Agent-based negotiation in cooperative process: automatic support to underwriting insurance policies

M. Comuzz and C. Francalanci;
ACM International Conference Proceeding Series;
Vol. 60; 2004; 121 - 129.
Outline

1. Introduction
2. State of the art
3. A question and answer negotiation framework
4. A decision model for negotiation
5. Negotiation objectives and protocol
6. Experimentation
7. Discussion
8. Conclusion and future work
In a cooperative context, negotiation represents the process that allows organizations to create this base of common knowledge.

Organizations have at the same time shared and divergent objectives and, thus inevitably raises competitive behaviors.

Co-opetition = cooperative + competitive

Organizations tend to implement cooperative processes that allow them to preserve a competitive behavior while accomplishing conflicting objectives that cannot be reconciled through negotiation.
This paper provides a model of the coopetitive negotiation processes leading to underwriting a business insurance policy.

Negotiation is modeled as an iterative question and answer process through which the parties create a common knowledge base of client’s requirements and supplier’s quality of service.

- The characteristics of the insurance policy.

The model has been

- implemented as an agent-based negotiation environment
- analyzed through simulation
The goal of negotiating agents is to maximize their own advantages from buying or selling goods and services.

Negotiation is limited to the identification of the optimal alignment between the agents’ utility functions.
The variables that influence behavioral patterns are classified into five categories:
1. Concerns on one’s own outcomes
2. Concern on others’ outcomes
3. Trust among parties
4. Parties’ commitment to cooperation
5. Specific threats that can be used against others

→ a fundamental contribution of social psychology studies to research on negotiation.
Game theory

- Aiming at optimizing negotiation results starting from a variety of initial conditions.

The following fundamental process variables are considered:

- Negotiation objectives
- Negotiation protocol or rules
- Decision model of agents
2. State of the art (3/4)

- Classical software agents (software engineering approach)
  - Decision rules are embedded and must be redesigned if the negotiation objective or rules are changed.
    - Auction-based models
    - Bilateral models
    - Argumentation-based models
    - Trade-off-based models
2. State of the art (4/4)

- **Machine learning agents**
  - Agents **learn** the decision rules **from historical negotiation data**.
  - Learning phase is computational complexity, so the negotiation model underlying this phase must be simple.
    - Using bilateral negotiation rule (1 buyer + 1 seller)

- **Negotiation trade-offs** represent an important concept in coopetitive negotiation.

- **This paper** proposes a trade-off based negotiation model for a cooperative B2B insurance negotiation context.
Table 1: Sample questions for restaurants’ insurance products

<table>
<thead>
<tr>
<th>Client Questions</th>
<th>Supplier Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questions evaluating supplier’s commitment to cooperation</strong></td>
<td>Questions evaluating client’s commitment to cooperation</td>
</tr>
<tr>
<td>How many restaurants do you insure?</td>
<td>Has your restaurant been previously insured?</td>
</tr>
<tr>
<td>Do you have any ongoing legal action with your customers?</td>
<td>Did you own your restaurant’s premises?</td>
</tr>
<tr>
<td>For how long have you been operating in the restaurants’ insurance business?</td>
<td>Are you the only owner of your business (or is it a corporation, joint venture, other...)?</td>
</tr>
<tr>
<td>Has the number of restaurants that you insure increased over the past year?</td>
<td>Do you have any other insurance policy with us?</td>
</tr>
<tr>
<td>What is your average customer turnover in the restaurants’ insurance business?</td>
<td>Where did you hear about us?</td>
</tr>
<tr>
<td><strong>Questions evaluating supplier’s competencies</strong></td>
<td><strong>Questions evaluating client’s requirements</strong></td>
</tr>
<tr>
<td>Does your insurance product include food spoilage protection?</td>
<td>What type of building is your restaurant located in?</td>
</tr>
<tr>
<td>Does your insurance product include 50% fire damage protection?</td>
<td>How old is the building?</td>
</tr>
<tr>
<td>How long does it require to estimate a 30% fire damage and repair it?</td>
<td>When was the building last rewired?</td>
</tr>
<tr>
<td>How many experts of kitchen safety do you have?</td>
<td>Do you cook flambé dishes?</td>
</tr>
<tr>
<td>What kind of crime insurance do you provide?</td>
<td>When did you last change grease filters and fryers?</td>
</tr>
<tr>
<td><strong>Questions evaluating supplier’s costs</strong></td>
<td><strong>Questions evaluating client’s returns</strong></td>
</tr>
<tr>
<td>What is the frequency of a 50% fire damage for restaurants?</td>
<td>Which was your previous insurance company?</td>
</tr>
<tr>
<td>How many experts do you need to evaluate a 30% fire damage?</td>
<td>What type of insurance coverage did you have?</td>
</tr>
<tr>
<td>How many claims per restaurant do you manage every year?</td>
<td>How many losses did you experience over the past three years?</td>
</tr>
<tr>
<td>What is the frequency of a 50% food spoilage in a restaurant?</td>
<td>How much did the losses amount to over the past three years?</td>
</tr>
<tr>
<td>What is the mean amount of losses for a restaurant in a year?</td>
<td>Is there any mortgage on your premises?</td>
</tr>
</tbody>
</table>
3. A question and answer negotiation framework (2/2)

1. Questions evaluating the counterpart’s commitment to cooperation are necessary to evaluate the degree to which the goals of client and supplier overlap and collide.

2. Questions on competencies and requirements are critical to formulate an offer that reflects the client’s needs and the supplier’s ability to meet those needs.

3. Questions on costs and returns allow negotiation parties to attribute an economic value to the transaction.

- The interaction terminates when both parties ask all questions in their question sets or reach agreement.
A given question $q_i$ is associated with a set of possible answer $A = \{a_{ij}\}$.

Each answer is represented by a set of numerical values

$$a_{ij} = (v_{ij1}, v_{ij2}, v_{ij3}; w_{ij1}, w_{ij2}, w_{ij3})$$

- $v_{ij1}$, $v_{ij2}$ and $v_{ij3}$ represent the numerical evaluation of the commitment to cooperation, competencies/requirements, costs/returns.
  - The value range between 1 (low) and 7 (high).
- $w_{ij1}$, $w_{ij2}$, $w_{ij3}$ represent three weights corresponding to $v_{ij1}$, $v_{ij2}$ and $v_{ij3}$.
  - The value range between 0 and 1.
4. A decision model for negotiation (2/4)

- Global value are evaluated as:
  1. The client’s and supplier’s commitment to cooperation.
     \[ coop_s = \frac{\sum_{i=1}^{n} v_{ij1} \cdot w_{ij1}}{\sum_{i=1}^{n} w_{ij1}} \]
     \[ coop_c = \frac{\sum_{i=1}^{m} v_{ij1} \cdot w_{ij1}}{\sum_{i=1}^{n} w_{ij1}} \]
     n and m represent the number of answers provided by client and supplier until the current time instant.

  2. The supplier calculates his own costs.
     \[ costs = a_1 \cdot e^{\frac{\text{reg}c}{c}} \]

  3. The client calculates his own returns.
     \[ returns = b_1 \cdot e^{\frac{\text{comp}R}{R}} \]
4. A decision model for negotiation (3/4)

- Global value are evaluated as (cont.):

4. The supplier estimates the client’s returns.

\[ \hat{\text{ret}}s = [(1 - a_2) \cdot b_1 \cdot e^{\frac{\text{rets}}{R}} + a_2 \cdot \text{rets}] \cdot (a_3 \cdot \text{coop}_c + a_4) \]

5. The client’s estimate the supplier’s costs.

\[ \hat{\text{cost}}s = [(1 - b_2) \cdot a_1 \cdot e^{\frac{\text{costs}}{C}} + b_2 \cdot \text{costs}] \cdot (a_3 \cdot \text{coop}_s + a_4) \]
The following output variables are evaluated.

- **Sell price (SP)** (proposed by the supplier): 
  \[ SP = \alpha \cdot \text{costs} + \beta \cdot \text{retr} \]

- **Buy price (BP)** (proposed by the client): 
  \[ BP = \alpha \cdot \text{costs} + \beta \cdot \text{retr} \]

- **Payoff** (for the supplier): 
  \[ P = SP - \text{costs} \]

- **Marginal Payoff** (for the supplier): 
  \[ MP = P - \gamma \cdot \text{costs} \]
The negotiation protocol is defined by setting the number of questions in each set and the order with which questions are asked.

1. The participants ask all questions of each set in sequence.
2. The client and supplier ask a single question, picked from the same set.
3. The client and supplier ask a single question, picked from the different set.
The participants can dynamically change their behavior, which is defined by following variables:

- Responding sincerely or insincerely.
- Revealing or not revealing costs/returns.
Three variables have been found to influence simulation result:

- Order of magnitude of costs and returns;
- Order of questions;
- Amount of information disclosed to the counterpart.

<table>
<thead>
<tr>
<th>Table 2: Values assigned to model parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_1 = 0.96$</td>
</tr>
<tr>
<td>$\mu_5 = 0.8$</td>
</tr>
<tr>
<td>$a_3 = 0.033$</td>
</tr>
<tr>
<td>$\gamma = 0.05$</td>
</tr>
</tbody>
</table>

$\gamma$ is determined by the mean value of $w_{ij3}$ in client’s answers.

$\alpha$ is determined by the mean value of $w_{ij3}$ in supplier’s answers.

$(a_1, b_1) = (951.55, 7292.09)$ Case 1
(See next section)

$(9515.2, 7292.09)$ Case 2

$(951.55, 72920.9)$ Case 3
Three cases in simulation

- **Case 1: Costs >> Returns**
  - Client reaches a better agreement when behaving sincerely.

- **Case 2: Costs ≈ Returns**
  - Client should leave the process at the first agreement, while supplier should ask all his questions.

- **Case 3: Costs << Returns**
  - Supplier should avoid questions evaluating the client’s commitment to cooperation.
6.1 Result

Figure 3, 4, 5 show results from three simulation following the second negotiation protocol with a different order of magnitude of costs and returns.
6.2 Sensitivity Analyses

- Sensitivity is evaluated by applying a percent variation to the weight.

\[ \sum_{i=1}^{n} \frac{|BP_i - SP_i|}{n} \]  \hspace{1cm} (1)

\( n \) is total number of questions

### Table 3: Results of sensitivity analyses

<table>
<thead>
<tr>
<th>Weights variation Considered</th>
<th>Average variation of BP</th>
<th>Average variation of SP</th>
<th>Average difference between buy and sell price (Eq.1)</th>
<th>Failure of negotiation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier’s answers weights &lt;15%</td>
<td>&lt;10%</td>
<td>none</td>
<td>&lt;0.8%</td>
<td>NO in 90% of all simulations</td>
</tr>
<tr>
<td>Supplier’s answers weights between 15% and 40%</td>
<td>&gt;13%</td>
<td>none</td>
<td>&lt;9%</td>
<td>YES in 80% of all simulations</td>
</tr>
<tr>
<td>Client’s answers weights &lt;15%</td>
<td>none%</td>
<td>&lt;10%</td>
<td>&lt;2.8%</td>
<td>NO in 85% of all simulations</td>
</tr>
<tr>
<td>Client’s answers weights between 15% and 40%</td>
<td>none%</td>
<td>&gt;13%</td>
<td>&lt;8%</td>
<td>YES in 75% of all simulations</td>
</tr>
</tbody>
</table>
Results indicate that estimation of costs and returns represents the most critical issue, since it drives the choice of the negotiation strategy.
8. Conclusion and future work (1/2)

A fundamental finding

- The negotiation strategy must change with the type of insurance product and, in general, with the target market.

Automatic support to negotiation is less straightforward in a coopetitive context.

- Highly specialized software agent

The quality of insurance services could greatly benefit from an automatic support to negotiation.

If the client side is also automated, a service-oriented architecture for negotiation would support price negotiation along the entire supply chain.
8. Conclusion and future work (2/2)

- The model could be extended to the case of multiple suppliers and clients.
- The sets of questions and answers could be
  - Enriched
  - Validated with an extensive empirical study testing their generality
- The semantics of the relationship between questions and answers should also modeled and formally analyzed.
In our research of expectation measurement, what would be the global values?

- In this paper, the global values are calculated as a weighted sum of corresponding $v_{ij}$ and $w_{ij}$ weight. (ref section 4)
  - The other party’s commitment to cooperation
  - Requirement/ competence
  - Returns/ costs
AeSL, Ambient e-Service Lab

Please visit our website:
http://www.aesl.nccu.edu.tw

Research Topics: SOA & SSME (service science)