Bilateral E-Services Negotiation Under Uncertainty
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Bilateral E-services Negotiation Under Uncertainty[1]

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Abstract

This paper presents an approach for bilateral negotiation between an e-service provider and an e-service consumer in the presence of uncertainty. The approach can be applied to any type of negotiation, including buyer/seller negotiation. The type of uncertainty discussed is uncertainty of what offers and counteroffers to make, at a particular point in the negotiation. The approach makes use of reputation to arrive at a list of candidates who have negotiated the same or similar issues in the past, from whom the negotiator can learn the possible offers and counteroffers that could be made.

1. Introduction

With the proliferation of e-services on the Internet, the need for the ability to negotiate for these services is becoming more and more apparent. Negotiation is usually bilateral, between the consumer and the provider of an e-service. It may concern preferences for privacy, security, service delivery, content, or cost structure of the e-service. E-services for which there is a need for negotiation include e-learning and e-business in general.

We present an approach for bilateral negotiation under uncertainty, where a negotiator is uncertain as to what offer or counteroffer to make, at a particular step in the negotiation. This uncertainty is resolved by making use of the negotiation experience of reputable parties. Our approach can be applied to any type of negotiation involving e-services. The approach can be implemented by software agents, which are either autonomous or semi-autonomous (requiring some degree of ongoing user input).

In the literature, most negotiation research involves negotiation among autonomous software agents. This research focuses on methods or models for agent negotiation [1,2,3] and can incorporate techniques from other scientific areas such as game theory [4], fuzzy logic [5] and genetic algorithms [6].

After this introductory section, section 2 considers negotiation under certainty and uncertainty. It also explains how reputation can be computed. Section 3 presents an overall scheme for negotiating under uncertainty. Section 4 presents conclusions.

1.1. Example negotiation

The example presented here is based upon the negotiation that would be undertaken to produce a privacy policy for a person who wishes to take a course from an e-learning provider, funded by the person's employer.

Suppose the items for negotiation are the privacy of two elements of the person's involvement in the course: the examination results and the amount of time spent on each question in the exam. The instructor of the e-learning course would like to know how much time was spent on each question in order to identify questions that are poorly worded or are overly difficult. The objective is to improve them for future clients. The employer would like to know how well the person performed on the course in order to assign the person appropriate tasks at work. Moreover, management (Bob, David and Suzanne) would like to share the results with management of other divisions, in case they could use the person's newly acquired skills. The negotiation dialogue can be expressed in terms of offers, counteroffers, and choices, as follows (read from left to right and down):

Table 1. Example negotiation for e-learning

PROVIDER	CONSUMER
OK for your exam results to be seen by your management?	*Yes, but only David and Suzanne can see them.*

OK if only David and Bob see them?	*No, only David and Suzanne can see them.*
OK. Can management from Divisions B and C also see your exam results?	*OK for management from Division C but not Division B.*
How about letting Divisions D and C see your results?	*That is acceptable.*
OK if your course instructor sees how much time you spent on each question?	*Absolutely not!*
OK if your instructor sees your times after they are merged with the times of other learners so that you can't be identified?	*OK if the instructor does not share this information with any other party.*
The instructor needs to share the information with a course design specialist. Will you agree to this for a 10% discount on your next course?	*I would agree if I get a 20% discount on my next course.*
I can only offer 15% maximum. Will that be OK?	*That is acceptable.*

2. Negotiation in certainty and uncertainty

For this work, every negotiation has an interest or purpose (e.g. for e-learning, negotiating privacy policy for "Psychology 101") and issues (e.g. viewing of exam results by others) to be negotiated. At each step in the negotiation, each participant needs to have a number of alternative offers he can make and an offer that he will make.

Definition: Party i negotiates in *certainty* if for every negotiation step k, party i knows a) what alternative offers he can make and b) what offer to make. Otherwise, party i negotiates in *uncertainty*.

Negotiation in certainty is therefore the type of negotiation illustrated in section 1.1. What may be more interesting, however, is negotiating in uncertainty. A negotiating party may arrive at a state of uncertainty in a number of ways, for instance:
   a. The other party's last offer may be a surprise (e.g. it is not understood).
   b. He does not fully appreciate the value of the item under negotiation.
   c. He may not be able to discern the values of his alternatives.

2.1. Example negotiation in uncertainty

Suppose you have been offered new employment and it is time to negotiate your benefits, including your salary. The negotiating parties are yourself and the hiring manager. You know what you want in terms of vacation, sick leave, and training. However, when it comes to salary, you find it difficult to know what would be a fair salary, since both the job and the company are new to you, and you don't yet know what is really expected of you on the job. You have to negotiate in uncertainty. In this case, and what you may do naturally, is seek out others who you trust and who have negotiated salaries with this company in the past, for similar types of jobs. You would like to know the course of their salary negotiations, what alternatives had they considered, and what counteroffers ensued. You may not use their figures exactly but you may use their alternatives with different figures.

As this example shows, negotiating an item in uncertainty may be facilitated through the use of negotiations knowledge from other parties who have dealt with the same item in the past. As mentioned, such knowledge consists of the alternatives used by these other parties, as well as the decisions or offers that were made. The question now is "Which other parties' negotiations knowledge should be used?" This is where reputation is needed.

2.2. Reputation

Definition: The *reputation* of a provider or consumer is a quality that represents the degree to which he has fulfilled the commitments that he has made, either explicitly or implicitly.

The idea is to use the relevant knowledge of those you trust. For this work, the parties you trust would need to have a sufficiently high reputation. There may be other factors too, such as whether or not you know the party personally or have dealt with the party in the past. However, such factors can be included under reputation, i.e. a party's reputation may be higher if you have dealt with the party in the past.

A party's reputation is built-up over time from transactions that the party has had with other parties. A particular transaction t occurs between 2 parties and has associated reputation factors that contribute to determining the reputation of either party from the point of view of the other party. For example, if party 1 purchases a book from party 2, factors contributing to party 2's reputation (from party 1's point of view) include whether or not the book received was the one ordered, whether or not the book was delivered on time, party 2's performance history with other buyers, and so on. Factors contributing to party 1's

reputation (from party 2's point of view) include party 1's credit history, the nature of past dealings with party 1, party 1's performance history with other sellers, and so on. One way (not the only way) to compute reputation is simply to rate the performance of a provider or a consumer on the associated reputation factors for a given transaction t, as follows.

Let $t_{i,j}$ ($i \neq j$) represent a transaction that party i has with party j. Let $q_1(t_{i,j})$, $q_2(t_{i,j})$, ..., $q_n(t_{i,j})$ be the associated n reputation factors for transaction $t_{i,j}$ where each reputation factor (rating) is in the real interval [0,1] (each factor is an assigned score such as 3/5 or 6/7). Then party i assigns party j a reputation component $p(t_{i,j})$ corresponding to transaction $t_{i,j}$, where

$$p(t_{i,j}) = \frac{1}{n} \sum_{k=1}^{n} q_k(t_{i,j}), \quad i \neq j \quad .$$

Over the course of m transactions $t_{i,j}$, party i assigns party j a reputation $P_{i,j}$, where

$$P_{i,j} = \frac{1}{m} \sum_{t_{i,j}} p(t_{i,j}), \quad i \neq j \quad .$$

Notice that $0 \leq p(t_{i,j}), P_{i,j} \leq 1$. In practice, the $P_{i,j}$ can be computed and stored by software agents representing either the consumer or the provider for use in finding reputable consumers and providers. For every transaction, the ratings of the reputation factors would need to be input by the consumer or the provider, as the case may be.

Let party 1, party 2, ..., party h be h parties other than party k that have had transactions with party j. Then *for party k*, party j has reputation P_j, $0 \leq P_j \leq 1$ where

$$P_j = w_k P_{k,j} + \frac{1-w_k}{h} \sum_{i=1}^{h} P_{i,j}, \quad i \neq j, k \neq j$$

and $0 \leq w_k \leq 1$ is a weight that party k applies depending on whether he had transactions with party j ($0 < w_k \leq 1$) or not ($w_k = 0$, $P_{k,j}$ undefined). A typical value for w_k is $w_k = 0.7$, meaning that party k places more emphasis on his own interactions with party j than the interactions of others in determining party j's reputation, which is what one would expect. Notice that P_j is obtained by averaging over the $P_{i,j}$ (building consensus) so that any bias by a particular party (other than party k) is mitigated to some extent. Of course, the degree of mitigation increases with the number of parties averaged.

In the literature, there has been much research done on reputation [7]. Our formulae are consistent with the approach taken by other researchers. In particular, Zacharia and Maes [8] have claimed that reputation in an online community can be described in terms of ratings that an agent receives from others. As a well-studied example, eBay client transaction ratings [9] are not too unlike our proposal above. The novelty in our approach is applying reputation to find trustworthy candidates whose

negotiation experience can help when negotiating under uncertainty.

3. Scheme for negotiating under uncertainty

We now describe an overall scheme on using the experience of others for negotiating under uncertainty:

1. Every e-service participant records his negotiation experience in the form of alternatives, offers, and counteroffers, for each negotiation interest and issue.
2. Every e-learning participant calculates and stores the reputations $P_{i,j}$. A *reputation agent* can access these $P_{i,j}$ to calculate and store the P_j when needed.
3. A participant who is negotiating in uncertainty would obtain assistance, in the form of negotiation alternatives and offers made, from other reputable participants who have negotiated the same issue. The participant would:
   a. Identify which parties are reputable by asking the reputation agent for reputations P_j which exceed a reputation threshold H. Call this set of reputable parties J. That is, $J = \{j : P_j \geq H\}$. The value of H can be set according to the level of reputation desired.
   b. Among the parties in J, search for parties that have the same interest I as the participant. This produces a subset J_s.
   c. Among the participants in J_s, search for negotiated items r that match the item the participant is currently negotiating. This produces a subset $J_r \subseteq J_s$.
   d. Retrieve the negotiation records of participants in J_r. Use the alternatives and offers in these retrieved records to formulate alternatives and offers. This is generally a manual step (to be automated in the future through machine learning), supported by an effective user interface for displaying (or summarizing) the information to the participant for a decision on the alternatives.

Step 3 may be done in real time if reputations and past negotiation records are all in place. Hence a negotiator can receive help in this manner at any negotiation step, if desired. Figure 1 illustrates the above scheme, using $H = 0.7$. In Figure 1, I, I_2, I_3 represent negotiation interests; r, s, u, v, w represent negotiation issues and corresponding records (alternatives, offers, counteroffers).
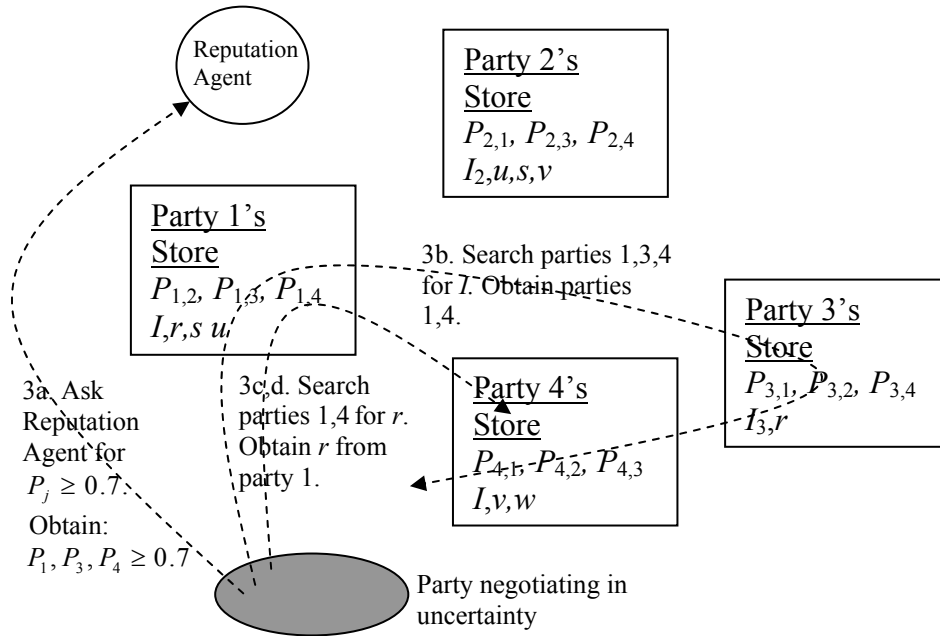
Reputation
Agent

Party 2's
Store
$P_{2,1}$, $P_{2,3}$, $P_{2,4}$
I_2,u,s,v

Party 1's
Store
$P_{1,2}$, $P_{1,3}$, $P_{1,4}$
I,r,s u

3b. Search parties 1,3,4
for I. Obtain parties
1,4.

Party 3's
Store
$P_{3,1}$, $P_{3,2}$, $P_{3,4}$
I_3,r

3a. Ask
Reputation
Agent for
$P_j \geq 0.7$.
Obtain:
P_1, P_3, $P_4 \geq 0.7$

3c,d. Search
parties 1,4 for r.
Obtain r from
party 1.

Party 4's
Store
$P_{4,1}$, $P_{4,2}$, $P_{4,3}$
I,v,w

Party negotiating in
uncertainty

Figure 1. Using the negotiating experience of others

4. Conclusions

We have presented a solution to the problem of negotiating in uncertainty – that of using the negotiation experiences of trusted people with matching interests as aids in deciding which negotiating alternatives and offers should be employed. For legal and other purposes, records should be kept of e-service negotiations (e.g. for non-repudiation). We use this information plus a reputation approach to provide a means for enabling parties to more rapidly carry out a negotiation based upon the experiences of others.

A prototype of a reputation-based negotiation mechanism for privacy in an agent-based e-learning application is currently under development. A separate paper will report on the implementation and performance of this prototype.

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