible alternative considering the several conflicting criteria such as price, quality, service etc. Accordingly, various decision making methods such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and their integrated forms have been proposed in the literature (Saaty, 1980) (Crispim & Sousa, 2010) (Sari, et al., 2007).

There is quite extensive literature in the field of partner selection of VE each proposing a new method; however, there is lack of study for how to choose a proper methodology for particular projects. One may propose, to conduct a benchmarking study and comparing the results of each method with others. However, this idea would not be much usable since the partner selection problem is MCDM type and there isn't any definite correct answer for each decision problem. Therefore, the authors of this study have focused on the question, "Which is the best partner selection methodology for each customer's order?". In this respect, an algorithm is proposed which selects the most suitable partner selection technique (among three alternative techniques) depending on the customer type.

This paper is organized as follows. The partner selection model and its corresponding algorithms are presented in section 2. Then in section 3, an illustrative example is conducted to demonstrate the models applications. Finally, concluding remarks and future research domains are presented in section 4.

2. Methodology

Formation of VE is triggered by a demand from a customer who comes to a VE systems operator, and order a product. Based on the product requirements and its manufacturing necessities, VE experts decompose the main project into its subprojects. This step requires high levels of expertise in process planning so that the operations are classified appropriately. At the same time, preliminary time table of the project is also organized. In the next step, each subproject's responsibilities would be given to each partner of VE. These partner companies are selected from the Virtual Breeding Environment (VBE) pool of registered enterprises. Considering the subprojects necessities only the enterprises with necessary resources (such as machinery, or skilled worker) are sieved to be considered in assigning the subproject. Moreover, customer's specific requirements like certificates and standards are also used as elimination criteria for unqualified enterprises. The remaining enterprises would receive the invitation to bid for the subproject. The volunteered enterprises submit their bidding proposals competing with each other to win the

subproject. Selecting the most appropriate enterprise among the bidders is the main focus of the partner selection problem. Once the winner of each subproject is selected and announced the partners of the consortium sign their contracts and operation phase begins. The performance of enterprises are inspected during their operation and when all the subprojects have finished successfully the product is delivered to the customer and the VE consortium dissolves. The level of commitment of each enterprise is assessed, scored and saved in VE system database to be used in future project's partner selection phase. Figure 1. demonstrates the main steps of VE schematically.

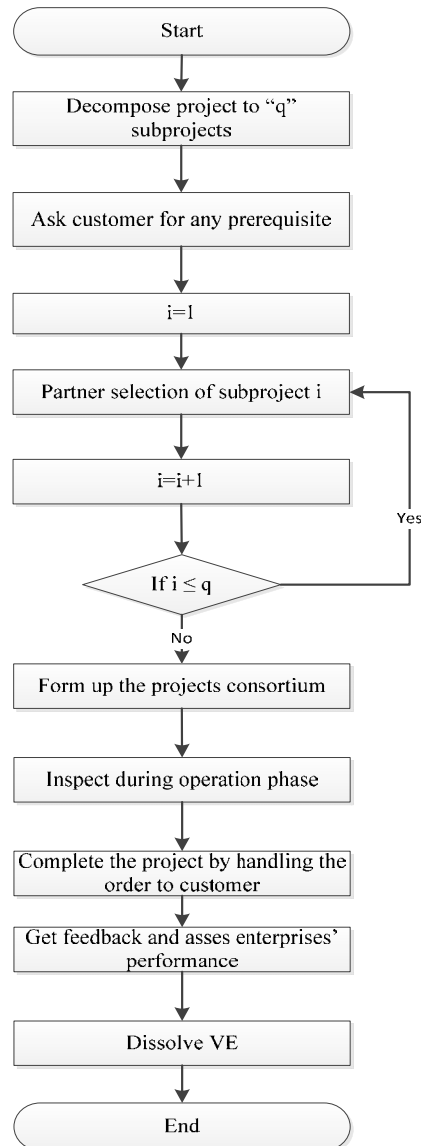


Figure 1. VE's operation flowchart (Nikghadam, et al., 2015)

The most fundamental issue of any decision making problem is choosing the appropriate set of evaluation criteria. Since the alternatives assessment would be based on these criteria no important criteria should be neglected. This aspect is of very influential especially in VE systems because of their flexible structure. Different customer and partners with different attitude and culture may participate in VE systems and the evaluation parameters should be

able to handle this diversity. Among tens of evaluation parameters highlighted in literature the most frequently used parameters; price, delivery time, past performance and service are chosen. Past performance of each enterprise is evaluated based on its commitment level to quality and on time delivery in its previous contracts. Service itself contains three sub criteria; after sale service, communication skills and environmental friendliness.

The customer of VE is asked to fill out the questionnaire containing pairwise comparisons of four main criteria; price, delivery time, past performance and service. The overall weight of each criterion is derived by applying Fuzzy-AHP method (Buckley, 1985). Three scenarios may happen considering the different attitudes of customers in taking out the survey;

1. The customer may not be eager to fill out the questionnaire.
2. The customer is willing to carry on the questionnaire and requests are reasonable under normal conditions.
3. The customer fills out the questionnaire, though his/her requests may not be fulfilled in normal conditions, for instance tight delivery dues.

Each of these customer types requires a specific partner selection methodology, because in each scenario problem's characteristics change. For each customer type, a specific partner selection method is assigned.

2.1. Passive customer

When customer of VE project is not eager to take time to fill out the questionnaire, this leads to high level of vagueness in data. And since the bidders' overall scores are directly influenced by customer's preferences, it is crucial for the model to be able to perform consistently even in uncertain environments. Fuzzy logic proposed by Zadeh in 1965 is one of the best approaches to handle uncertainty (Zadeh, 1965). Practical applications of Fuzzy logic for partner selectin problem of VE has also presented by Nikghadam et al. (Nikghadam, et al., 2015). In this case, pairwise comparisons of criteria are no longer needed and the customer is only asked to sort the criteria (price, delivery time, past performance, service) from the most important to least important.

Price, delivery time, past performance and service are defined as fuzzy logic inputs of the model. The Mamdani's fuzzy inference technique is applied to evaluate the input data based on fuzzy logic rules and the output of the model is the partnership chance for each enterprise (Mamdani & Assilian, 1975). Accordingly, an enterprise with highest partnership chance is selected as the winner of the subproject.

The model's ability to handle the vague data accommodates VE to respond to passive customers. However, where customers are strictly emphasize on their preferences fuzzy logic model may cause some inaccuracies. Therefore, the customer is recommended to fill out the questionnaire so that the more reliable assessment can be performed.

2.2. Standard customer

The standard customer of VE eagerly takes time to answer the questionnaire so that more trustworthy outcomes could be obtained. By analyzing the customer's request, if it is found out that the order is reasonable and it can be accomplished in standard conditions (which is previously estimated by VE experts), this type of customer is classified as standard customer. In this scenario, integrated form of TOPSIS with Fuzzy-AHP technique is used to model this type of problem. The first step in this model is to employ fuzzy-AHP approach to calculate the importance weight of each criterion by analyzing the customer's questionnaire.

Accuracy of the customer's judgments are verified if consistency ratio index (C.R) is less than 0.1, if not, the customer is asked to fill out the questionnaire more carefully until a reasonable respond with $C.R < 0.1$ is reached (Saaty, 1980). When the reliable survey is conducted, the preference weights are calculated and the model proceeds to TOPSIS step. Here, the classical TOPSIS calculations are followed, except that, the weighted normalized performance matrix is formed using the weights obtained from Fuzzy AHP. TOPSIS lists the candidates based on their distance from to Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). Accordingly, the enterprise which is ranked first is the winner of the subproject.

2.3. Assertive customer

The third type of customer is who request a demand which cannot be fulfilled simply. For instance, if the order's delivery due is extremely tighter than the usual time required, fulfilling the demand is not possible unless more than one enterprise are involved in performing each subproject. Hence, this case requires multi-sourcing and the partner selection model should be able to find the optimum solution for order allocation as well. These issues cannot be handled by either of the previous techniques. Therefore, Goal Programming (GP) based approach proposed by Nikghadam et al. is used to model the problem (Nikghadam, et al., 2015) (Charnes & Cooper, 1977). The outcome of GP model is the optimum order allocation for each subproject by incorporating more than single enterprise. Interestingly, in assertive customer scenario, GP does not push the limits to find cheaper bids if the customer accepts to pay more. This trend extends VE's capability to compromise between customers and enterprises mutually. Because, the customer is already satisfied by accomplishing his/her challenging demand while enterprises are rewarded by higher profits for participating in this urgent project.

The partner selection algorithm of VE and the approaches it adapts based on each customer type, is summarized and demonstrated graphically in Figure 2.

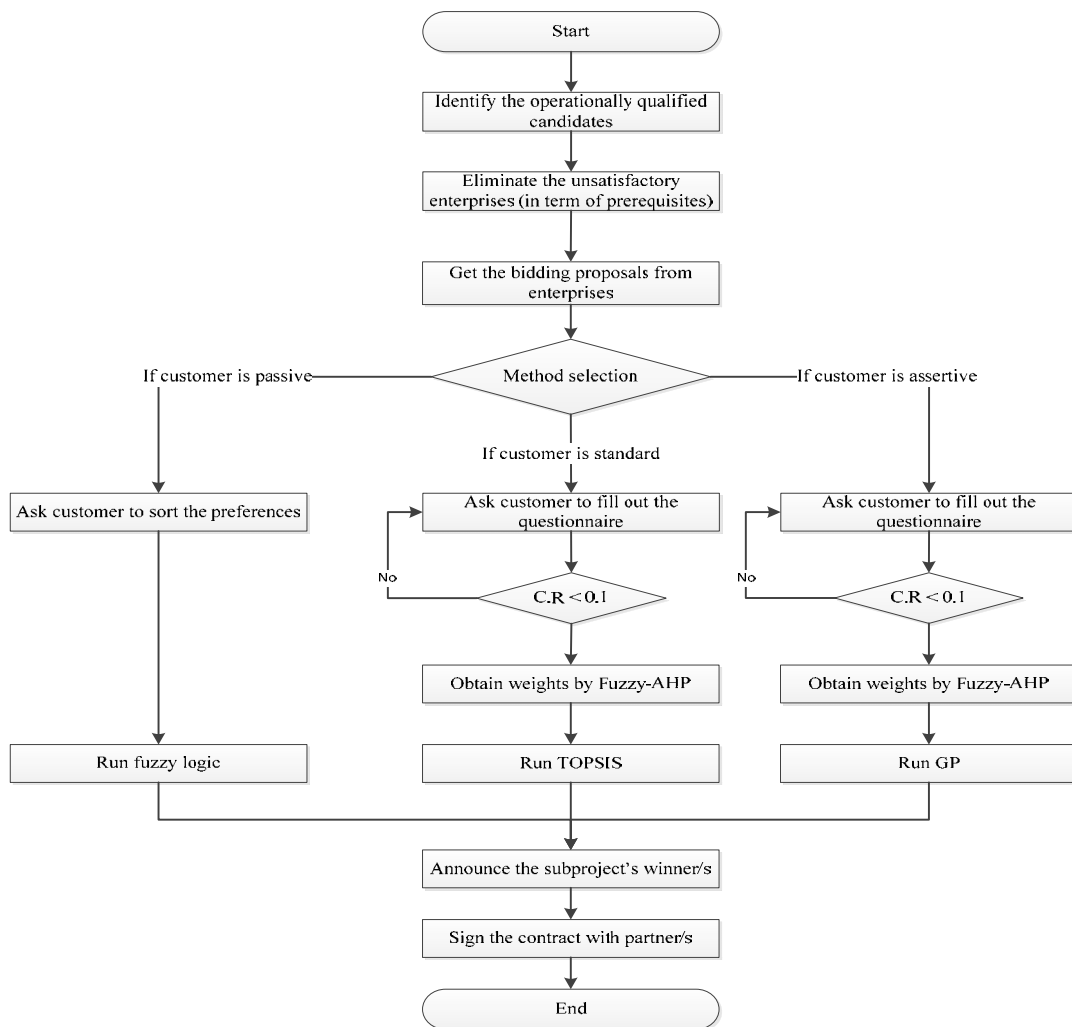


Figure 2. Partner selection flowchart for each subproject

3. Illustrative example

A sample case study is presented in this section to illustrate the practical applications of the proposed multi step algorithm in forming up VE consortiums. In this sample, VE receives an order for manufacturing a product. This project is decomposed into three subprojects by VE experts. And VE searches for the best partners to assign each subproject.



Figure 3. Subprojects of VE's project

8 enterprises; A, B, C, D, E, F, G, H are volunteered to take role in subproject 1. Subproject 2 has 5 bidders; L, M, N, O, P and Subproject 3 has 4 candidates R, S, T, U. Data about bidding proposals and their calculations are lengthy and in order to observe space limitations, only the final results are presented for discussion purposes.

Scenario 1, is a passive customer who asserts that, roughly cares more about price followed by past performance of in-charge enterprises. In his/her opinion delivery time and service are his/her third and fourth important factors respectively.

Scenario 2, is a standard type customer whose order can be accomplished in normal conditions (within 25 days). And the analyzes of his questionnaire reveals that his preference weights for price, delivery time, past performance and service are 0.44, 0.275, 0.18, 0.11 respectively. It is expected that, the algorithm assign different set of partners for this scenario in comparison to scenario 1, since customer preferences are different.

Scenario 3, is an assertive customer who accepts even paying 200,000 \$ for delivery within 18 days. According to the schedule prepared by VE's production planning experts this order cannot be fulfilled unless more than one enterprise are involved in performing each subproject. So, this scenario uses GP-based approach to form up the VE consortium. As expected, the results of questionnaire shows that delivery time is the most critical factor for this customer. The second most influential factor is the past performance of the company. Past performance score is also representing the commitment level of the company in its previous works. Higher the past performance score is, easier VE can trust the enterprise's promises in terms of quality and delivery. So the next determinant parameter is past performance followed by price and service. Corresponding weights are 0.49, 0.25, 0.2 and 0.05 respectively.

Different scenarios, and results of the algorithm for each scenario is summarized in Figure 4.

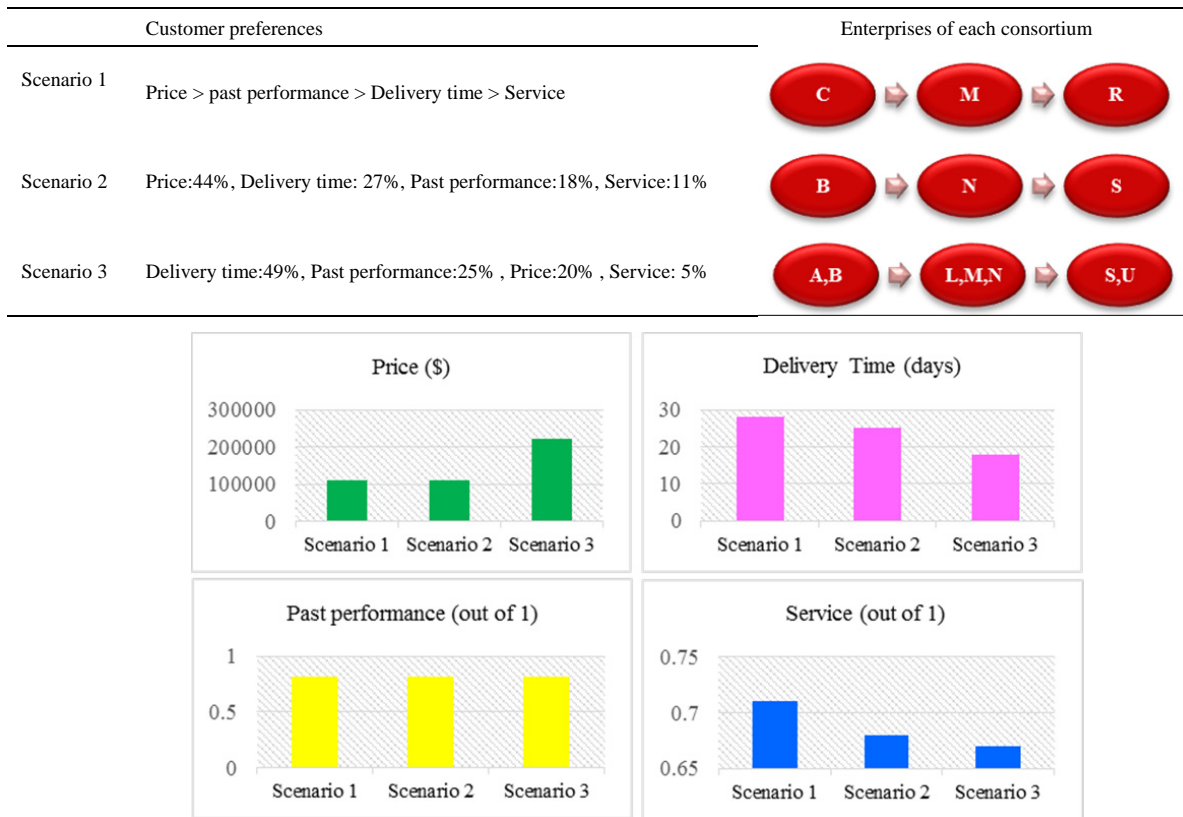


Figure 4. Results of the algorithm for different scenarios of the case study

The results show that all of three methods are loyal to the customer priorities. Since, customers of scenario 1 and 2 are very price sensitive, their price is kept as affordable as possible. Considering scenario 1 and 2, customer of scenario 2 out-weighted delivery time more, so the delivery due of consortium for this case is earlier than scenario 1. Considering scenario 3, VE forms a consortium of seven enterprises for three subprojects. In this case, model sacrifices from price to fulfill the customer's demand in a short period. Considering, service, as the least important parameter for all scenarios, the model takes it for granted when it is required.

When the consortiums are formed up, they perform their responsibilities and by completing all the planned necessities, products are handed to the customer. In last phase, participants of projects are assessed in term of quality of their finished products, their promised delivery dates, communication skills and environmental friendliness. By asking the customer and related staff of VE, each enterprise's performance score is calculated and saved into system's database to enrich the information regarding enterprises background to be used in future. The final phase inspects the order, handles it to the customer and completes the project by dissolving the VE.

4. Conclusions

This study was developed an algorithm which helps VE to choose the most appropriate partner selection methodology based on the customer's type. Employing this new algorithm, enhances VE's applicability in several aspects;

- Applying fuzzy logic accommodates the model to perform even in uncertain environments with vague input data from passive customers.
- Easy programmable, yet effective TOPSIS method is used for partner selection of standard customer.

- By applying GP, VE extends its flexibility even further by responding to urgent orders with tight delivery dues. This is the first step to attract the customers of just-in-time concept as well. This policy, provides mutual benefit for both VE members with available capacity and customers who are seeking to fulfill their critical request.

Unlike most of the studies in the literature which most of them propose a single method, this study combines three different methodologies for different scenarios to enhance flexibility.

This study can be extended by developing new survey data analysis and adding different evaluation criteria to the problem. By having deeper understanding of customer's preferences, more reliable VE consortiums can be established, hence increasing the overall performance of a VE system.

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