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An Approach on Multilateral Automated Negotiation

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Abstract

In E-commerce, numbers of transactions are increasing day by day in B2B and B2C trade. Online negotiation is possible because of automated negotiation. In this paper, we propose linear programming and pattern matching based multilateral automated negotiation system and study some multilateral system with several methods. We have studied fuzzy inference logic based system, multithreading based automated negotiation system, linear programming based system and genetic algorithm based system and we have compared some methods of automated negotiation. Multilateral negotiation system gives better result to participant than bilateral automated negotiation. Technique of pattern matching based automated negotiation gives fast result and reduces overhead of calculation.

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Keywords: Multilateral automated negotiation; fuzzy logic; multithreading; linear programming based system.

1. Introduction

Automated negotiations have allowed people for online negotiations. An automated negotiation can be done in two ways: bilateral automated negotiation and multilateral automated negotiation. In bilateral negotiations, two agents negotiate on single or multiple issues on behalf of people. When more than two agents come together to negotiate, with different constraints and preferences, then the process becomes complicated. The complicated process of automated negotiation is referred as multilateral automated negotiation. Many people do not like traditional negotiation process because they view it as time consuming and complex process as people participation is required till the process is complete. This problem is solved by automated negotiations. Negotiations are conducted using bidding, bargaining or auctions. It is difficult when the behavior of opponents is unknown.

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Prediction methods are used to identify the behavior of opponents. A prediction method of utility function gives good result to identify the behavior of opponents [5].

2. Related Work

As per Ricardo Buttner, automated negotiation is classified mainly as structure, theoretic foundation and restriction. We are going to focus on the protocol for the structure. The Protocols can be classified into bilateral, one-sided and double-sided protocols. One-sided and double-sided negotiations are also called as multilateral automated negotiation [10]. In bilateral automated negotiation, maximum utility for a single agent can become minimum utility for opponent agent, and therefore the chance of agreement is low. Considering Figure 1, agent A and agent B have limited space to take their decision[14]. This problem is avoided by multilateral automated negotiation. A major challenge in the negotiation using the bilateral protocol is that the agents hide their preferences. So agent does not know which preferences the opponent will prefer. Susanne Klaus, Karl Kurbel and Iouri Loutchko, in 2001, gave an overview of game theory based negotiation, multi-attribute utility theory based negotiation and auction based negotiation. As per their paper, there is scoring function problem and user dependent problem in many-to-many multilateral negotiation. For linear scoring function, optimal solution can be found but for non-linear scoring function, the mathematical analysis is very difficult. How to construct the negotiation strategy is not cleared in this paper. As per this paper, multilateral negotiation using game theory is very difficult to use. Utility theory can give better results than the game theory [19]. Sanghyun Park and Sung-Bong Yang have proposed a negotiation agent system based on the incremental learning in order to increase the efficiency of bilateral negotiations and to improve the applicability towards multilateral negotiations. For the system, they also have introduced a framework for multilateral negotiations in an e-marketplace in which the components can dynamically join and disjoin. They proposed an automated negotiation system that can efficiently carry out multilateral negotiations with multi-attributes in pervasive computing environments[17]. Also they developed linear programming based automated negotiation system. They used concept of mediator agent and two bilateral automated negotiation schemes based on linear programming. The experimental results show that the proposed system produces higher joint profits and is faster in reaching agreements on an average under the condition of agreement for reciprocity than a negotiation system based on the trade-off mechanism. [15].

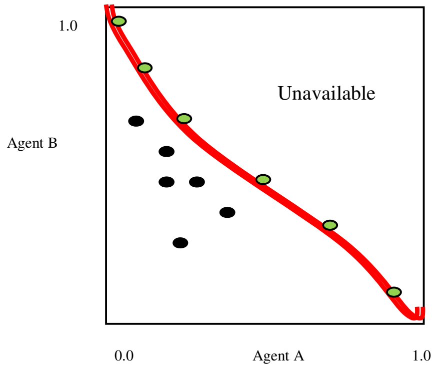


Fig 1. A point indicates the utility for both agents of a bid. The red line is the Pareto optimal frontier .

The multi issue negotiation model with distributed problem solving was presented by P Faratin, C Sierra, N R Jennings and P Buckle. In this, they developed fully autonomous agent who coordinates both agents' interaction and handles individual agent also [21].

Monotonic Concession Protocol for Multilateral Negotiation has been described by Ulle Endriss. It is a deadlock free protocol in which they restricted on the utility function. It is not applicable for all the cases of negotiation [17]. When the participant does not share his preference in the negotiation, the agent needs to analyze the behaviour of the opponent. Performance of negotiation can be measured in two ways: using agent's performance as a benchmark for the model's quality and directly evaluating its accuracy by using similarity measures. As per Tim, there is an almost linear correspondence between accuracy and performance of the system. They measure accuracy of system over timing but do not consider system based on resource dependent [9]. Dong proposed multi-attribute negotiation model based on internal factors argumentation, the system can achieve Pareto efficiency solution and promotes the cooperation between agents and then reach a win-win result. In multi issues negotiation protocol, MAS (multi agents system) is used for decision making. [13].

Considering these papers, we can say multilateral automated negotiation gives better result to buyers and sellers. In multilateral negotiation, we can use *desperate* or *patient* coordination strategies. In desperate strategy, if one of the sub agent successes then process is stopped. In that, agent wants negotiation process to be completed as early as possible and in patient strategy, if one of the sub agents gets success then process will be continued till all agents get success. After completing the process, the score of each agent is checked and among them, the agent who gives more profit is selected. The protocol determines the flow of messages between the negotiating parties. Request based negotiation protocol and sequential bilateral negotiation protocol are used for bilateral negotiation. Automated mediation, baseline mediation, multiple bilateral, feedback based mediation and contract net protocol are used for multilateral negotiation. Win-win strategy gives better outcomes to buyer and seller [3]. Intelligent techniques such as neural networks, genetic programming, fuzzy logic theory and Bayesian theory are used to learn opponent's behaviour, decision-making and generating offers and fuzzy system, multithreading, game theory, genetic algorithms and linear programming are some of the methods which can be used for multilateral automated negotiations.

3. Methods of Multilateral Automated Negotiation

Multilateral negotiation is classified in two ways 1) one sided and 2) double sided. One sided is also called as one-to-many and double sided is also called as many-to-many respectively. Some of the multilateral automated negotiation methods are as follows:

3.1. Fuzzy System

In fuzzy system, the two effective factors considered are requirements and preferences. (Requirements may be qualitative or quantitative which is given by the participants). Priority is assigned to the preferences. In this system mediator is used, and mediator uses the issue tradeoffs strategy. Analytic hierarchy process can be used to take the preferences of participants in this system. This model supports many to many multilateral negotiations. A negotiation specification of the model has been presented by Bahdor. In that method they have proposed FANA (fuzzy system based automated negotiation) architecture as shown in Figure 2 [2].

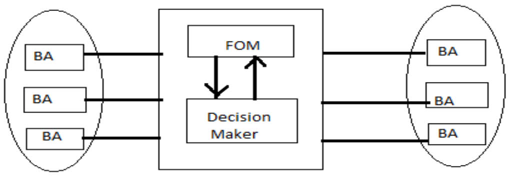


Fig 2. FANA model architecture .

In FANA architecture, they consider two components such as FOM (fuzzy system based offer modifier) and decision maker. FOM is the fuzzy system based offer modifier. Offer in FOM component is modified by seller, with respective buyer's requirement and this passes to decision maker component. After taking input from FOM, decision maker component decides to reject or accept the offer. It makes decision on the basis of seller's and buyer's proposal and compute partial score for each issue [2].

3.2. Multithreading

In multilateral automated negotiation using multithreading, compromise is done on game theory, heuristic method and argumentation method. In that coordinator creates thread for each issue and sub issue. All these issues are arranged in hierarchical pattern. They take preference in the form of advertisement and save into the database. According to their condition [10] buyer and supplier are matched on the basis of constrain of unique product id. Utility function is used to generate counter offer. Evaluation of utility function is U_{min}= non function attribute * actual cost. U_{max}= non functional attribute * Cost with margin. Where, U_{min} is minimum utility of product, U_{max} is maximum utility of product, the function attribute is overall cost. Minimum payoff is summation of U_{min} and maximum payoff is summation of U_{max}.

Considering the paper [10], negotiation is started by buyer, initially buyer generates offer for seller then seller inspects the offer and calculates the utility of each issue. After calculating they accept/reject the offer based on their price. If seller rejects offer then they decrease the utility. Therefore new utility is calculated by using product of old utility and F1.Where,

$$F1= 1 - (\text{No. Of rounds X penalty}) /\text{weight}$$

where x(penalty) = Sum of cost of attribute on which agreement has not been reached of penalty. This penalty is sent to thread on which negotiation is still in progress then accepted offer are temporally stored while issues are rejected. Negotiation process will go on until the time limit of counter or offer will be accepted. Time limit counter will be updated as per round. Parallel process will be done in multithreading based negotiation [8].

3.3. Linear programming

According to Sanghyun Park and Sung-Bong Yang, linear programming system produces higher joint profits in negotiations and it is faster in reaching agreements on the average under the condition of agreement of reciprocity than the trade-off mechanism based negotiation system. Agent can participate dynamically. In that, they extend Faratin (2000) system. In this paper, the multi-attribute utility theory (MAUT) is applied to evaluate the profits of the participants. In this they used mediator, client agent and proxy server. They proposed Jini LUS architecture [8]. The seller agent and buyer agent are connected to each other through proxy of mediator. The mediator agent evaluates the profits of the entire negotiation participant and sorts them in decreeing order of joint profit. Thereafter, the final couples are determined from the sorted list. The time complexity determines the final couples with the maximum profit criterion is O(N log N), where N is the number of negotiation partners, since sorting takes longer time than any other operations.

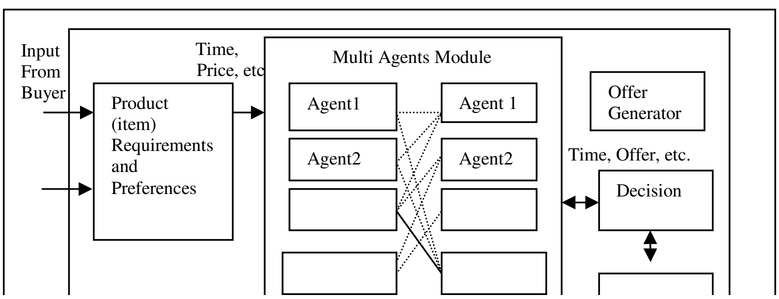
The formula is used as, the objective function: Maximize $z = Profit^{buyer}(Xi) + Profit^{seller}(Xi)$

The constraint conditions:
$|Profits^{buyer}(Xi) - Profit^{seller}(Xi)| \le \sigma$
The boundary conditions:
The lower bound of $CNR_i \le X_i \le$ the upper bound of CNR
(i = 1, 2, …, n). Where, common negotiation ranges ($CNR_{i)}$ = {Negotiation_range$_i$for buyer} ∩ {Negotiation_range$_i$ for seller}.

In this, they focus on the efficiency of a system with respect to joint profit, execution time, and the capability of extending toward multilateral negotiations in a virtual market. It is used in distributed system. It gives more profit and faster than trade-off based negotiation system. Practically it does not support for all types of frameworks. There are some more methods are developed. Some of few we explained here in short. Each method has different advantages on different cases. It is difficult to say that particular method is best for multilateral automated negotiations. But from our survey we can say that game theory is suited for B2B framework. In the game theory based negotiation, it is difficult to compute behaviour of software agent in all situations. Genetic algorithm based negotiation is not suitable for large scaled system. If number of participant will increase then its searching complexity of agents can be increased then it will require more time. This problem is over come by linear programming. Linear programming negotiation system is faster than genetic algorithm based negotiation system. Parallel process is done using multithreading negotiation based system. We can improve performance of negotiation by adopting the environment conditions. The quality of an opponent model can be measured by using agent's performance as a benchmark or directly evaluating its accuracy by using similarity measures [12].

4. Proposed Architecture

As shown in Figure 3, in multilateral automated negotiation, number of buyers and sellers are involved [1]. The requirement of buyer and seller are passed to the product and preferences block. Each buyer and seller have their own preferences, as per their priority of item and weight will be assigned to each item. Each buyer and seller selects their agents by manually or automatically. The multi-agent module is used to select the agent. Agent performs negotiation on the behalf of buyer and seller.



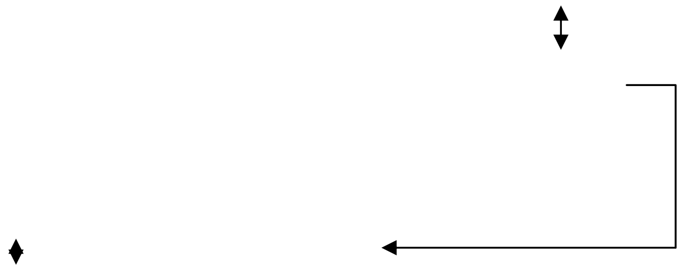


Fig 3. Architecture for multilateral automated negotiation

There should be one agent for each participant and this is a constraint in our model. Decision function is used to take the decision about negotiation process. After checking the constraints of system, decision function decides whether offer will be accepted or rejected. Offer generator is used to generate offers for buyer and seller. For offer generation we will use multi attribute utility function. Decision function saves each offer into the database, which is generated by offer generator. Available package is used by decision function in the case of emergency. The case of emergency is depending on time factor. If required time of buyer decreases then decision function sends direct available package to multi agent module. Among these packages, buyer's agent selects one which is the most suitable for buyer preferences. Package will be available on the basis of market basket analysis. Market Basket Analysis is the discovery of relations or correlations among a set of items. Decision function sends final output of negotiation process to negotiation result module. In graphical analysis, we are trying to analysis the graph of negotiation in which preferences are taken using Matlab and analyzed using XLS.

4.1. Mathematical model

Mathematical model of multilateral automated negotiation as denoted by M_N is as follows:

$M_N = \{I, M, N, X, P, R, T, S, G, O_f, O_e, D, P_{k,}, O\}$

Where,

- I -The set of possible inputs (items, issues, preferences).
- G -The set of possible environments (Time deadline, MAS, Offer generator, Offer evaluations, Decision function and Available packages).
- O -The set of possible outputs (action and strategies). These are main module of Multilateral Automated Negotiation which are further divided into sub module.

I € {M, N, X, P, R, T, S,E}

Where, M, N, X, P, R, T, S are sub set of I.

- M - Number of participants, N-Number of issues.
- X -Value of issue.
- S -Scoring function.
- P –Preferences.
- T -Required time of negotiation.

Each preference has weight in between (0, 1).

M-> A_s, A_b

$A_s = (A_1, A_2, \ldots, A_i)$ and $A_b = (A_1, A_2, \ldots, A_j)$, i.e i = j, are number of agents, which are selected by sellers and buyers respectively.

G € {O_f, O_e, D, P_k}, means O_f, O_e, D, P_k are subset of G, where, O_f, O_e, D, P_k are sub set of G

- O_f- Offer generation function

- O_e-Offer evaluation
- D- Decision making function
- P_{k-} Available packages of automated negotiation

Decision D depends on emergency E, where O_f, O_e, $P_{k \rightarrow}$ D offer generation, offer evaluation and package selection depend upon decision function. Output O is declared on the basis of Time T and Round R.
Therefore, O --> R, T, where O depends upon round R and Time T.

If $M_N = 0$, then negotiation is withdrawn.

4.2. Algorithm for Multilateral Automated Negotiation

1. Agent's selection and registration of preferences are done by participants // Emergency is optional.
2. Number of rounds, Time, Emergency= 0;
3. Call Agent-Matching ();
4. Decision _Maker (Preferences, Offer, Round, Time, Emergency, $S_{Discount}$) // Offer received;

```
  If (Emergency=0) then // Offer generation and offer evaluation;
     Call linear _programming (); // calculate profit by using linear programming.
     Round=round -1;
     Time=Time-1;
     Return offer;
  If (Emergency=1)
     Call packages (); // Packages from DB using market basket analysis.
     Return offer;               // Packages.
     Exit;
  Else
Print "Error";
```

5. New agent's entry then goes to step 1.
6. Negotiation process will be continued until time or round or successful negotiation process;
7. Exit;

4.3. Procedure

Buyer and Seller register their preferences on registration form of Multilateral Automated Negotiation. Preferences can be taken by using Matlab or XLS. Excel is better than Matlab when you need to keep a table of your data (input, output, and descriptions) in front of you at all times, since "formatted output" is inherent in the tool. MATLAB is best for sophisticated math, especially on large data sets and for things like matrix algebra, differential equation integration, Laplace transforms in the process control, etc. In the perspective of theoretical approach we conclude that for small data set use XLS and for large data set use MATLAB.

Agent_Matching (): Agent can be selected by manually or automatically. For automatic selection of agent gets overhead of computation. Here we consider manual agent selection process.

$$\begin{pmatrix} \mathbf{U_{BS1}} & U_{BS2} & U_{BS3} & U_{BS4} & U_{BS5} & \ldots & U_{BSn} \\ U_{BS1} & \mathbf{U_{BS2}} & U_{BS3} & U_{BS4} & U_{BS5} & \ldots & U_{BSn} \\ U_{BS1} & U_{BS2} & \mathbf{U_{BS3}} & U_{BS4} & U_{BS5} & \ldots & U_{BSn} \\ U_{BS1} & U_{BS2} & U_{BS3} & \mathbf{U_{BS4}} & U_{BS5} & \ldots & U_{BSn} \\ U_{BS1} & U_{BS2} & U_{BS3} & U_{BS4} & \mathbf{U_{BS5}} & \ldots & U_{BSn} \\ | & | & | & | & | & & | \\ U_{BSn} & U_{BSn} & U_{BSn} & U_{BSn} & U_{BSn} & \ldots & \mathbf{U_{BSn}} \end{pmatrix}$$

Matrix 1 Final pair selection of agents

Here, U_{BS} is product of buyer and seller utility. Bold letters indicate maximum value of utility of buyer and seller. After matching, if more than one maximum values get then pair will be made on the basis of second maximum value (first come first serve). If one column or row has more than one maximum value then the conflict between agents will be happened. This conflict situation is solved by considering next maximum value of pair of agents.

Decision function (Preferences, Offer, Round, Time, Emergency): Decision function checks an emergency variable. If emergency=0, then total utility is calculated by using linear programming method on both side of participants such as Total_utility = $w_1u_1 + w_2u_2 + \ldots . w_nu_n$, where w is weight and u is utility of participant.
Offer = (min_utility+0.1) U_B+ (Max_Utility – S $_{Discount;)}$ $U_{S;}$
Consider an example, if seller gives discount of 20% then discount= 0.2, utility limit of Buyer (0.1, 0.4) and of seller (0.2, 0.8) then we will get offer such as:

First iteration: Offer = $0.2^*U_B + 0.6^*U_{S;}$
Second iteration: Offer = $0.3U_B + 0.4^*U_{S;}$
Third iteration: Offer = $0.4^*U_B + 0.2^*U_{S;}$

If UB=US=1 then maximum profit=0.8. Offer will be calculated until minimum and maximum utility limit. On the basis of values the maximum offer will be generated, so this offer's values will be selected to calculate maximum profit. Constraints are: if utility is calculated or increased by more than one then it is rounded 1 and the value less than zero is rounded to 0. If maximum profit is 0 then negotiation is withdrawn. Maximum profit is calculated by

Maximum profit= profit (U_B) + profit (U_S);

The process will be continued till the specified rounds, time or successful negotiation. Otherwise negotiation will be withdrawn.
Packages (): If emergency=1 then decision function calls package function. Packages are stored in the database using market basket analysis. Frequent data set or pattern matching are core concept of data mining for researcher .Consider Table 1: frequent data set of automated negotiation. If buyer and seller are negotiating on product e.g. Camera, and have minimum and maximum utility equal to or between the minimum and maximum utility of Camera's data set then negotiation on camera will be declared successful. Here constraints are: name of product will be same, buyer's and seller's attribute of product will be same or subset of product's attribute will be matched on Table's attributes and vice-versa. Otherwise negotiation gets to be withdrawn or not successful.

Table 1 Data Set of Multilateral Automated Negotiation.

PRODUCT NAME	ATRIBUTE 1	ATRIBUTE 2	ATRIBUTE 3	ATRIBUTE4	ATRIBUTE 5	ATRIBUTE 6	MIN UITILITI	MAX UTILITY
1.CMERA	MAKER	BODY	LENS	TRIPOD	BAG	ACCESSORY	0.07	0.33
2.LAPTOP	HARDISK	RAM	HEADPHONE	EXTERNAL SPEAKER	COMPANY	SCREEN SIZE	0.18	0.38
3.SMART PHONE	MAKER	SCREEN SIZE	COLOR	CARRIER	OS	ACCESSORY	0.2	0.9
4.FLAT	AREA	RATE	2 BHK	GARDEN	SCHOOL	MARCKET	0.16	0.4
5.CAR	ENGINE	COMPANY	COLOUR	COST	DRIVING	ACCESSORY	0.2	0.5
6.HALL	NUMBER OF PEOPLE	LAWN	CATERING	ROOMS	DECORATION	PARKING	0.3	0.8

5. Conclusion

Multilateral negotiations are more complicated and time consuming than bilateral negotiations, because in the multilateral automated negotiation we require to do multiple matching between the participants. Multilateral automated negotiation system gives better result than bilateral automated negotiation system. In liner programming based multilateral system, they used sorting to find final pair of agents. It takes O(N log N) complexity, in our system we used matrix method which reduced the complexity. It takes O(log NM) where N is number of seller's participants and M is number of buyer's participants. If Web service is used in the multilateral automated negotiation system then it can give faster results to the participant. Considering some of the previous papers, we found that multilateral negotiation system can be developed in fuzzy systems, Multithreading, time dependent systems, systems on linear programming and genetic algorithms. Various experimental results show that the predictive decision-making gives better results in terms of the utility gains for the adaptive negotiation agent as compared to the range of non-predictive negotiation strategies.

Distributed or parallel computation based multilateral automated negotiation will give fast result. For real time multilateral automated negotiation, cloud will be more helpful. Cloud requires low maintenance on data and is more secure, but it is useful for large application because cloud is costly. Pattern matching techniques give more appropriate result in minimum time.

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