MINING ASSOCIATION RULES FOR FINDING KEY SUPPLIERS IN SCM

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ABSTRACT

In today's ever-changing markets, businesses around the world are attempting to position themselves to operate in a highly competitive marketplace. Supply chain management (SCM) becomes a key strategy for most enterprises. One of the main causes of complexity in a supply chain is an unwieldy number of suppliers. Supplier selection and reduction is an important goal in SCM. This paper aims at contributing an effective methodology that combines the extended association rule algorithm with set theory to find the primary suppliers and the secondary suppliers. An example of finding key supplier in an electronic devices manufacturer in Taiwan is showed for its effectiveness.

INTRODUCTION

In order to solve and survive in high uncertainty and globalization competes, enterprises are looking for their suppliers to work together as their partners to stand against or reduce the risk of uncertainty under current environment competition. Enterprises can increase their supply chain competition by using selecting excellent suppliers to develop collaborative relationships with suppliers by cutting supplier lists and treating the remaining suppliers as allies, thus reducing the supplier base has become a priority for some firms. Goffin et al. [5] find that in a variety of industries in the United Kingdom between 1991 and 1996, the number of suppliers decreased by as much as 36 percent. Chrysler and General Electric have been reducing the size of their supplier base and have begun to arrange suppliers in a tiered structure. Therefore, in many research studies, the authors have stressed the importance of reducing the supplier base.

LITERATURE REVIEW

The field of data mining has emerged as a new method in business, engineering and computer science. Data mining comprises a number of techniques, such as clustering, classification, association rules, prediction, regression, and neural networks. One of the important problems in data mining is the association rule that implies certain association relationships among a set of objects in a database. Agrawal et al. [1] introduced association rules to the data mining community. There has been a marked tendency to extend the association rule in a wider variety of problems of academia and practitioners with applications, such as customer relationship management (CRM), market baskets analysis (MBA), economic and financial time-series analysis, production process, are manufacturing diagnosis [1] [6] [2]. The association rule, based on the market basket analysis, is directed toward establishing "aggregate" customer behaviors to help managers determine, which items are frequently purchased together by customers. With an enormous amount of historical purchase data having been collected in databases, data mining tools can allow buyers collecting and analyzing such data to find buyer and supplier relationship for support further purchase decision making.

The selection of an appropriate supplier can be important for a firm's competitive advantage. Selecting the right suppliers can significantly improve corporate competitiveness. Selection of the wrong suppliers could cause many problems for the purchasing company such as operation, quality, cost, and so on. Thus, today's fierce competitive environment and strong emphasis on efficient supply chain management entices companies to select appropriate suppliers. Some publications have addressed this issue in recent years to discuss the complexity of the supplier selection. The literature survey reveals that various methodologies have been suggested in linear programming, mixed integer programming and other quantitative approaches [8] [11] [10]. Some other different methodologies [4] [7] [3] for supplier selection have been proposed in the literature including linear weighted point, cost ratio, analytic hierarchy process (AHP), data envelopment analysis (DEA) and some others. In all of this research, the strongest emphasis is placed on the strategic factors that need to be considered in selecting suppliers.

METHOD

The approach, called Supply Chain Member Selection (SCMS), combines the extended association rule algorithm with set theory, to identify a set of suppliers, and evaluate the degree of membership between suppliers (supplier groups). The processes involved in the proposed SCMS methodology including: 1) identify the required parts; 2) Find the maximum frequent supplier-sets; 3) identify primary supplier(s) and 4) Identify secondary suppliers for substitution/complementary, are explained as follows:

1. **Identify the required parts:** Usually an organization has complex product lines with deep bills of materials which offered by a lot of suppliers. Parts should be classified according to their importance.
2. **Find the maximum frequent supplier-set(s):** To find the maximum frequent supplier-sets, the Association Rules algorithm is applied for finding the largest k-supplier-sets.
3. **Identify primary supplier(s):** A cluster is a subset of suppliers from maximum frequent suppliers-sets. To measure the cluster has a high required priority, an availability value of a group is used as follows:

$$A(G_j) = \frac{Card\ (A \cap C^j)}{Card\ (A)} \quad (1)$$

The availability value $A(G_j)$ equals to 1.0 means that the group is satisfying the requirements. Otherwise, the group is incapable of satisfying the requirements. When the availability value is below 1.0, the maximum frequent suppliers-sets will be extended by adding some key suppliers into the original primary suppliers to increase the availability value. However, primary suppliers for certain part are the suppliers that rank the best in the process of supplier selection.

4. **Identify secondary supplier(s):** As the selected primary supplier cannot satisfy all the manufacturers' needs, more than one supplier is selected in the increasing order of their exchangeability values. Primary suppliers may have substitution and/or complementary relationships with other suppliers to satisfy the manufacturers' needs. $M = I - \left[(C_{S_i} \cap C_{S_j}) \cup (C_{S_j} \cap C_{S_k}) \cup ...(C_{S_l} \cap C_{S_i})\right]$ (2)

   $S_x \in G_j$ (Primary supplier set); x = {*i, j, k,…, l*} and parts (M) are provided by primary suppliers.

   Choose secondary suppliers from maximum frequent *k*-supplier-sets which do not include primary suppliers, unless maximum frequent *k*-supplier-sets is only one set, then find secondary suppliers from (*k*-1)-supplier-sets. List those parts (*N*) that can be provided by secondary suppliers and if $M \subseteq N$, identify secondary suppliers and stop; Otherwise, find supplier(s) from the next supplier-set of secondary suppliers until add supplier into the original secondary suppliers. These secondary suppliers will form a good alternative supplier pool for parts complementary/substitution.

RESULTS

An example is necessarily simplified to illustrate the methodology. The shipment database is shipment No. = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10} and Supplier No. = {S_1, S_3, S_4, S_6; S_3, S_4, S_6, S_{12}; S_1, S_4, S_5, S_8, S_9; $S_2, S_5, S_8, S_9, S_{12}$; S_1, S_3, S_4, S_7; $S_2, S_5, S_8, S_{11}, S_{12}$; S_1, S_3, S_4, S_7; S_2, S_5, S_8, S_9; $S_1, S_3, S_4, S_{10}, S_{12}$; S_1, S_4, S_5, S_8, S_9 } which consists of the shipment number and the suppliers provided in the shipment, respectively. This case assumes that individual suppliers may supply multiple parts and multiple suppliers can supply individual part. There are twelve suppliers, i.e., S = {$S_1, S_2,...S_6,..., S_{12}$}, and ten shipments. Each of these shipments has at least 4 suppliers ordered by a unique shipment.

By applying SCMS Methodology, the required parts were identified based on the shipment data are 8 required parts {$I_1, I_2,...I_3,..., I_8$} and 12 suppliers {$S_1, S_2,...S_6,..., S_{12}$} involved in this example. To find the maximum frequent supplier-sets, the example of finding the maximum frequent supplier-sets algorithm is applied. Obtain the Maximum frequent supplier-sets including $\{S_1, S_3, S_4\}$ and $\{S_5, S_8, S_9\}$. The results get from Table 4. Maximum frequent 3 supplier-set include $\{S_1, S_3, S_4\}$ as a group1 and $\{S_5, S_8, S_9\}$ as a group2. There are these parts $C^1 = \{I_1, I_2, I_3, I_4, I_5, I_7, I_8\}$ included group 1. Group 2 includes $C^2 = \{I_2, I_4, I_5, I_6, I_7, I_8\}$. To find primary groups, using $A(G_j) = \frac{Card\ (A \cap C^j)}{Card\ (A)}$ computes the availability of maximum frequent supplier-sets. $A(G_1)$ is equal to 0.875 and $A(G_2)$ is equal to 0.75. Due to $A(G_1) > A(G_2)$, the members in group 1 are primary suppliers. But $A(G_1)$ is below 1, this should find supplier(s) from next supplier-set until the value of $A(G_1)$ is equal to 1. From the above step, the primary suppliers include $\{S_1, S_3, S_4, S_7\}$.In order to find out which parts provided only by one supplier from primary suppliers, using formulate (2) shows 5 parts $\{I_4, I_5, I_6, I_7, I_8\}$. From Table 4, the maximum frequent *2* supplier-sets have two supplier-sets; one belongs to primary suppliers, the other can be considered as secondary suppliers $\{S_5, S_8, S_9\}$. According to the algorithm for identifying secondary supplier, $\{S_5, S_8, S_9\}$ can be identified as secondary suppliers.

In this research, SCMS methodology allows for an abstraction of information, removing many of the complexities, while retaining the ability to analyze the more important characteristics of the buyer and suppliers' relationships. This allows, for example, different domain considerations to be easily modeled and analyzed. The methodology is suggested to reduce the set of all suppliers to a smaller set of acceptable suppliers. The benefit for this reduction is that firms could not only devote more time and resources to each supplier, but also allow them to more easily track supplier performance. The other benefit is the possibility of favoring a win-win situation for both buyer and supplier.

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