IMPERFECT INFORMATION IN ELECTRONIC NEGOTIATIONS: AN EMPIRICAL STUDY

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ABSTRACT

This paper analyzed 96 current electronic negotiation models concerning their ability to handle imperfect information situations. The results of the empirical investigation show that most of the negotiation models assume imperfect information situations but mainly related to the negotiation partner. Research on imperfect described environments and negotiation items are not sufficient represented. There is a need of research activities.

KEYWORDS

Electronic negotiation, imperfect information, incomplete information, uncertain information

1. PROBLEM DESCRIPTION

Although the mathematical-normative branch of the decision-oriented approach [Laux and Liermann 2003] and basic works of game theory [von Neumann and Morgenstern 1944] assume perfect information and thus a decision situation of certainty, the majority of modern organizational approaches, e.g., behavioral-decision-theory [March and Simon 1958, Cyert and March 1963], system-oriented approach [Ulrich 1968], transaction-cost-theory [Williamson 1985], principal-agent-theory [Ross 1973] and extensions of game theory [Harsanyi 1967, Kreps et al. 1982] imply an **imperfect information situation** (incomplete and/or information situation of uncertainty). To date, a lot of electronic negotiation models have been developed and manifold negotiation challenges have been already addressed. However, in order to evaluate the state of the art of electronic negotiations concerning their ability of handling imperfect information situations this paper researched 96 current electronic negotiation models.
The text of the paper is divided into 4 parts: Section 2 sketches the research methodology. Section 3 presents an overview of electronic negotiations. After that, section 4 shows the research results.

2. RESEARCH METHODOLOGY

Table 1. Journal scope of analysis

Journal	Space of time
Autonomous Agents and Multi-Agent Systems (AAMAS)	2006 – 1998
Group Decision and Negotiation (GDN)	2006 – 1997
Int. Journal of Cooperative Information Systems (IJCIS)	2006 – 1998
Wirtschaftsinformatik (WI)	2006 – 1999
Robotics and Autonomous Systems	2006 – 1998
Information Systems Frontiers (ISF)	2006 – 1996
Artificial Intelligence (AI)	2006 – 1995
IEEE Intelligent Systems (formerly IEEE Expert)	2006 – 1988
Logic and Computation	2006 – 1999
Data and Knowledge Engineering	2006 – 1995
Electronic Markets	2006 – 1999

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In line with the analysis a systematic inquiry of the journals in Table 1 has taken place. Additionally some important publications concerning electronic negotiation models were included. Overall an amount of 96 publications was researched.

3. A BRIEF DESCRIPTION OF ELECTRONIC NEGOTIATIONS

The electronic automating of negotiations was forecasted by [Davis and Smith 1983] more than 20 years ago. However, the automation level of current negotiation systems is still different (fully automated, process support and hybrid negotiation models [Rebstock 2001]). Fully automated models work without any human interaction and are strictly structured. Process support models, e.g., [Kersten and Noronha 1997] or www.ebay.com only facilitate the negotiation. Hybrid models are partly-automated, for example [de Paula et al. 2001]. The literature shows many definitions for (electronic) negotiations [Lee 1996, Rosenschein and Zlotkin 1994]. A common way to define a negotiation is the following [Bichler et al., 2003, p. 316]:

Definition 2. A negotiation is an iterative communication and decision making process between two or more participants who: (1) cannot achieve their objectives through unilateral actions, (2) exchange information comprising offers, counteroffers and arguments, (3) deal with interdependent tasks, and (4) search for a consensus which is a compromise decision.

At first, [Rosenschein 1985, Zlotkin and Rosenschein 1989, Rosenschein and Zlotkin 1994] analyzed strategic interactions between self-interested agents on the basis of the game-theoretic approach by [von Neumann and Morgenstern 1944, Nash 1950, Nash 1951, Schelling 1960, Harsanyi 1967, Harsanyi and Selten 1972, Selten 1975, Kreps et al. 1982, Kreps and Wilson 1982]. Game-theoretic models are deemed to be mathematically elegant, but they are very restricted in use because of their assumptions of perfect rationality and unlimited resources [Jennings et al. 1998]. In order to relax these restrictions, heuristic approaches have been adapted for electronic negotiations. Heuristic approaches solve the problematic assumption of unlimited resources by using thumb rules, e. g., [Kraus 2001]. Thus, the assumption of perfect rationality is also rejected. But, electronic negotiation models based on heuristic approaches need an intensive evaluation, regular via simulation or empirical investigations [Jennings et al. 2001, p. 210]. Finally argumentation-based models have been developed. There, the agents have the possibility to reason about their positions. This approach increases the possibility and the quality of an agreement compared to game-theoretic or heuristic approaches [Rahwan et al. 2003, Karunatillake and Jennings 2004]. The first argumentation-based approach was realized in PERSUADER [Sycara 1987].

Electronic negotiation models can handle many organizational challenges [Buettner 2006]. For example, concerning structural issues, bilateral, one-sided multilateral and double-sided multilateral negotiations can be separated [Rebstock 2001, Bichler et al. 2003]. Bilateral negotiations are restricted to two negotiation partners (one buyer and one seller) and were firstly analyzed by [Smith 1980, Davis and Smith 1983]. One-sided multilateral negotiations are deemed to be the standard form of auctions and are either characterized by one seller and many buyers or vice versa [Rebstock 2001, p. 611]. Finally, double-sided multilateral negotiations are characterized by many buyers and many sellers. A lot of research has focused on multi-attribute negotiations. In contrast to single-attribute negotiations, in multi-attribute negotiations more than one characteristic is simultaneously taken into account, e.g., [Kersten and Noronha 1997]. Beyond, electronic negotiation models with the ability for negotiating more than one independent negotiation item has been researched, e.g., [de Paula et al. 2001]. Furthermore, negotiations can be separated into non-mediated, e.g., INSPIRE [Kersten and Noronha 1997] and mediated negotiations, e.g., [Hanachi and Sibertin-Blanc 2004].

In addition to the negotiation structure a lot of process-related challenges have been already considered. First, a negotiation can be separated into public and closed sessions [Bichler et al. 2003, p. 318]. As in public negotiations new participants can take part dynamically, this is not allowed in closed sessions. Furthermore, electronic negotiations can be distinguished by the binding type. Binding negotiations, e.g., www.ebay.com/ ask for an authentication of every participant in advance. Finally, time has an enormous influence on negotiations [Pruitt and Drews 1969, Stuhlmacher and Champagne 2000]: At first, [Kraus et al. 1995] took time limits into account in electronic negotiations.

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4. RESEARCH RESULTS

In a perfect information situation the decision takes place under certainty conditions, for example [Zlotkin and Rosenschein 1989, Kraus et al. 1995, Zlotkin and Rosenschein 1996a, Tennenholtz 2002]. However, the majority of the researched publications (94 percent) assume an imperfect information situation. In the following the individual cases concerning the inspection subject (negotiation partner, environment and negotiation item) will be presented.

4.1 Imperfect Information about the Negotiation Partner

Most of the researched papers assume imperfect information related to the negotiation partner. They presume that the utility, e.g., [Zlotkin and Rosenschein 1996b, Faratin et al. 1998, Beam et al. 1999, Wooldridge and Jennings 1999, Bichler 2000, Yokoo et al. 2001, Faratin et al. 2002], the deadline of the negotiation, e.g., [Fatima et al. 2004], resource constraints of the negotiation partner, e.g., [Faratin et al. 2002], the price limit of the negotiation partner, e.g., [Mařík et al. 1999, Faratin et al. 2002, Fatima et al. 2004], the goals, e.g., [Zlotkin and Rosenschein 1996b] or the identity of the negotiation partner, e.g., [Beam et al. 1999, Yokoo et al. 2001, Schoop 2002, Schoop et al. 2003] are unknown or rather imperfect described.

The publications show a general solution of the imperfect information situation in **probability-based approaches**, e.g., [Sen and Durfee 1994, Bui et al. 1999, Tesch et al. 2001, Fatima et al. 2004, Kehagias et al. 2005, Li et al. 2006]. Especially, [Choi et al. 2001, Gerding and La Poutré 2006] use genetic algorithms to estimate the use function or rather the behaviour of the negotiation partner. [Kehagias et al. 2005] assume an incomplete information situation of the negotiation partner regarding his bidding behaviour and uses time series analysis to forecast the behaviour. Further solutions are shown by **fuzzy-logic** [Zadeh 1965], e.g., [Faratin et al. 2002] or by means of a **mediator component** that is more informed about the preferences of the negotiation partner, e.g., [Mařík et al. 1999]. Finally, in the electronic trading system AMTRAS [Budimir and Gomber 1999] users may specify **bandwidths** in the context of the search phase (e.g., risk of default or maturity). Based on this, the agents are looking for matching negotiation partners. But the situation fraught with risk is not taken into account in the actual negotiation. Instead of this, a perfect information situation is assumed.

4.2 Imperfect described Environment

E.g., [Rabelo et al. 1999, Bui et al. 2001, Peters 2002, Yee and Korba 2003, Atkinson et al. 2005] use **mediators** for imperfect described environments: The negotiation system HOLOS [Rabelo et al. 1999] addresses the problem of incomplete information situation related to the environment through the mediator component CIM-IS. The mediator collects all relevant information regarding the environment and provides it to the negotiating agents. The multi-attribute decision support system [Bui et al. 2001] suggests the increase of the transparency of the imperfect described environment by means of additional information from a signaling-agent. However, there is no integration of the signaling-information in the decision heuristics; the user gets the information only as an additional notice. [Peters 2002] takes up the problem of incomplete information related to the environment insofar as a "sufficient information model" is used to represent the relevant information. "Sufficient" means in this case that upon completion of an auction, the agent gets exactly the information he needs to evaluate any hypothetical offer ex post. The approach in [Yee and Korba 2003] makes use of experiences to arrive at a list of trustworthy 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. In [Atkinson et al. 2005] a third party and his authoritative knowledge will be asked in order to resolve the dispute in case of a disagreement.

[Thomé and Sandholm 1999, Larson and Sandholm 2001, Peters 2002, Sandholm and Zhou 2002] show **probability-based solutions** for imperfect described environments: [Thomé and Sandholm 1999] consider imperfect information regarding the environment through the Bayes-theorem on the basis of subjective probabilities. [Larson and Sandholm 2001] consider the environment insofar as the potential negotiation partner is not known prior to the negotiation. The imperfect information situation is existent concerning the <

and the precise problem of the negotiation partner. The parameters of the related distributions are assumed as known. [Peters 2002] proposes a statistical extrapolation of known information in order to forecast future activities. [Sandholm and Zhou 2002] model risk related to the environment via a probability-based approach. Their approach implies that the contractors best (lowest) offer is ex ante probabilistically known by the agents, and is characterized by a probability density function. Finally, the approach of [Khedr and Karmouch 2004] uses a **fuzzy-based** inference mechanism.

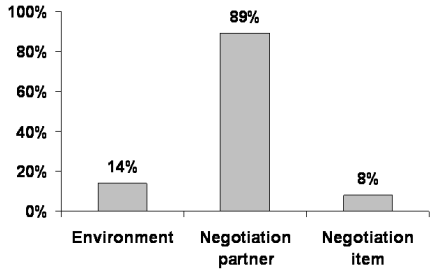
4.3 Imperfect Information about the Negotiation Item

[Luo et al. 2003, Teuteberg 2003, Kurbel et al. 2004] use the **fuzzy approach** [Zadeh 1965] in order to model imperfect information: E.g., the negotiation system FuzzyMAN [Kurbel et al. 2004] was designed for the electronic labor market. FuzzyMAN and the model implemented therein [Teuteberg 2003] express the agent preferences related to the negotiation item in fuzzy terms (here characteristics of the employees like salary, number of working hours per week, duration of the employment, and social benefits). [Teuteberg 2003] depicts risky information about the negotiation item by means of a utility function which is also based on the fuzzy approach. The non-argumentation-based negotiation models [Cardon et al. 2000, Kersten and Noronha 1997] use **probability-based approaches** to reduce the information disadvantage concerning the negotiation item: INSPIRE/INSS [Kersten and Noronha 1997] implement a conjoint scheme, [Cardon et al. 2000] use a genetic algorithm. Finally, the negotiations support system Negoplan [Matwin et al. 1989] uses **bandwidths** in order to model risky information related to the negotiation item.

5. CONCLUSION

Results from this research show different solutions for modeling imperfect information situations: Probability-based approaches, bandwidths, fuzzy logic and mediators were used. The analysis shows, that 90 of the 96 researched articles assume that the information circumstances are incomplete and/or fraught with risk, whereas the focus is mainly on the negotiation partner. 14 percent of the publications can handle imperfect information situations concerning the environment. But, **only 8 percent** (8 models) **consider imperfect information with regard to the negotiation item** (Fig. 1).

Figure 1. Evaluation of publications with imperfect information situations



To summarize, the research in the field of electronic negotiations is concerned with many aspects. But, despite of the fact, that imperfect information situations play an important role, most of that work focuses only on the negotiation partner. The negotiation item and the environment should be more considered. **Incomplete or uncertain information situations related to the negotiation item or the environment** should be a future research direction in the field of electronic negotiations.

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