A Concept-based Model to Facilitate Automated Negotiation in Multi-agent Systems

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Abstract

A refined model for automated negotiation with reference to how we human perceive different concepts for the same product is examined in this paper. In multi-agent e-commerce environments, the requesting proposal from an agent is usually composed of attributes and weights that define the criteria and the preferences. Such a proposal is then posted to an electronic market place for matchmaking. When an agent finds no exact match, the proposal will be taken back, revised and re-submitted again. This process will continue as long as it takes. In most scenarios, we suppose that the requesters would already have the alternatives in their mind in case of no exact match. The concept-based model that we proposed allows requesters first specify their requirements and the alternatives altogether, in one proposal, before it is sent out to the e-marketplace. The alternatives are defined according to the different concepts that can possibly be perceived on a product. Different attributes may lead to different concepts under which the values of most attributes and weights may have to be changed. It is believed that by incorporating with the alternatives in the proposals, negotiation time could be shortened by saving some communication costs.

1. Introduction

The growth of electronic commerce, especially the business-to-business online trading has increased exponentially in the recent years. Traders that include both the buyers and sellers have leveraged the Internet and the advances in agent technology to conduct their online business activities efficiently. In particular, there are some areas of online trading that deserve concerns. They take parts in making electronic commerce more secure and yet more sophisticated. The tedious parts of the process that otherwise to be carried out manually would chosen to be automated, e.g. negotiation.

Negotiation mechanisms allow interaction between buyers and sellers towards the resolution of an agreement [1]. On the online platform such as Internet, in the past people would have to negotiate by using emails, EDI, fax and even personal contacts. For efficient electronic commerce to flourish we are looking for ways to expedite negotiations and provide standardized protocols and methods for the automation or partial automation of negotiation as a step towards agreement resolution. In view of this, we in this paper tried to shed some light on how negotiation can be improved by (1) describing all the available concept-based alternatives for finding a closest match and, (2) the matchmaking process should be preemptively delegated to all the seller agents instead of having a separate long-winded negotiation dialogue with each individual seller agent.

2. Background

Electronic commerce has largely limited to selling goods available in catalogs with fixed characteristics. This context will quickly change by the insertion of negotiation mechanisms in the buying scenario of electronic commerce. Automated negotiation will ensure speed, consistency and less human-prone errors. It usually works by allowing the buyer to specify a desired product, and then the terms and other related attributes such as price may vary as negotiation progresses [2]. One of the important aspects of negotiation is the ability to find a similar product to satisfy the customer should the exact match is not available.

Suppose the customer is looking for a new car, model *Honda Civic*, *color blue* and with other accessories. The features are represented by attributes and their corresponding priorities are by weights as shown in Table 1 for negotiation. Tables 2 and 3 show similar cars found to that desired by the customer, and the respective weights. Table 2 presents a car which is more similar, according to our metric, than the one which is illustrated in Table 3, as shown by its greater value of W_T. The first Table contains a more similar car, because this Table has more attributes which match the most relevant features requested by the customer. The most relevant features here in this example are the car model and the color, which none of them are present in Table 3. From this example, we can conclude that the weights set by the customer are crucial to find a similar product.

The similarity measure is calculated by the sum of all square values of the weight of each potential field. If the value found in the catalog is equal to the value requested by the buyer, the square weight value is added. However, if the value found is not equal, a zero value is added. This process is formalized through equation 1.

$W_T = \sum w^2{}_i \cdot x_i$…for $i = 0$ to n…… (1)

where, W_T is the final similarity value; w_i is the weight value of each field; x_i is 1 or 0 depending on whether the field value of the offer matches that of the request; and n is the number of features considered. The greater the value of W_T is, the more similar will be the product to the requested by the consumer. By squaring the weights, we put an emphasis on the values of greater weights preferred by the customer. Otherwise we can emphasize the weight value in a general form by simply summing each of these values.

3. Our Proposed Model

This similarity measure works quite well and it forms the basis for our concept-based multi-dimensional negotiation model. In such a model, a proposal made by a customer consists of a set of concept templates. Each concept template has the information of the product desired by the customer, similar to that of Table 1 in terms of attributes, values and weights. Following the example that we described earlier, a concept template is basically a definition of the product that is preferred by the customer. But it has a particular concept or theme associating with it as a caption. Among the attributes, there is at least one that connects or transits from one concept template to another, as shown in Table 4.

Our concept-based model is designed according to how we human think, and the way we reason in finding a product. Some attributes of a product are believed to be the deciding factors (that usually have higher weights), and they would associate with a theme. Changing these attributes will change the whole perception of the product which is called a concept, and it will in turn change the weights of the other attributes. For example, to some customers, the color attribute blue corresponds to a concept of a mature-looking and luxury car, whereas the color attribute silver gives a concept of stylish and cool sporty car. In the negotiation process, when a customer is offered a similar counter-proposal in which the deciding attribute is not exactly the one that he first proposed, he may want to consider other alternative concepts. It is more than just a matter of looking at the total weights summed by the other attributes and decide on whether the similar product could be accepted or not, but he may want to consider the similar products based on another concept. For a realistic example, a customer who considers either getting a luxury car or a sporty car is told by the seller agent that only the silver color is available. The customer then will readjust his criteria for he is now considering buying a sporty type of car because only silver color is available. Hence the weights on some attributes would have to be changed according to the new concept under consideration. A manual gearbox would be rated more desirable, and having a spoiler becomes more importantly, for a sporty car.

In order to capture the automatic changes on the attribute weights in shifting concepts, we have extended the automated negotiation model suggested by Maderia [3] by associating a concept into each template that contains the product attributes, values and weights. In the traditional negotiation approach, when the most similar product is found by the similarity measure, in case of no exact match, usually there are four possible options the customer can have: (i) accept the offer, (ii) decline the offer, (iii) resubmit another proposal to the same seller, or (iv) submit the same proposal to somebody else. The latter two options would likely to be cyclical and continuous, either with the same agent, or with a group of other agents in round-robin. This may not be very efficient especially in multi-agent environment where many actions of proposing and counter-proposing are prone to occur, and the coordination and synchronization among the agents may be an issue. We attempted to improve the efficiency of automated agent negotiation in a slightly different approach. This is done by describing all the alternatives in terms of concepts and the predefined attributes, values and weights in the RFQ stage, and hoping to minimize the amount of messages exchanged and reduce the time leading to the convergence of final conclusion in the negotiation stage. As shown in Figures 1 and 2, we can see that time is saved when we send out our proposals (or RFQs) in batch with all the predefined alternatives in a batch, collect the offers returned by the seller agents, select the best available offer(s), and we concentrate the price negotiation with a particular agent(s). This is especially useful in a multi-agent procurement environments (e.g. online tendering) where many seller agents are involved. Upon receiving the quotations from all the agents, we can assume that they have already gone through all the possible concepts and alternatives that we are interested in, so that we would be able to shortlist only a few of them for further negotiation at a refined level, such as price and payment details. Each concept is defined by the appropriate attributes, values and weights that have been informed by the customer in advance. The preferential order of the concepts is sorted in the meta-table as shown in Table 5, which will be explored by the seller agents.

It is quite trivial to see that the key idea in making negotiation oriented procurement more efficient is the ability to eliminate the redundant processing time on the less important attributes and to find a shorter path to the convergence of a solution. As an example given in Tables 6 and 7, we see that it is a norm for manufacturers to consider purchasing orders that could only be fulfilled by a stringent time constraint. For orders that must meet a deadline, we call them *urgent* orders otherwise *normal* orders. Therefore we have two concepts *urgent* and *normal* in this case, and they have different weights on the attributes, e.g. a large quantity is not required if the materials cannot be delivered on time for the forthcoming round of production, and a discount is not of a relevant attribute for negotiation in urgent orders. By detailing the possible concepts and their corresponding attributes cum weight distribution in advance, the reasoning process for choosing the best deal could be delegated to the seller agents rather than involving both the seller and buyer to negotiate in a one-to-one communication. Certain parallelism could be achieved in the matchmaking and reasoning process. Furthermore, when the offers are returned from the sellers to the buyer, we can be quite sure that they are the best selected from all the available alternatives. So further negotiation could be only concentrated on a few short-listed agents.

4. Definition of Concept-based Model

The concept-based model is formed by a set of two-dimensional tables known as concept templates. A proposal or RFQ is defined by ($P_k : D_k \otimes C$) where D_k is the domain of subjects at the instance of k, and C is a set of concept templates. D_k will be needed in our subsequent research for defining the appropriate ontology for knowledge management. C, that can be viewed as a three-dimensional data cube (as shown in Figure 3) consists of a set of templates C_i where i = 1 to maximum number of concepts in the domain D_k. i is the index of the concept templates under the same domain. C_i has the associated attributes, values and weights making a tuple, ($C_i : a_j, v_j, w_j$). In each concept template, there is at least one triggering attribute that drives the similarity search from one to another alternative concept. So there exist a set of semantic mappings in each domain such that $S_k : a_x \oplus v_y \Rightarrow C_z$ where x and y are the index positions of the attribute and values respectively on the concept template that leads to transiting to another concept template. The algorithm for searching through different concepts for the best match is given below.

```
match = no;
REPEAT
{
match = calc_similarity(P_k, D_k, C_i);
IF match != yes THEN
        BEGIN
                // Locate the first triggering attribute a_x that didn't get any match
                FOR x = 1 TO Max_Atr
                        IF w^2_x == 0 THEN
                        BEGIN
                                X = x; break;
                        END
                // Locate the semantic mapping and hence the next template of concept
                C_z = find_semantic_map(a_x, C_i);
                // Continue searching on the next template of concept
                C_i = C_z
        END
} UNTIL ((match==yes) OR (run out of concept templates))
```

5. Negotiation Protocol

Our model provides three types of search: *specific*, *negotiable under the same concept*, and *negotiable under a different concept*. The first type is selected when the buyer is only interested in finding a specific product with specific attributes, and will not accept a similar product. In this case, the similarity measure is not used, and only the product indicated by the buyer will be searched. If the specific product cannot be found, a message which informs the failure will be delivered to the buyer. The second type of search is called the negotiable under the same concept. This type of search is an extension of the first one. Firstly, the accurate product described by the buyer is searched. However, if the exact product could not be found, a similar one will be searched in order to satisfy the buyer, using the similarity measure on the attributes, values and weights specified under the original concept or the first concept initially specified. The last type of search works similar to the second type, except that it has the ability to switch over to another concept template in which the weights (or the preferences) are defined differently. The switch of the search is directed by a triggering attribute whose value is not found matching during the initial search.

Our protocol is divided in four phases: Request for Quotation, Selection, Negotiation, and Closing. The main features of this protocol are at the RFQ and Selection. The comprehensive set of concept templates are predefined at the RFQ phase, then they are sent to a number of seller agents to do matchmaking. This ensures a more thorough search on different concepts of preferences towards a desired product is achieved; the results of the closest matches are returned, and the best offers can be short-listed in the Selection phase. Due to the space limit in this paper, the detailed operations of the protocol will be described elsewhere.

6. Conclusion

In this paper we proposed a refined model for automated negotiation with reference to how we human perceive different concepts for the same product when its attributes find no match. For example, two different colors for a shirt may be put under consideration of wearing it as formal or casual. We attempted to implement this idea by allowing a proposal under search for a closest deal to have alternative options with different attributes and weights. The similar products collected from each concept layout are returned to the buyer agent for consideration. The overall negotiation protocol also would have to be modified from the traditional one. Instead of spending a substantial time and effort in negotiating with an individual seller agent while exploring the alternatives progressively in a one-to-one dialog, all the alternatives according to each concept towards the desired product are predefined, then broadcast to all the seller agent for doing matchmaking. This concept-based automated negotiation model incorporates the benefits of allowing greater flexibility in describing the desired product under different concepts, and certain concurrency in executing the search for the best-matched products by individual agents.

During the project it became obvious that a lot of work still needs to be done such as product specifications standard. While the tools to develop and implement such a model are available today, no single standard has yet emerged.

Further development work will enable more sophisticated negotiation strategies using probabilities and AI learning technology to improve the agents' performance. Simulation results will be used to find the best choices for the many parameters and weights of the strategy functions [4]. We are also investigating how the strategy of the negotiation partner could be recognized through the semantic mappings in the meta-table and how this knowledge could be used.

References

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Appendix

Attribute	Value	Weight
Model	Honda Civic	10
Color	Blue	9
New	Yes	6
Air Conditioned	Yes	8
CD Player	Yes	5
Alarm	Yes	6
Air Bag	Yes	5
Spoiler	Yes	4
Gear Box	Auto	6
Seat	Leather	7
Concept:	*Luxury*	

Table 1. Attribute names and values described by the customer

Attribute	Value	w^2_i
Model	Honda Civic	100
Color	Blue	81
New	Yes	36
Air Conditioned	No	0
CD Player	No	0
Alarm	Yes	36
Air Bag	No	0
Spoiler	No	0
Gear Box	Auto	36
Seat	Leather	49
Concept:	*Luxury*	

Table 2. Similar car found with $W_t = 302$

Attribute	Value	w^2_i
Model	Honda Civic	0
Color	Blue	0
New	Yes	36
Air Conditioned	Yes	64
CD Player	Yes	25
Alarm	Yes	36
Air Bag	Yes	25
Spoiler	Yes	16
Gear Box	Manual	0
Seat	Cotton	0
Concept:	*Luxury*	

Table 3. Similar car found with $W_t = 202$

Attribute	Value	Weight
Model	Honda Civic	10
Color	Blue	9
New	Yes	6
Air Conditioned	Yes	8
CD Player	Yes	5
Alarm	Yes	6
Air Bag	Yes	5
Spoiler	Yes	4
Gear Box	Auto	6
Seat	Leather	7
Concept:	*Luxury*	

Attribute	Value	Weight
Model	Honda Civic	10
Color	Silver	9
New	Yes	6
Air Conditioned	Yes	5
CD Player	Yes	5
Alarm	Yes	5
Air Bag	Yes	6
Spoiler	Yes	8
Gear Box	Manual	8
Seat	Leather	3
Concept:	*Sporty*	

Table 4. Two concept templates defining different weights

Attribute	Concept
Color	
Blue	Luxury
Silver	Sporty

Table 5. Meta-table defining the concepts and their indices

Attribute	Value	Weight
Part No.	S001234	8
Qty	1000	8
Unit Price	0.5	4
Delivery Date	By next Monday	9
Color	White	6
Payment Terms	Wire transfer	1
Discount	0.00%	3
Concept:	*Urgent*	

Table 6. An example of *urgent* concept template for manufacturer

Attribute	Value	Weight
Part No.	S001234	8
Qty	500	5
Unit Price	0.5	4
Delivery Date	By end of next month	6
Color	White	4
Payment Terms	Wire transfer	1
Discount	10.00%	7
Concept:	*Normal*	

Table 7. An example of *normal* concept template for manufacturer

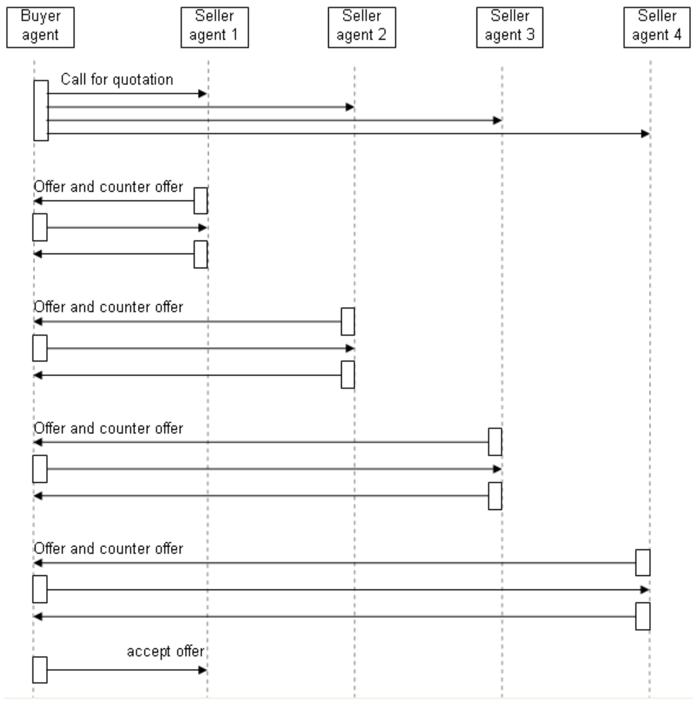

Figure 1. A sequence chart showing how multi-agent negotiation is typically performed (assume that the offer by seller agent 1 is finally accepted)

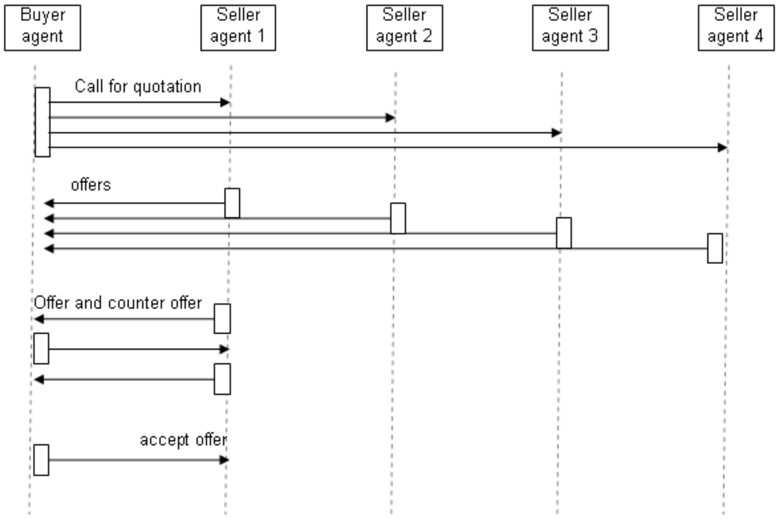

Figure 2. A sequence chart showing how multi-agent negotiation is performed using our model (assume that the offer by seller agent 1 is finally accepted)

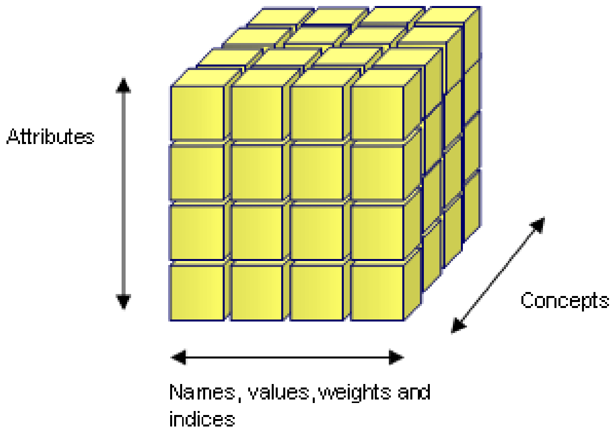

Figure 3. A conceptual view of concept-based model