GROUPBUYMULTIPLE: A NEW MULTI-ATTRIBUTE GROUP BUYING

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Abstract

A buyer coalition is a group of buyers joining together to negotiate with sellers to purchase items for a larger discount. A novel buyer coalition scheme, called the GroupBuyMultiple scheme, is presented in this article. The mechanism of approach starts with preparing normalized data for driving the next step. Then, it adopts a k-mean clustering algorithm to form the buyer coalitions. The utility of each buyer coalition is determined in the final step. Based on the simulation results, the new scheme gives the total utility of buyer coalitions and the number of successful buyers more than those of the random one.

Keywords: electronic commerce, buyer coalition, n-person game theory, k-mean clustering

Introduction

A Buyer coalition is a group of buyers joining for purchasing any items at a larger discount (M.Tsvetovat et al. 2003). It has become increasing attention because it gives benefits to both buyers and sellers. The buyer coalitions help buyers in improving their bargain power and negotiation with seller (M.Tsvetovat et al. 2003) including reduction of the communication's cost between buyers and sellers. On the other hand, sellers will benefit from selling their items in large lots through buyer coalitions.

There are several buyer coalition researches. However, all of these researches will form buyer coalition with one attribute such as reservation price. For example, the researches (i.e., J. Yamamoto and K. Sycara 2001; S. Kraus et al. 2004, 2003; J. Chen et al. 2002; J. Chen et al. 2010; C. Li et al. 2004) form a buyer coalition with single of item and the researches (i.e., C. Li and K. Sycara 2004; H. Linli and R. I. Thomas 2004; L. He and T. Ioerger 2005; H. Fu-Shiung and L. Jim-Bon 2012; L. Cuihongi et al. 2010) form a buyer coalition with bundles of items.

Forming buyer coalition with multi-attributes can be found often in the real world situation, for example, when a theatre have a lot of seats left while the time of starting show is nearly reached and buyers are in different locations. Forming buyer coalition in this situation would take into account both ticket prices and buyer locations. However, there are a few researches that concentrate on buyer coalition with multi-attributes. Matsuo et al. (2004)

addressed decision support systems for buyers in group buying. They integrate buyers with multi-attribute preferences (utility) into a coalition. The system using an analytic hierarchy process to supports buyer's decision-making.

This paper proposes a novel technique in forming buyer coalition with multi-attributes. The K-mean clustering algorithm in cluster analysis is combined with n-person game theories in this algorithm in order to give solutions for forming a buyer coalition with multi-attributes. The major contribution of the current study is twofold: (i) the proposed algorithm provides forming a buyer coalition with multi-attributes; and (ii) as a result of the above, various amounts of discounts/benefits can be calculated based on the different schemes. These in turn will assist in considering buyers locations attributes for forming a buyer coalition.

The article is organized as follows: Section 2 provides details of the proposed scheme with two attributes. Section 3 is a simulation study of this scheme. Finally, Section 4 concludes the paper.

The GroupBuyMultiple Scheme

We recall the necessary basic notions used for representing a multi-attribute buyer coalition scheme, as described below.

Let $\boldsymbol{T = \{t_1, t_2, \dots, t_k\}}$ be a set of theatres where $\boldsymbol{t_k}$ is a theatre $\boldsymbol{k^{th}}$. When there are available seats $\boldsymbol{P}$ of each theatre left before movies are shown in shortly time, the messages will be send in order to invite members who our system can detect based on identified distances. The members are persons who are willing to get news of our system. A descending function is $\boldsymbol{P_{t_k}: a_{t_k} \rightarrow real\, number}$ when $\boldsymbol{P_{t_k}(a_{t_k})}$ is a unit price that the theatre would expect from selling a bundle of size '$\boldsymbol{a_{t_k}}$' of the movie tickets. Assume that all of theatres have the same show and price schedules. Each member $\boldsymbol{m_i}$ who wants to purchase the ticket is called buyer $\boldsymbol{b_i}$, will send the reservation price $\boldsymbol{r_k^j}$ back to the inviting theatres *k*. The reservation price is the maximum price that buyers still satisfy in purchasing a unit of item. The buyers normally expect to get high utilities. A utility of buyer *i* of theatre *k*, ($\boldsymbol{u_k^i}$) is defined as;

$$\boldsymbol{u_k^i = r_k^i - P|(C_k)| - costD_k^i}$$

where $\boldsymbol{P|(C_k)|}$ denotes the unit price when $\boldsymbol{|C_k|}$ of tickets are sold together, and $\boldsymbol{|C_k|}$ denotes the cardinality of $\boldsymbol{C_k}$. And $\boldsymbol{costD_k^i}$ denotes the cost of buyer's travelling can be defined as;

$$\boldsymbol{costD_k^i = \begin{cases} |d_k^i - F(C_k)|\beta & , if\ d_k^i > F(C_k) \\ 0 & , otherwise \end{cases}}$$

where $\boldsymbol{d_k^i}$ is the distance between the $\boldsymbol{i^{th}}$ buyer and the $\boldsymbol{k^{th}}$ theatre, $\boldsymbol{F(C_k)}$ is the mean of distance of the coalition's members, and β is the cost per unit. The utility of coalition is defined as;

$$v(C_k) = \sum_{b_i \in C_k} u_k^i$$

The winner coalition of the theatre t_k, called $C_k^* = W_k = \{w_k^1, w_k^2, \dots, w_k^p\}$, is the coalition that is selected via k-mean clustering and have coalition value is more than zero or $v(C_k^*) \geq 0$. Afterwards, the surplus of coalition is divided $X_k = \{x_k^1, x_k^2, \dots, x_k^p\}$ to the winners, which are based on their reservation prices and their locations.

Finally, the third-party sends the final prices $F_k = \{f_k^1, f_k^2, \dots, f_k^p\}$ back to the winners from $f_k^j = r_k^j - x_k^j$ where r_k^j is a reservation price of the j^{th} winner for the k^{th} theatre. Moreover, the reject messages will be sent to buyers without the coalition. The mechanism of GroupBuyMultiple scheme consists of the following three major steps.

Step 1: Preparation of data

In this step, the reservation price data and the location data of all buyers are transformed into a standard normal distribution, called z-score (with mean = 0 and standard deviation = 1), in order to adjust value on different scales to a common scale.

Step 2: Selecting a buyer coalition structure using k-mean clustering

The k-mean clustering method is a method of cluster analysis which aims to partition *n* observations into *k* clusters. Therefore, this method is suitable for selecting a buyer coalition structure which each buyer belongs to the coalition with nearest properties. In other words, a buyer would like to join if he/she is not forced to pay more to support other buyers.

The k-mean clustering algorithm in this paper is adopted from Jain and Dubes (1988) as shown in Figure 1.

Algorithm 1: k-mean clustering algorithm

Input: $B = \{b_1, b_2, \dots b_n\}$ be the set of buyers, r_k^i is the reservation price of the i^{th} buyer expected to the k^{th} theatre, and $l_i(x_i, y_i)$ is the location of buyer i^{th}.

Output: C_k

1) Select initial centroids of each coalition
2) Assign each buyer to closet cluster based on similarity.
3) Compute new cluster centroids.
4) Repeat steps 2 and 3 until cluster membership stabilizes.

Figure 1 The k-mean clustering algorithm

Step 3: Calculating Coalition Value of the buyer coalition structure

After the second step, we have a coalition of buyers equal to the number of sellers. At this step is to calculate the utility of such coalitions, and it ensures that if the utility of coalition is greater than or equal to zero. If so, all members of the coalition will become the winner. If verified, the utility of coalition is less than zero; the members who have the least utility of buyer are eliminated and then re-calculate the utility of coalition. We repeat this process until the utility of coalition is more than or equal to zero. The remaining members are the winners. The processes of this step are described in Figure 2.

Algorithm 2: *Coalition's Value Calculation*
Input: $B = \{b_1, b_2, \ldots, b_n\}$be the set of buyers, r_k^j is the reservation price of the i^{th} buyer expected to the k^{th} theatre.
Output: $C_k^* = \{b_k^1, b_k^2, \ldots, b_k^p\}$ be the set of winners for the k^{th} theatre.

1) WHILE $1 \leq k \leq K$
2) Calculate $F(C_k)$ from $F(C_k) = \frac{MAX(d_k^i)+MIN(d_k^i)}{2}$
3) Calculate u_k^i from $u_k^i = r_k^i - P(|C_k|) - costD_k^i$ where

$$costD_k^i = \begin{cases} |d_k^i - F(C_k)| & , if\ d_k^i > F(C_k) \\ 0 & , otherwise \end{cases}$$

4) Calculate $v(C_k)$ from $v(C_k) = \sum_{b_i \in C_k} u_k^i$
5) IF $v(C_k) < 0$
   - Eliminate the lowest buyer utility u_k^i
   - GOTO 4)
6) $C_k^* \leftarrow C_k$
7) GOTO 1)
8) END

Figure 2 The coalition's value calculation algorithm

Simulation

This section is a simulation study to evaluate performance of the GroupBuyMultiple scheme and compare it in a situation with forming buyer coalition using random method. In this performance evaluation, we measure the utility of buyer coalition and the number of successful buyers. We have conducted 100 times for various simulation parameters and calculate the average result for the evaluation criteria. Table 1 shows the set of simulation parameters in our evaluation.

Table 1 Simulation parameters

Parameters	Ranges
The number of Buyers	100
The reservation price	[80, 99]
The locations of buyers (X, Y)	[1, 20]
Discount Rate (DR)	0.2, 0.4, 0.6, 0.8, 1.0
Cost per walk	1, 2, 4, 6, 8, 10

In this table, there are five significant parameters. Firstly, the number of buyer is equal to 100. Secondly, buyer's reservation price is the maximum price that a buyer is willing to pay. The value of the reservation's price is varying from 80 to 99. Thirdly, the location of each buyer on two dimensional planes (x, y) is varying from 1 to 20. The individual buyers' distance is a distance from the location of individual buyer to the locations of theatres, and derived from the Euclidian distance formula. Fourthly, *DR* is the basic Discount Rate determining the amount of basic discount. Finally, cost per walk is cost of current location of buyers to items.

The simulation was designed to compare performance of the proposed GroupBuyMultiple scheme with random method. The performance is measured in terms of number of successful buyers and total utility of coalitions at different discount rates and different costs per walk. The results, as shown in Figure 3 a) and 3 b), show that number of successful buyers of the GroupBuyMultiple scheme is greater than of the Random scheme in most of discount rates and costs per walk. In addition, total utility of buyer coalitions of this scheme is more than those of the random one at every discount rate and every cost per walk - as shown in Figure 4 a) and 4 b).

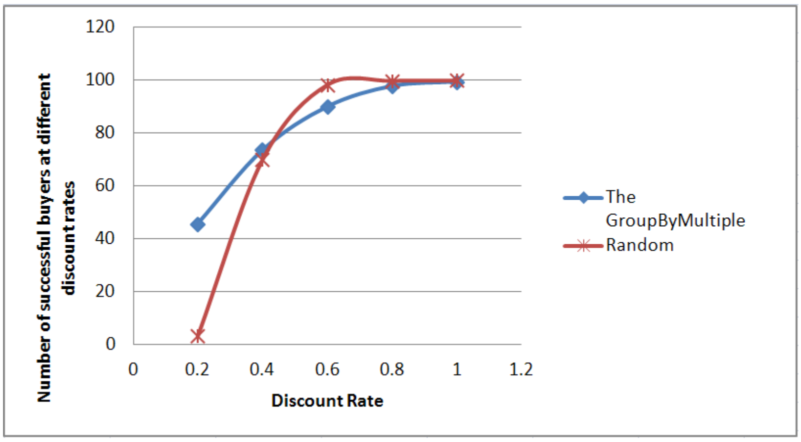

Figure 3 a) Number of successful buyers at different discount rates

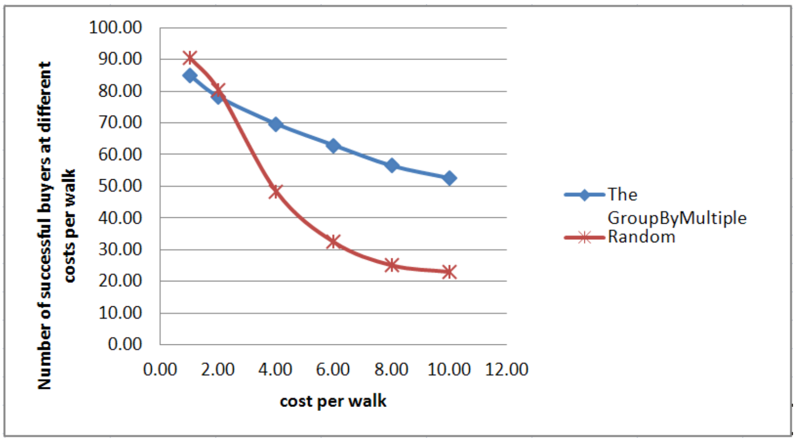

Figure 3 b) Number of successful buyers at different costs per walk

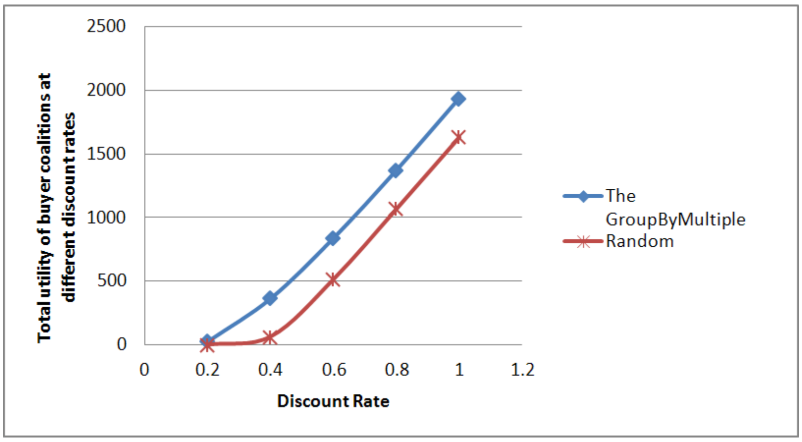

Figure 4 a) Total utility of buyer coalitions at different discount rates

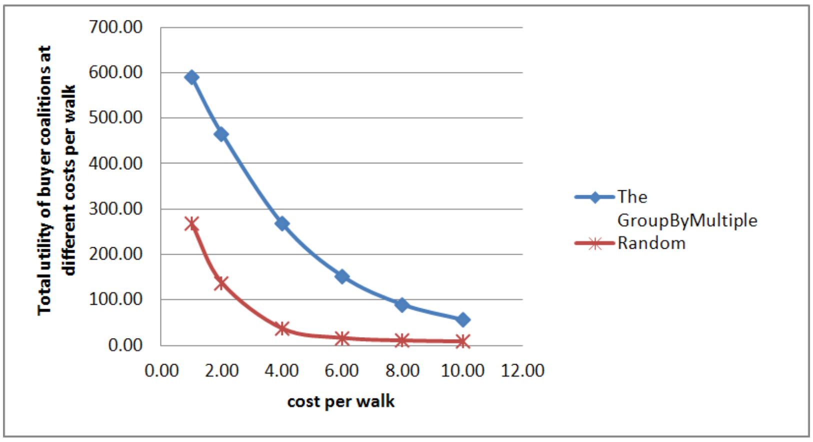

Figure 4 b) Total utility of buyer coalitions at different costs per walk

Conclusion

This research proposes a novel group buying scheme with multi-attributes. The new scheme employs the K-mean clustering algorithms and n-person game theories. Its mechanism consists of three steps. The first step is data normalization. Then, a k-mean clustering algorithm is used for forming the coalition. Calculation the utility of each buyer coalition is in the last step. Simulation results show that that the total utility of buyer coalitions and the number of successful buyers of the GroupBuyMultiple scheme are more than those of random scheme. Moreover, successful buyers of our approach do not hesitate to join the coalition, because they do not pay more to subsidize other buyers.

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