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A Two Tier Vendor Selection with Fuzzy Case Based Reasoning

Manasa V
Department of Computer Science and Engineering
MeenakshiSundararajan Engineering College
Chennai, India

***Abstract*—Vendor selection is a very important part of the supply chain of an organization, as the vendor's goods essentially form the foundation of the organization's product. With the existing system, all the power vests in the hands of their vendors and the end party of the purchase is more at disadvantage as they are not in control of the choices that might affect the various standards of their end product. This paper puts forth an efficient method of vendor selection for a management by introducing a two tier architecture. This facilitates them to not only choose their direct seller but also allows them to make choices that have an impact on their indirect sellers. It is designed such that the management gets as much an optimal solution as the other middle level vendors who are a part of the supply chain. The paperproposes improvements to the two tier architecture system with enhancements in the first level vendor selection methods.**

Keywords—Vendor Management, Supply Chain Improvement, Vendor Selection, Fuzzy Logic, Two Tier Architecture

I. INTRODUCTION

Every organization has the need for outsourcing resources that are not internally available. The resources may include software plugins, hardware components and even trainers. The resources that are outsourced are bought or leased from a third party vendor. For most enterprises, these purchase cost takes up more than 70% of the total cost.The organizations therefore have to ensure that the most optimal practice is followed in decision making of vendor selection, as the vendor selection-decision-making is an important part in production and logistics management. Vendor Selection process includes choosing of suitable vendors and determination of order quantity from the chosen vendors. These decisions affect the competitiveness of the enterprise severely. So a reasonable choice of vendor will directly reduce cost, increase flexibility and improve competitiveness. The market competition is becoming global and fierce, product life cycles are getting shorter, and thus the emphases on factors that affect vendor selection are also seeing a shift.

With the advancing technology, more and more components are available in standard or custom made form. This makes the production simpler for various enterprises. The vendor management system provides a solution that, takes care of all the processing involved in making purchases from the vendor.

Another reason for the changes in the trend of vendor evaluation can be attributed to increase in the number of vendors. The surplus availability of vendors who are open for providing service has made it more difficult for the buyers. The selection of the vendor has turned into a multi criteria decision making problem with conditions that might conflict with one another. For example, if the selection of a vendor with low cost is preferred, then he might not necessarily provide the most efficient of the services. It lies upon the procurement managers to weigh in these criteria and choose a vendor who brings an optimal solution to the enterprise in terms of efficiency in delivery of services and that prices at which they are placed.

II. EXISTING WORK

The commonly prevalent system is a single tier system where the procurement decision makers choose a suitable vendor for the services required along with the quantity and the vendor in turn chooses his own manufacturers based on his inclinations. Here the vendor has an advantage of making choices that are optimal only for him. And thereby the other participants of the supply chain are at a disadvantage as the optimization of a single participant is not the optimization of the entire supply chain.

In the single tier architecture, the procurement manager who is responsible for the resource management can choose only the vendor and allocate a quantity of purchase to that vendor. There is no say for him in the manufacturers that the vendor in turn chooses. So the optimization of only an individual is achieved.

Furthermore, the vendors who are selected are done so on the basis of past experience as there is a large recurrence of the same purchases for a given organization. Generally, the purchases follow the pattern cycle of Retrieve-Reuse-Revise-Retain. This is also known as the 4RE cycle.

The vendor's services are typically appraised by ratings. The ratings are gauged on a points scale, say a range of 10. The total rating is an aggregate of the points that are awarded for their performance against various standards such as quality of the product; post sale service, etc. The vendors are classified as those with high ratings, those with moderate rating and those with low ratings. Future endeavors generally favor those vendors who have high ratings. Only in a scenario where the vendor with high rating's services is not permissible are the vendors with moderate rating taken into consideration.

Because the rating scale is very subjective, one cannot make a weighted decision based on the rating. It can also be observed, that the difference in the ratings between the high rating vendors and moderately rated vendors can be as low as a few points.

For instance, the scale may be set as, if the rating is greater than 89, then the vendor is falls into higher rated category, if

the vendor rating is greater than 40 but lesser than 90 he falls into the moderate category, else he falls into the low category. If a vendor scores 89, he might have a difference of only 2 or 3 points from a vendor who was classified as a high rated supplier but he will be qualified as a moderate. This is not rational as the judgment is made on cumulative ratings and the vendor might have scored more on the delivery rating than the vendors with ratings of 90.

III. ARCHITECTURE

In two tier architecture, there is precedence given not only to the first level vendors, but also the second level vendors who are the sub-contractors of the first level vendors. This overcomes the issue of a single individual having an advantage over all the others in a given supply chain, thereby, making the entire supply chain optimal.

The proposed two tier architecture optimizes the complete supplier chain. The procurement personnel not only choose the vendors and quantity of allocation for each but also the suppliers that the first level vendor buys from and their respective quantity.

This ensures optimization of the complete supplier chain. If the vendor feels that the organization is operating against his, as he can penalize them by never working with them in the future, thereby making sure even the interests of the vendor are protected.

The goal of this architecture is to achieve maximum customer satisfaction. The process of choosing the vendor is made on the basis of three criteria, which are delivery, price and quality of the service. The value of each criterion has to be given necessary emphasis at each tier of the architecture. High level of customer satisfaction is same as the lower level of customer dissatisfaction, so a model is generated to calculate the customer dissatisfaction level. This mathematical model for the single tier architecture can be given in Equation 1.

$$Z_1 = \sum_n \sum_i \min \sum_c W_{cin} (V_{cin+1} - V_{ctn+1}) \sum_j Q_{in,jn+1} \quad ..(1)$$

The expansion for various parameters specified in the above equation is given in Table **1**Table **1.**

Table 1: Parameters in Equation 1

i_n	The vendor-i in tier-n
j_n	The vendor-j in tier-n
w_{cin}	t is the weight given to any criterion c in tier-n vendor-i
v_{cin}	The actual value of criterion c in tier-n for the vendor-i
v_{ctn}	The value set as target for standard c in the tier-n
$Q_{in,jn+l}$	The order quantity that tier-n vendor-i gives to tier-(n+1) vendor-j

In the above model, the optimal solution is chosen on the basis of the minimum value of a single tier. This has been revamped to a new model of two tier architecture. In the model the optimal solution is a solution that takes into consideration the values at both tier 1(the vendors) and tier 2 (the sub vendors). The mathematical model for the same is given in Equation 2.

$$Z_2 = \min \sum_n \sum_i \sum_c W_{cin} (v_{cin+l} - v_{ctn+l}) \sum_j Q_{in,jn+l} \quad ..(2)$$

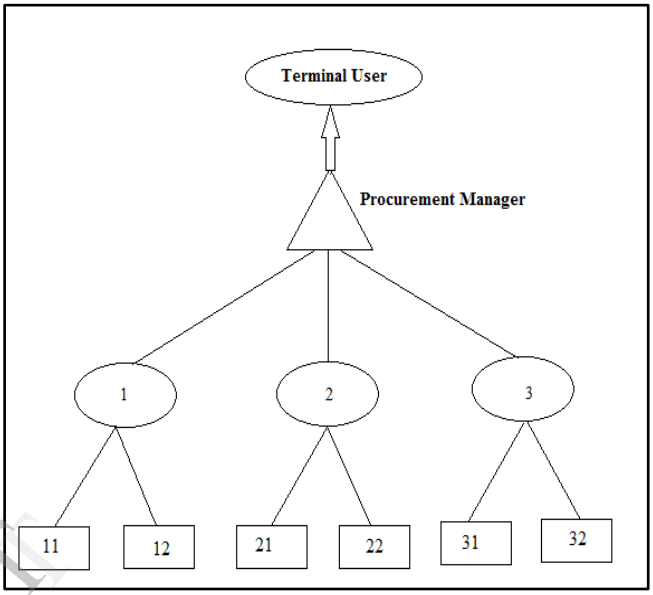

Figure 1: Two Tier Architecture

In Fig 1, we can see a graphical version of the two tier architecture; the terminal user is the procurement manager. Entities 1, 2 and 3 are the tier 1 of the first level vendors and entities 11 and 12 are the sub vendors of the tier 1 vendor numbered as 1; similarly, the sub vendors 21 and 22 for vendor 2 and 31 and 32 for vendor 3.

For example, consider a mobile phone manufacturer as the procurer of services; he out-sources the manufacture of the batteries to a vendor who is the first level vendor. The first level vendor might in turn sub contract his raw materials to other vendors who form the second level vendors.

IV. FUZZY FIRST LEVEL VENDOR SELECTION

Even while using the two tier system, there is a high rate of repetition in the purchase requests. So the details from the earlier purchases can be reused and recycled.

The system reuse of existing data is called the system of 4 R's. It can be expanded as, Retrieve – Reuse – Revise – Rewrite. When a purchase request is received, the first step is to retrieve all the records from past purchases that are similar to the current requirement. Once all the similar records are retrieved, the most suitable can be chosen on the basis of the weightage that they have been given for various criteria in the past.

Once a particular vendor is chosen and the service is obtained, the ratings given for various criteria can be revised and updated to the data store for future reference.

The process of selection of the vendor based on the purchasing request is done from the retrieved vendor records.

But, once the vendor records are retrieved, they need to be classified on the basis of the weight of the various criteria that the vendor has been assigned on the basis of previous service. The categorizing process doesn't essentially give an exact result. The value of those vendors with closer values might fall into different categories as the boundaries are rigid values. To overcome this, we can use the retrieval combined with a method that realizes a fuzzy definition.

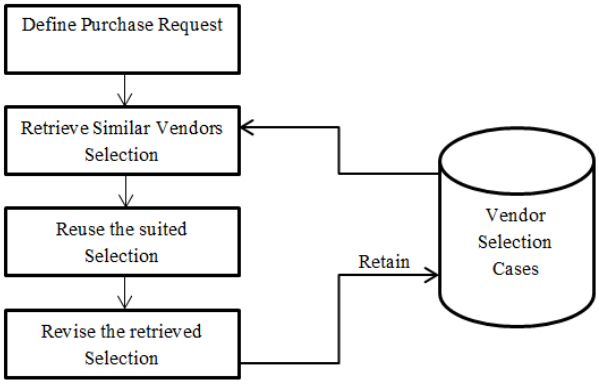

Figure 2 Recycling Vendor Data

For example, consider the criteria of quality rate of the product delivered. The defective rate is categorized into three types – high (90% and greater), average (greater than 40% and lesser than 90%) and low (40% and lower). These traditional definitions can be replaced with a fuzzy definition as given in Equation 3.

$$Q_{high} = \begin{cases} \dfrac{q - 35/10^3}{8/10^2} & \dfrac{35}{10^3} < q \leq \dfrac{50}{10^3} \\ 1 & q > \dfrac{50}{10^3} \end{cases}$$

$$Q_{avg}$$

$$= \begin{cases} \dfrac{q - 0.5/10^2}{1.5/10^3} & \dfrac{5}{10^3} \leq q < \dfrac{10}{10^3} \\ 1 & \dfrac{10}{10^3} \leq q < \dfrac{30}{10^3} \\ \dfrac{q - 3/10^2}{7/10^2} & \dfrac{30}{10^3} \leq q \leq \dfrac{40}{10^3} \end{cases} \quad ..(3)$$

$$Q_{low} = \begin{cases} \dfrac{q - 0.1/10^3}{1.1/10^3} & \dfrac{1}{10^3} \leq q \leq \dfrac{40}{10^3} \\ 1 & 0 < q < \dfrac{1}{10^3} \end{cases}$$

Here in equation 3, the q stands for number of defective pieces per thousand pieces. Consider that q value is $40/10^3$, then Q_{low}=0,Q_{avg}=0.14 and Q_{high}=0.06. Therefore by the property of maximum membership, we can say that Q = (Average; Q_{avg}=0.14).

This improves the effectiveness of the search and the data retrieval can be done more efficiently when records are retrieved from history of purchases.

This is because there is an overlap in the various categories of the classification and the classification is based on a fuzzy definition.This selection is more sensitive to the likeness of various purchases weightage and thereby the current analysis becomes more optimal.

V. SECOND LEVEL VENDOR SELECTION

Thenumber of eligible vendors can be brought down by the fuzzy analysis. But the final selection of the vendor is still to be done. For this, a second level selection process has to take place.Assuming that there are hundreds of vendors that are eligible for providing the service, the fuzzy selection reduces it or rather narrow it down to the most suitable top three.

The further selection can be done using Delphi method, and a scale of rating that is used can be as suited to the enterprise. Even the criteria to be evaluated upon can be specified by purchase experts who form the panel.A matrix can be created and the current potential vendors can be weighed against the categories. The weights of the various categories help reach an optimal decision. The process can be repeated until a conclusive selection is made.

VI. CONCLUSION

It can be seen that the enterprise benefits from a two tier vendor selection system where the selection process in each tier is processed with an Analytical Hierarchy Process. Thereby, assuring the management of the quality of the products they are out-sourcing. The fuzzy definition helps in a more optimal retrieval and classification of the vendor records from the history of purchases. This solution helps in selecting the most optimal vendor for a purchase request who matches the standards that are required by the organization.

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