Ant Colony Optimization for Buyer Coalition with Bundle of Items

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Abstract—**To date, several new problems interesting for an ant colony optimization (ACO) are proposed and evaluated. However, in electronic marketplaces, there are no schemes focusing on forming a buyer coalition with bundle of items by ACO. In this paper, the new proposed approach, called GroupBuyACO scheme, applies ACO technique for forming buyer coalitions with the aim at maximizing the total discount. The solution of the algorithm is a collective outcome of the solution found by all the ants. The pheromone trail is updated after all the ants have found out their solutions. The simulation results of a proposed approach are compared with the genetic algorithm technique called GroupPackageString scheme [1]. Extensive computational experiments indicate that ACO technique performs better than GroupPackageString scheme in any environments.**

Keywords— **Ant algorithm, ant colony optimization, buyer agent, group buying, buyer formation, bundle of items.**

I. INTRODUCTION

In present, several companies have investigated the electronic commerce for selling their products because it is one of the fastest ways to advertize the product's information to the huge number of customers. Tons of products can be sold rapidly in few days. So, the companies can get better profits from selling a large number of products. Ordinarily, many sellers provide some attractive products with the special prices. One of the strategies which sellers prefer to make is selling their goods in a bundle of items[1] with the special prices. Moreover, several commercial websites usually offer the volume discount for customers if the number of selling is big. For buyer side, most of buyers prefer to build the corresponding purchasing strategies to minimize the purchase cost. The buyer's strategy is becoming popular on the Internet because buyers can improve their bargaining power with sellers to purchase goods at a lower price.

There are several group buyer schemes in electronic marketplaces. The main objective of these schemes is to gather all buyers' information for forming a buyer coalition to purchase goods at low cost. It helps to reduce the cost of communication and makes buyers comfortable in joining a coalition. In the recent years, several existing buyer coalition schemes have been developed. The work of Ito, T., Hiroyuki O., and Toramatsu S. in [3] presented an agent-mediated electronic market by group buy scheme. Buyers or sellers can sequentially enter into the market to make their decisions. Tsvetovat, M., Sycara, K.P., Chen, Y. and Ying, J. [4] have investigated the use of incentives to create buying group. Yamamoto, J. and Sycara, K. presented the GroupBuyAuction scheme [5] for forming buyer coalition based on item categories. Then, the paper of Masaki H., Tokuro M., and Takayuki I. [6] presented an optimal coalition formation among buyer agents based on a genetic algorithm (GA) with the purpose of distributing buyers among group-buying site optimally to get good utilities. The Combinatorial Coalition Formation scheme by Li, C., Sycara, K. [7] considers an e-marketplace where buyers place a bid on a combination of items with the reservation prices and sellers set special offers based on volume. However, there are two schemes by Anon S. [1] called GroupPackageString scheme and Laor, B., Leung, H. F., Boonjing and V.,Dickson, K. W [8] called GroupBuyPackage scheme that form a buyer coalition with bundles of items. Only the GroupPackageString scheme applied by heuristic function called genetic algorithm (GA) to form the buyer coalition with bundles of items while the other is not.

In this paper, the proposed approach applies ACO technique for forming buyer coalitions with the aim at maximizing the total discount. In ACO, several generations of artificial ants search for good solutions. The main characteristic of ACO is that every ant reads and updates pheromone value associate with good or promising solutions thought the edges of the path. The following ants of the next generation perceive the pheromone and tend to follow the paths where pheromone concentration is higher. However, there is no guarantee for convergence of ACO, but the experimental results have shown that in most cases the effciency of the proposed algorithm is acceptable. The paper is divided into six sections including this introduction section. The rest of the paper is organized as follow. Section 2 outlines group buying with bundle of itmes and the motivating problem in detail. Section 3 details the problem formulization to buyer formation with bundles of items. Secion 4 overviews the describes the approach applied in the paper using ACO technique for forming buyer coalition with bundle of items. Section 5 shows the simulation and parameter setting for the experiments including the discussion of GroupBuyACO scheme performance. The conclusions are in Section 6.

II. OUTLINE OF GROUP BUYING WITH BUNDLE OF ITEMS

In electronic marketplaces, sellers have more opportunity to sell their products in a large number if their websites are very well-known among buyers. Moreover, the pricing strategy of sellers might expedite the selling volume. Some

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[1]bundles of items refer to the practice of selling two or more goods together in a package at a price which is below the sum of the independent prices [2].

simultaneously make a single take-it-or-leave-it price offer to each unassigned buyer and to each buyer group [9]. In this paper, I assume that the buyer group is formed under one goal to maximizing aggregate buyer's utility, the price discount received by being members of a coalition. Additionally, the definition of bundle of items is a slightly difference from [2] referring to several items together in a package of one or more goods at one price. The discount policy of sellers based on the number of items bundled in the package. If the package is pure bundling, the average price of each item will be cheaper than the price of a single-item package. Suppose that there are three competitive sellers in the e-marketplace selling some similar or the same products. These sellers prepare a large stock of goods and show the price list for each product. Then, conceptually, price watcher agent retrieves competitors' product prices from seller websites or agent sellers over the World Wide Web as shown in Fig. 1. Generally speaking, both seller agent and buyer agent are a software entity that assists its owner to achieve some delegated goals [10]. The example of three sellers' information is shown in table 1. The first seller, called s_1, is selling two sizes of facial toner, 100 cc and 200 cc. To get attract to buyers seller s_1 has made the special offers to attract the buyers. For instance, seller s_1 offers a package of number p^1_3 with the price of $32.0. The package p^1_3 composes of 3 bottle of facial toner (200 cc). The average price of each facial toner (200 cc) is about 32.0/3 = 10.67 dollars/bottle which is 14.0-10.67 = 3.33 dollars/bottle cheaper than a sing-bottle of facial toner (200 cc) in package $p^1_{2.}$ At the same time, the third seller called s_3 offers package p^3_3 which comprises of 3 bottles of facial toner (200 cc) and 1 bottle of body lotion (250 cc) at the price of $49.5. However, a single bottle of facial toner (200 cc) and body lotion (250 cc) are set individually in the package p^1_2 at the price of $14.0 and the package p^2_2 at the price of $19.0. Suppose there are some buyers who want to purchase some products listed in the table 1. In the heterogeneous preference of buyers, some buyers do not want to purchase the whole bundle of items by their own. Some buyers need to buy few items at a cheapest price, but they do not want to buy the whole package. Suppose a buyer called b_1 who wants to purchase a bottle of facial toner (200 cc) and a bottle of body lotion (250 cc) as shown in table 2. Typically, a buyer has seen the price list provide by sellers before making orders. The problem of buyer b_1 is described as follows. If buyer b_1 goes straight to purchase those products by his own, the total cost that buyer b_1 needs to pay is 14.0+19.0 = 33.0 dollars which is the highest price at that time. So, buyer b_1 comes to participate in the group buying with the aim of obtaining better prices on the purchasing. Then, buyer b_1 places the orders to specific items with the reservation prices[2] of $9.0 for facial toner (200 cc) and $10.5 a bottle of body lotion (250 cc).

In common scenario in participation of group buying, the buyer agent collects buyer's requests and joins a buyer coalition for some period of time to allow new orders to come in. At the end of specified period of time, buyer agent eases the new buyers' requests, and buyer agent forms a coalition based the specific algorithm. Buyer agents can be loaded at the sites other than the seller websites. The algorithm presented in this paper provides means for buyer coalition formation by ACO in an e-marketplace.

[2]The reservation price is the maximum price a buyer is willing to pay for a good. It varies for the buyer according to their desire for the good and their information about substitute goods.

In particular constrains, buyers are quoted a buyer-specific price after they have seen the price list of all packages provided by sellers. The buyer coalition is formed concerning only the price attribute. And, the price per item is a monotonically decreasing function when the size of the package is increasing big. Additionally, the rule of the coalition is that each buyer is better forming a group than buying individually. The buyer coalition could be fail if there is no utility earned from forming the group buyer.

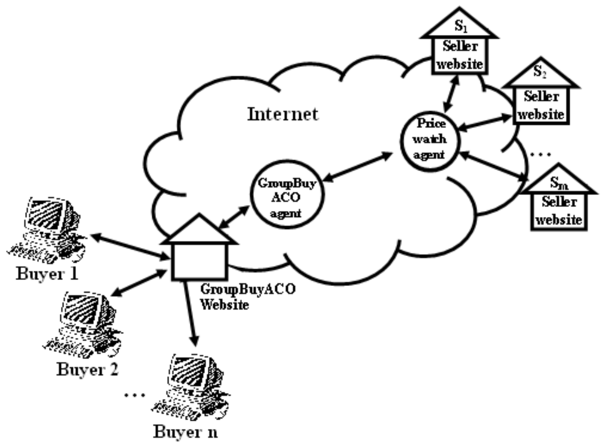

Figure I. The outline of the GroupBuyACO scheme

TABLE I. THE PRICE LIST EXAMPLE

Seller	***Package Number***	***Facial Toner***		***Body Lotion***		***Price ($)***
		100cc	200cc	150cc	250cc	
s_1	Package[1]$_1$	Pack of 1	-	-	-	8.9
	Package[1]$_2$	-	Pack of 1	-	-	14.0
	Package[1]$_3$	-	Pack of 3	-	-	32.5
	Package[1]$_4$	Pack of 1	Pack of 6	-	-	50.9
s_2	Package [2]$_1$	-	-	Pack of 1	-	10.5
	Package[2]$_2$	-	-	-	Pack of 1	19.0
	Package[2]$_3$	-	-	-	Pack of 4	67.0
	Package[2]$_4$	-	-	Pack of 1	Pack of 8	92.0
s_3	Package[3]$_1$	-	Pack of 1	-	-	14.00
	Package[3]$_2$	-	-	-	Pack of 1	19.0
	Package[3]$_3$	-	Pack of 3	-	Pack of 1	49.5

The symbol '-' appearing in the Table 1 means that the seller does not put the product item in that package number.

TABLE II. A SAMPLE OF BUYERS' ORDER

Buyers	***Buyer's Order (Number of item × (price $))***			
	Facial Toner		***Body Lotion***	
	100cc	200cc	150cc	250cc
b_1		1 x (9.0)		1 x (10.5)
b_2	-	-	-	2 × (10.95)
b_3	-	-	3 × (6.0)	1 × (6.0)
b_4	1 × (8.0)	4 × (11.0)	-	-

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III. Problem formation to buyer formation with bundles of items

In the period of time, there is a set of sellers on the Internet called S = {$s_1,s_2,\ldots,s_m$} offering to sell a partial or all goods of G = {$g_1,g_2,\ldots,g_j$}. Let B = {$b_1, b_2,\ldots,b_n$} denote the collection of buyers. Each buyer wants to purchase several items posted by some sellers in S. The seller i has made special offers within a set of packages, denoted as $Package^i$ = {$Package^i_1$, $Package^i_2$,…, $Package^i_k$} The price per item is a monotonically decreasing function when the size of the package is increasing big, an each package is associated with the set of prices, denoted Price = {$price^i_1$, $price^i_2$,…, $price^i_k$}, where the $price^i_k$ is an item list denoted by a vector {g^{ik}_1 g^{ik}_2,…, g^{ik}_j}. If any goods g_j is not available in the $package^j_k$ of seller s_i, $g^{ik}_i = 0$. Each buyer b_m needs to buy some items offered by sellers, denoted as Q_m = {q^m_1 ,q^m_2,…,q^m_j}, where q^m_j refers to the quantity of items g_j of buyer m. If $q^m_j = 0$, it means that buyer b_m does no request to purchase goods g_j. Also, any buyer b_m places the reservation price for each particular goods associated with Q_m, denoted as Rs_m = {rs^m_1, rs^m_2,…,rs^m_j} where $rs^m_h \ge 0$, $0\le h\le j$. The objective of the problem is to find best utility of the coalition; the following terms and algorithm processes are needed to define. The coalition is a temporary alliance of buyers for a purpose of obtaining best utility. The b_m's utility gained from buying q_m of g_j at the $price_j$ as $(rs^m_j - price_j)q_m$, so the total utility of the group is define as follow:

$$U = \sum_{b_m \in B}\sum_{q_m \in Q_m}(rs^m_j - price_j)q_m \qquad (1)$$

IV. Ant colony optimization for Buyer Coalition scheme

A. Background

Ant colony optimization (ACO) algorithms are inspired by the behavior of real ants for finding good solutions to combinatorial optimization. The first ACO algorithm was introduced by Dorigo and Gambardella [11], [12] in 1997 which known as Ant System (AS). ACO applied to classical NP-hard combinatorial optimization problems, such as the traveling salesman problem [13], the quadratic assignment problem (QAP) [14], and the shop scheduling problem and mixed shop scheduling [15]. In nature, real ants are capable of finding the shortest path from a food source to their nest without using visual cues [16].

In ACO, each artificial ant builds a feasible solution by repeatedly applying a stochastic greedy rule. While constructing its tour, an ant deposits pheromone on the ground and follows the path by previously pheromone deposited by other ants. Once *all* the *m* ants have completed their tours, the ant which found the best solution deposits the amount of pheromone on the tour according to the pheromone trail update rule. The best solution found so far in the current iteration is used to update the pheromone information. The pheromone τ_{ij}, associated with the edge joining i and j, is updated as follow:

$$\tau_{ij} \leftarrow (1-\rho)\cdot\tau_{ij} + \sum_{k=1}^{m}\Delta\tau^k_{ij}, \qquad (2)$$

where ρ is the evaporation rate which $\rho \in (0,1]$. The reason for this is that old pheromone should not have too strong an influence on the future. And $\Delta\tau^k_{ij}$ is the amount of pheromone laid on edge (i, j) by ant k:

$$\Delta\tau^k_{ij} = \begin{cases} Q/L_k & \text{If edge (i, j) is used by ant k.} \\ 0 & \text{otherwise,} \end{cases} \qquad (3)$$

where Q is a constant, and L_k is the length of the tour performed by ant k.

In constructing a solution, it starts from the starting city to visit an unvisited city. When being at the city i, ant k selects the city j to visit through a stochastic mechanism with a probability p^k_{ij} given by:

$$p^k_{ij} = \begin{cases} \dfrac{\tau^\alpha_{ij}\cdot\eta^\beta_{ij}}{\sum_{c_{il}\in N^k_i}\tau^\alpha_{il}\cdot\eta^\beta_{il}} & \text{if } j \in N^i_k \\ 0 & \text{otherwise,} \end{cases} \qquad (4)$$

where N^i_k is a set of feasible neighborhood of ant k, representing the set of cities what ant k has not been visited. α and β are two parameters which determine the relative influence of pheromone trail and heuristic information, and η_{ij}, which is given by:

$$\eta_{ij} = \frac{1}{d_{ij}}, \qquad (5)$$

where d_{ij} is the length of the tour performed by ant k between cities i and j.

B. Forming buyer group with bundles of items by Ants

The procedure of ACO for forming buyer coalition with bundles of items is as follows. The first step is to represent the problem as graph where the optimum solution can be found in a certain way through the graph. In Fig. 2, the solid line represents a package selected by the ant k. If the selected package is picked more than one, the ant k moves longer along the solid line. Then, in this particular problem, the ant randomly chooses the other package which is represented by a dotted line. The probability of selecting i units of packages j^{th} is p^k_{ij} formally defined below:

$$p^k_{ij} = \begin{cases} \dfrac{\tau^\alpha_{ij}\eta^\beta_{ij}}{\sum_i\sum_{l\in D}\tau^\alpha_{il}\eta^\beta_{il}} & \text{If } j \in D\text{, the set of packages offered by all sellers which have not been selected.} \\ 0 & \text{Otherwise,} \end{cases} \qquad (6)$$

where $\Delta\tau^k_{ij}$ is the intensity of the pheromone trail on the solid line. For instance, at the starting point if the ant k has selected three sets (j=3) of $Package^1_2$, the ant deposits its pheromone only on the $Package^1_2$ at the unit of 3. The result is shown in the Fig. 2. The quantity of pheromone $\Delta\tau^k_{ij}$ is defined as follow:

$$\Delta\tau^k_{ij} = \begin{cases} 1/U^k & \text{If i units of package j is used by the ant k.} \\ 0 & \end{cases} \qquad (7)$$

where U^k is the total utility derived from the ant k. And, η_{ij} is given by:

$$\eta_{ij} = \begin{cases} \sum m_{ij} / \sum u_{ij} & \text{If some of the items in the selected package are unmatched to the buyers' requests.} \\ 1 & \text{If all items of the selected package are totally matched to the buyers' requests.} \\ 0 & \text{Otherwise,} \end{cases} \quad (8)$$

where m_{ij} is the number of items in the selected packages which is matched to the buyer's requests, and u_{ij} is the total number of items in the selected packages which is unmatched to the buyers' requests.

At the beginning all of the pheromone values of each package line are initialized to the very small value c, 0 < c ≤1. After initializing the problem graph with a small amount of pheromones and defining each ant's starting point, a small number of ants runs for a certain number of iterations. In each iteration, each ant determines a path through the graph from its starting point to the solid package line. The measurement of the quality of a solution found by the ACO is calculated according to the total utility of coalitions in (1).

TABLE III. DATA SETTINGS FOR GROUPBUYACO SCHEME

Constant	Detail	Value
NumOfBuyer	No. of buyers	3,10
NumOfSeller	No. of Sellers	2,3
MaxNumPackageSeller	Maximum packages for seller	4
NumOfTypeInPackage	NumberOfProductTypeInPackage	4,6

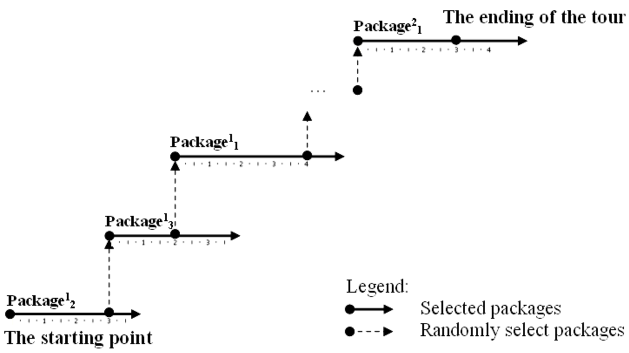

Figure II. Representing the formation of group buying as graph (no. of sellers = 2)

C. GroupBuyACO scheme

This section shows the implementation of ACO algorithm for forming buyer group with bundles of items called the GroupBuyACO scheme. The proposed algorithm can be described by the following procedure:

```
procedure GroupBuyACO(){
  Initialization of the GroupBuyACO;
      Initialization all pheromone values to
      a small numerical constant c > 0
  while not (isFinish(Iteration )){
    for Ant = 1 to MaxAnt {
        ManageAntsActivity();
        EvaporatePheromone();
        Save the best solution found so far
        UpdatePheromone();
    }
  }
}
ManageAntsActivity(){
    while not (isAntFinish(tour)){
       Select a package I to be visited and
       the exact j amount of package with
       probability p_ij^k in (4).
    }
}
EvaporatePheromone(){
   Old pheromone should not have too strong
   an influence on the future. The
   evaporation rate value is ρ which is
   initialized to be small, ρ∈(0,1].
}
UpdatePheromone(){
   Update all paths according to (2) and (3).
}
```

V. EXPERIMENTS AND RESULTS

This section demonstrates the simulation setup for group formation by the proposed algorithm, GroupBuyACO scheme. The algorithm has been tried several of runs with different number of artificial ants, and different value of α and β to find which values would steer the algorithm towards the best solution.

A. Simulation and data settings

The simulation program for the GroupBuyACO scheme is coded in C++ programming language. In the experiment, the two examples with different characteristic are used. Each example of operates several runs to get the average results. Table 3 summarizes the data settings for GroupBuyACO scheme in the evaluation.

1) Example1

For the sake of simplicity, this example is a simple case. In the marketplace, there are two sellers selling some product as listed in Table 4. And there are three buyers who want to purchase some of those products. They have placed the orders as shown in table 5.

TABLE IV. THE PRICE LIST FOR EXAMPLE 1

Seller	*Package Number*	*Product types*				*Price ($)*
		A	*B*	*C*	*D*	
s_1	Package$^1{}_1$	1	1	1	1	35.0
	Package$^1{}_2$	1	1	-	-	18.0
	Package$^1{}_3$	1	-	-	-	10.0
	Package$^1{}_4$	-	1	-	-	10.0
s_2	Package$^2{}_1$	-	-	2	1	24.0
	Package$^2{}_2$	-	-	1	-	10.0
	Package$^2{}_3$	-	-	-	1	10.0

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TABLE V. BUYERS' ORDER FOR EXAMPLE 1

Buyers	Buyer's Order (Number of item × Reservation price $			
	A	B	C	D
b_1	-	2 x 9.5	-	-
b_2	1 x 10.0	-	1 x 9.0	-
b_3	-	-	1 x 10.0	1 x 9.0

2) Example 2

In order to get best experimental results, for this example, the buyers' orders of this example are randomly chosen by the simulation to demonstrate that the proposed algorithm is possible to works in the real-world data. This example randomly chooses the requests of ten buyers form three different sellers. Each seller offers to sell various packages in which some of them are pure bundling packages and single-item packages. Table 6 shows the price list offered by individual seller, and Table 7 is the example of ten buyers who participate in the group buying.

TABLE VI. THE PRICE LIST FOR EXAMPLE 2

Seller	Package Number	Product types				Price($)
		A	B	C	D	
s_1	$Package^1_1$	1	-	-	-	1000
	$Package^1_2$	-	1	-	-	1000
	$Package^1_3$	-	-	1	-	1000
	$Package^1_4$	-	-	-	1	1000
	$Package^1_5$	1	1	-	-	1950
	$Package^2_6$	-	1	1	-	1900
s_2	$Package^2_1$	-	-	1	1	1925
	$Package^2_2$	1	-	1	-	1950
	$Package^2_3$	1	-	-	1	1920
	$Package^2_4$	-	1	-	1	1970
s_3	$Package^3_1$	1	1	1	-	2700
	$Package^3_2$	-	1	1	1	2690
	$Package^3_3$	1	-	1	1	2750
	$Package^3_4$	1	1	-	1	2700
	$Package^3_5$	1	1	1	1	3500

TABLE VII. A SAMPLE OF BUYERS' ORDER FOR EXAMPLE 2

Buyers	Buyer's Order (Number of item × Reservation price $)			
	A	B	C	D
b_1	-	1 x 955	1 x 960	-
b_2	-	-	-	1 x 980
b_3	-	-	2 x 980	-
b_4	-	1 x 970	-	-
b_5	-	-	-	1 x 989
b_6	1 x 965	-	-	-
b_7	-	-	1 x 970	-
b_8	1 x 960	1 x 975		-
b_9	-	-	1x 1000	-
b_{10}	2 x 969	-	-	-

B. Study of the GroupBuyACO scheme performance

Usually the main parameters of an ACO algorithm are α and β which are assigned fixed values during the run of the algorithm.

1) The effect of α and β

The first two parameters to be studied are α and β. As shown in previous equations of (6), these parameters are related to the probability of selecting i units of packages j^{th} (p_{ij}^k) because α is the exponent of $\Delta\tau_{ij}^k$ and β is the exponent of η_{ij}. Thus, the corresponding variations in values of both α and β might play an importance role on the GroupBuyACO scheme. Let both α and β value rang from 0.5 to 5, and the number of iterations is 200. The resulting of corresponding variation in values of α and β is shown in Table 8. The best result for the problem of example 1 and example are in bold. It can be seen that average of group's utility earned on group buying by GroupBuyACO scheme is high when α is 2 and β is between 0.5 and 1.

2) Number of Iterations

In Fig. 3 and 4, it can be observed that as the number of iterations increase, the total utility of the group derived by GroupBuyACO scheme also increases. Moreover, when the problem is huge, the number of iterations also is large. Thus the optimum number of iterations is needed to be chosen to give the stabilized solutions to the problems.

3) Evaporation rate

Evaporation rate ρ of the pheromone is one of the most important for the GroupBuyACO scheme. From Fig. 5 and Fig. 6, it can be seen that as the value of ρ = 0.1 the total utility earned from the group buying is the highest.

TABLE VIII. THE AVERAGE OF GROUP'S UTILITY (EXAMPLE 1) DERIVIED FROM CORRESPONDING VARIATION IN VALUES OF α AND β, ITERATION NUMBER = 450

	β				
α	0.5	1	2	3	4
0	-1.83	0.50	-1.57	-0.50	1.17
0.5	2.06	3.27	1.22	3.04	2.20
1	-0.07	1.82	3.70	3.50	0.58
2	3.73	**4.10**	1.85	2.30	-1.50
3	-0.77	2.73	-0.75	-2.67	0.11
4	-1.73	0.86	0.63	-0.75	2.60

TABLE IX. THE AVERAGE OF GROUP'S UTILITY (EXAMPLE 2) DERIVIED FROM CORRESPONDING VARIATION IN VALUES OF α AND β, ITERATION NUMBER = 2000

	β				
α	0.5	1	2	3	4
0	759.06	457.22	791.33	673.21	463.67
0.5	755.25	594.23	814.71	734.72	761.39
1	623.57	757.48	698.21	542.01	654.04
2	**927.24**	907.09	456.98	671.45	643.21
3	554.65	657.84	569.24	459.27	598.25
4	365.98	452.11	741.37	456.89	744.25

4) Comparison of GroupBuyACO scheme with GroupPackageString scheme in [1]

In order to evaluate the performance of GroupBuyACO, the initial parameters were set to the following values: α = 2, β = 1 and ρ = 0.1. It is interesting to see that both GroupBuyACO scheme and GroupPackageString give similar result for the example 1, but GroupBuyACO outperforms GroupPackageString for the example 2.

TABLE X. THE COMPARISON OF GROUPBUYACO SCHEME WITH THE GENETIC ALGORITHM IN [1]

Example #	GroupBuyACO scheme	GroupPackageString [1]
1	4.52	4.51
2	927.11	909.74

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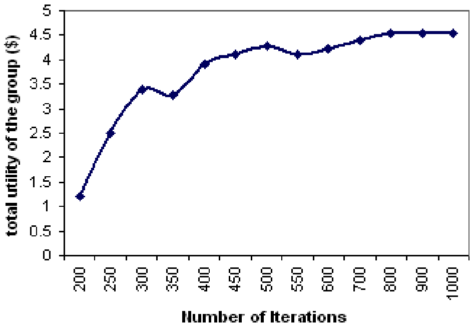

Figure III. Number of iterations for example 1, where initial settings α = 2 , β = 1, and ρ = 0.1.

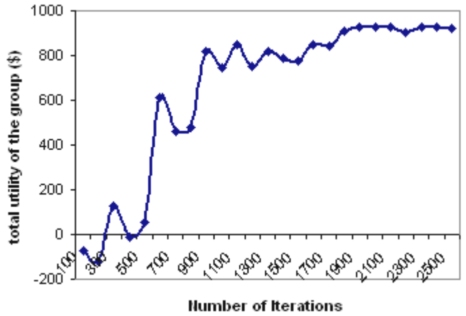

Figure IV. Number of iterations for examplpe 2 where initial settings α = 2 , β = 0.5, and ρ = 0.1.

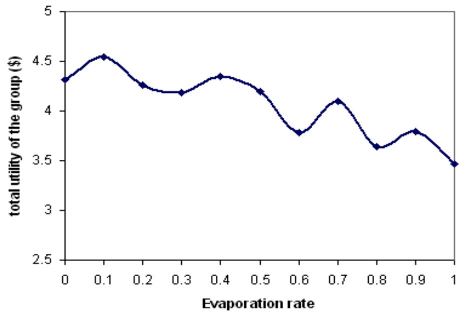

Figure V. Evaporation rate (ρ) for examplpe 1, where initial settings α = 2 and β = 1.

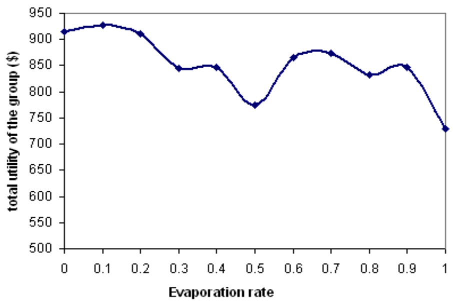

Figure VI. Evaporation rate (ρ) for examplpe 2, where initial setting α = 2 and β = 0.5

VI. CONCLUSION AND FURTHER WORK

This paper has introduced a new method for forming buyer coalition through the use of ant colony optimization technique, called GroupBuyACO scheme. The desired goal for the proposed algorithm is to form a buyer coalition in order to maximize the group's total utility. The ants construct the trail by depositing pheromone after moving through a path and updating pheromone value associate with good or promising solutions thought the edges of the path. From two illustrative examples, it is observed that the proposed algorithm is effective in dealing with finding best buyer coalitions with bundle of items. The solution quality of GroupBuyACO scheme is shown by comparing with the genetic algorithm technique called GroupPackageString scheme. In the experimental results, it turns out that in most cases the effciency of GroupBuyACO is acceptable. The GroupBuyACO scheme has restrictive constraints of forming a buyer coalition as follow: 1) buyers quote their reservation prices after they have seen the price list of all packages provided by sellers. 2) The buyer coalition is formed concerning only the price attribute. 3) And, the price per item is a monotonically decreasing function when the size of the package is increasing big. 4) The period of time for forming the buyer coalition is not under consideration even through it may change the results buyer coalition. These restrictions can be investigated in the future research.

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