AN INVESTIGATION OF THE NEGOTIATION DOMAIN FOR ELECTRONIC COMMERCE INFORMATION SYSTEMS

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Abstract: To support fully automatic business cycles, information systems for electronic commerce need to be able to conduct negotiation automatically. In recent years, a number of general frameworks for automated negotiation have been proposed. Application of such frameworks in a specific negotiation situation entails selecting the proper framework and adapting it to this situation. This selection and adaptation process is driven by the specific characteristics of the situation. This paper presents a systematic investigation of there characteristics and surveys a number of frameworks for automated negotiation.

1 INTRODUCTION

"Leo Baekeland sold the rights to his invention, Velox photographic printing paper, to Eastman Kodak in 1899. It was the first commercially successful photographic paper and he sold it to Eastman Kodak for $1 million. Baekeland had planned to ask $50,000 and to go down to $25,000 if necessary, but fortunately for him, Eastman spoke first." (Asimov, 1982).

More than one century later, this example of the importance of negotiation processes is still valid. In the new business paradigm, where businesses all around the world are connected via the Internet, the importance of negotiation stays the same. Electronic commerce enforces completely new infrastructures for doing business and negotiation has certainly its part in it. In order to provide automated support for the whole business cycle, electronic commerce systems need automated negotiation functions.

Electronic commerce information systems operate in domains that differ with respect to negation. The general frameworks for automated negotiation (Jennings et al., 2001; Bartilini & Preist, 2001; Lee, 2000; Wong, Zhang & Kara-Ali, 2000) that have been proposed in the past few years do not pay attention to these differences, which make it difficult to assess which framework is most applicable in a specific negotiation domain.

The aim of this paper is to address this problem. The paper first, in Section 2, provides a systematic investigation of possible negotiation domains by identifying all relevant factors. After that, in Section 3, the paper reviews four general automated negotiation frameworks that together constitute a good representation of the state of the art in the field of automated negotiation. In this section, common elements in all frameworks are related to the factors investigated in Section 2. This relation can be used to facilitate framework selection for specific domains. Section 4 concludes the paper.

An earlier and more extend version of this paper is published as a CTIT technical report (Zlatev, 2002).

2 NEGOTIATION DOMAIN

This section aims to investigate the negotiation domain. First, some definitions are discussed. After that, answers to the classical where, why, who, how and when questions are given.

2.1 Definition. The What question

We define negotiation as a process by which actors reach agreement about joint future behaviour. The

need for negotiation arises when more than one entity (actor) have overlapping interests. Whatever the origin of their problem is (conflicting or cooperative interests), an interactive process of exchanging intentions and positions on the matter of the problem takes place. The entities (actors) communicate their expectations about a potential mutually acceptable agreement. The result of the negotiation process is a kind of a contract upon which actors commit themselves for a certain future course of action. Therefore, negotiation is a mechanism for coordination.

A similar definition is used by Lomuscio, Wooldridge and Jennings in (Lomuscio, Wooldridge & Jennings, 2001). They introduce the notion of an agent as a substitution for the term actor. The term agent broadens the possible negotiating entities with supporting IS and autonomous software agents.

In contrast, Beam and Segev (Beam & Segev, 1997) situate their definition only in the business domain. They define a negotiation process as a bargain on resource reallocation and mutually intended gain.

2.2 Place in the real world. The Where question

Potential opportunity for negotiation can be found in every situation with coordination or reallocation problems. Negotiation happens before a certain future course of action is being adopted by the entities involved in the conflict. For exact positioning of the negotiation process, the business domain is taken for illustration. The following three infrastructures are used to show the place of negotiation.

An *electronic market* is an infrastructure similar to the open market. This infrastructure gives a primitive interface to participants for trading. The support for negotiation that this infrastructure gives is centralizing the place where announcements are placed. The participants are responsible for carrying out the negotiation process. The infrastructure supports them with a few rules, such as: currency rules or if A gives money than B will give goods.

An *auction* is a widely applied infrastructure. Similar to a market, an auction is a place where buying and selling participants meet each other. However, compared to a market, participants follow certain rules to reach an agreement on exchanging conditions. A complete classification of auctions can be found in (Kumar & Feldman, 1998). In all kinds of auctions, negotiation is viewed as a fixed set of rules that actors follow to agree on exchange value and/or exchange conditions for a product or service.

Business process schema is an infrastructure that supports relations between businesses. An illustration of the place of negotiation in this infrastructure is shown in (Angelov & Grefen, 2002). The authors see negotiation as a phase in a sequence conducting the contract business process. Negotiation precedes the phase in which a contract is signed. The contract is the consequence of the agreement reached in the negotiation process.

2.3 Negotiation vs. prescribed behaviour. The Why question.

The problem of coordinating mutual behaviour arises when a group of actors wants to perform a common task. The conflict resolution can be achieved by a variety of methods between pure coordination with standards and pure coordination with negotiation. Coordination with standards means using prescribed rules, which define a protocol for communication or standardize the behavior of the actors. The approach with prescribed behaviour has its advantages, but it cannot be applied in situations like the following:

- No standards for the coordination problem exist: a solution based only on standards is not possible, because no standards are established.
- There are too many standards and coordination for coordination standard is needed. In this case, none of the standards satisfies all actors and they agree to solve the coordination problem with negotiation.
- Standards are not complete: available standards cannot resolve all possible conflicts in the coordination process and negotiation is needed to resolve remaining issues.
- Actors require more flexibility than allowed by available standards.
- Actors are autonomous: it is not possible actors to be forced to use prescribed rules.

In these situations, some form of negotiation is needed to solve coordination problems.

2.4 Participants in the negotiation. The Who question

A participant represents one side in a negotiation process. One participant can be any composition of people and computer systems. The participants could be divided into several groups, assuming different criteria. The classification in this section aims to discover who or what could be a participant in a negotiation.

The first criterion is the *level of automation*. This division distinguishes three types of participants:

people, Negotiation Support Systems (NSSs), and autonomous software agents.

The first type is seen when only *humans* take the decisions during the negotiation process without any support from computer systems. The participants rely on knowledge, experience and moral norms. The negotiation process is manual.

The second type is when people use support from *Negotiation Support Systems (NSSs)*. The decisions are taken by people but they use an information system to make informed discussion and find optimal solutions. Negotiation support systems are decision support systems in the domain of negotiation (Su et al., 2001). NSSs are mainly based on DSSs from the model-oriented group (Alter, 1977; Kersten, 1998). NSSs have mostly been used in negotiation training with two notable exceptions: during the negotiation of The Law of the Sea (Sebenius, 1984) and the RAINS system used in EU trans-boundary air pollution negotiation (The International Institute for Applied Systems Analysis, 1998). Beam and Segev (Beam & Segev, 1997) provide an investigation of the NSSs domain. Their conclusion is that NSSs are powerful systems but they require constant interference with people.

The last type is when the negotiation is held by a software system with minimal or without human interference. These human-independent software systems are called *autonomous software agents* (Wooldridge & Jennings, 1995). Autonomous agents can be seen as NSSs on steroids which most important feature is that they are autonomous, flexible, problem solving entities. Therefore, they should be able to negotiate.

The second dimension of the classification scheme is the role played by the participants in a negotiation process. The division consists of two groups: the central roles group and the neutral roles group. These two groups are further divided into concrete roles. An entity in a negotiation process plays a central role if it is bound by, or represents an entity that is bound by, the resulting agreement. An entity in the negotiation process plays a neutral role if it only helps in reaching a commonly accepted agreement, but is not bound itself by this agreement. The further division of the central and neutral roles groups is based on the level of influence in the negotiation process.

The *Central role* group is divided into two subgroups:

Self-present. An entity is self-present when it takes responsibility for the commitments in the agreement. Resources, reallocated in the negotiation process, are owned by the entity. A self-present entity is not restricted in the offers it proposes and accepts.

Representative. An entity is a representative when it represents the interest of another entity and the commitments it takes are on behalf of the other entity. Resources, reallocated in the negotiation process, are not owned by the representative. Representatives are restricted in their freedom by the represented entity.

The *Neutral role* group is divided into the three subgroups listed below. A detailed division can be found in the book of Howard Raiffa (Raiffa, 1982).

Regulator - This role is the one with the least influence in the participants' behaviour. It is held by the organization that organizes the negotiation environment. It should not be seen as a real agent that takes decision during the negotiation process but as a preliminary defined regulation that all participants must obey. An example of this is an '*auctioneer*' – the one that runs an auction.

Facilitator – This role is more influential and takes place during negotiation. A facilitator provides competent and neutral facilitation services to parties in a negotiation. A facilitator keeps the agenda, and clarifies who, why and how should attend the negotiation. A facilitator helps running negotiations that are expected to be complex.

Mediator - Mediation is a voluntary and confidential process in which a neutral agent assists disputing participants to clarify issues, develop options and work toward a mutually agreeable resolution.

Roles that are mixture of the three listed above are possible.

2.5 Scenarios in negotiation. The How question

A scenario is a global characteristic of a negotiation process. A scenario is a common pattern observed in the behaviour of the participants under certain circumstances in the negotiation process. Scenarios are divided into three types, depending on how participants estimate the negotiated issue. The three types are cooperative, competitive and mixed. The *cooperative* scenario occurs when all the participants in the negotiation process could generate potential agreements, which satisfy all their wishes. According to game theory, this is a positive sum game. In other cases, fulfillment of the wishes of one participant may be directly detrimental to the fulfillment of the wishes of another participant. This is a *competitive* scenario or a zero-sum game in the context of game theory. If some of the participants have to make some compromises or they have to accept something for their own good and for the good of their competitor then a *mixed* scenario is seen.

The following three elements, *cardinality of the issues, cardinality of the participants* and *time*, shape the scenario. A pure form of cooperative or competitive scenario can be seen when the negotiation is about one issue, with one participant that offers or looks for something, or no time limitation exists. In all the other cases, these elements shape a mixed scenario.

2.6 Time and negotiation. The When question

Time is an important factor in the negotiation process. The behaviour of the participants can change significantly under the pressure of time. The following patterns of behaviour change over time are the major three.

Deadline – limitation in the duration of the negotiation process can influence the behaviour of the participants. Participants can change their objectives and they can evaluate a non-optimal agreement as better one than no agreement.

Iteration - when a negotiation is one of series of negotiations then participants can decide to lose one or two negotiations. This again influences their behavour. Series of negotiations can influence the parties to act more 'nicely' in order to build a fruitful environment for the continuing negotiation.

Long-term relation – The relations between participants always involve trust. In a long-term relations, trust is significant issue. Negotiation can be a milestone in building trust. This again is an influence in the participants' behaviour.

3 NEGOTIATION FRAMEWORKS

This section aims to make a small investigation of the automated negotiation literature and to relate it with the terms introduced in the previous section. To this end, four negotiation frameworks are selected and briefly described and compared.

The following definition of a framework is used in this section. Every reasonable collection of objects, rules and relations that conducts a negotiation process is referred to as a framework.

The first framework (framework one) is the one by N.R. Jennings, S. Parsons, C. Sierra, P. Faratin, P. Noriega, A.R. Lomuscio and M. Wooldridge (Jennings et al., 2001). The second framework (framework two) is the one by C. Bartolini and C. Priest (Bartilini & Preist, 2001). The third framework (framework three) is the one by K. Lee (Lee, 2000). The fourth framework (framework four) is the one by W.Y. Wong, D.M. Zhang and M.

Kara-Ali (Wong, Zhang & Kara-Ali, 2000). These four frameworks are believed to cover a big percentage of all possible negotiation framework variations.

The selected frameworks are compared according to the presence or absence of the following elements: negotiation protocols, negotiation objects and decision making models. The chosen three elements form a union of the elements of the selected frameworks. In the following paragraphs, the three elements are related with the terms from the negotiation domain defined in the previous section.

The negotiation protocol is the element of a framework that represents the rules that conduct the negotiation process. The set of negotiation protocols most closely relates to the rules that *neutral role participants* enforce (Section 2.4). The negotiation protocol is the element that differentiates the negotiation into a *market* or an *auction*, or a *business process scheme* (Section 2.2). The *scenario* of a negotiation process (Section 2.5) is yet another element of the negotiation domain which is related with the negotiation protocol. The scenario can be predetermined by the negotiation protocol.

The negotiation objects represent the matters on which the negotiation process takes place. The negotiation objects affect the way participants negotiate and the complexity of the negotiation process. The influence of the negotiation objects is pushing the *scenario* from *competitive* to *mixed*.

The decision making models are the element that distinguish among the three types of participants: people, NSSs and autonomous software agents (Section 2.4). A more complex decision model uses a more precise representation of the environment, the other agents and the desired objectives. The decision making models directly reflect into the behaviour of the participants.

3.1 Framework one

The first framework consists of three major elements: *negotiation protocols, negotiation objects* and *agents' decision making models*. The first element represents the rules, agreed beforehand, that govern the negotiation process. Protocols define the type of participants, the states (e.g. started, accepting offers, closed), the events that change the state (e.g. time elapsed, no more offers) and valid actions in each negotiation state. The *negotiation objects* represent the issues that the participants negotiate over.

The third element, *agents' decision making models*, represents the models that parties use to represent the negotiation environment. Based on

these models, parties build their strategy to achieve their objectives in a negotiation process. The complexity of the model can vary depending on the negotiation protocols and negotiation objects.

The authors propose the following three approaches for building agents' decision making models that guide each agent's search: game theory, heuristic and argumentation-based approaches. The game theory approach follows game theory techniques, which suppose rational behavior and common knowledge. The heuristic approach is based on imitating human behavior in certain situation and modeling it as a set of strategies. The argumentation-base approach is a logic-based approach, in which the other parties are influenced with arguments like promises, appeals and threats.

3.2 Framework two

The second framework focuses mainly on negotiation protocols and gives a detailed technical view on the negotiation process. This framework has a strong notion of negotiation protocols and a weak one for decision making model and negotiation objects. The negotiation strategies are seen as private for every participant and not an essential part of the framework.

The framework is based on a use-case driven approach. The intention behind this approach is to build a general negotiation framework. So, the proposed framework acts as a template for future specialization for concrete negotiation cases. The framework is an extension of a general message exchange system. The negotiation protocol that determines the rules that participants have to obey is a generalization of rules for exchanging messages.

The proposed framework defines in addition some primitives as a language for defining the rules of negotiation, a language for expressing negotiation proposals and taxonomy of rules of negotiation.

3.3 Framework three

The third framework also focuses on the protocol side of the negotiation process. More precise, the framework emphasizes the aspect of time involved in the negotiation process. The framework proposes a time attribute to be attached to each message to represent the time period in which the message is valid. The author proposes three different types of protocols depending on the time attribute attached to them.

The first type is *the Nothing-Guaranteed Protocol*. The time period of validity is zero. The protocol is valid only in the moment of generating the resulting message. The protocols without time attribute can be seen as Nothing-Guaranteed Protocols.

The second type is *the Acceptance-Guaranteed Protocol*. This protocol represents the other extreme when the stated offer in a protocol remains valid for an unlimited time period.

The third type is *the Finite-time Guarantee Protocol*. To every message in this protocol, a finite time period representing the time of validity of the message is attached.

The author shows that the optimal result for a particular kind of negotiation can be achieved with the Finite-time Guarantee protocol with a particular time period of validity.

3.4 Framework four

The fourth framework focuses on decision making models. The framework proposes Case Based Reasoning (CBR) as an approach to use past experience for choosing a concrete strategy in every concrete situation.

The framework is build on top of a database, the case base, with the following information in it. The core data is a collection of cases of past negotiations. These example negotiations are rated and kept updated during the operation of the framework. The negotiation case maintenance process can be seen as a learning process. The negotiation cases are kept in the database in the form of clusters. These clusters are formed assuming the following criteria which are also part of the database. The criteria are profiles for every product, every customer and every seller. The negotiation process is divided into episodes. Before starting the negotiation process, the profiles of customers, sellers, and products are known. For every step (episode) in the negotiation process, a matching procedure in the negotiation case database is performed. The results are rated and the best strategy for next step is chosen.

3.5 Summary

The following table shows comparison among the

	Negotiation protocols	Negotiation objects	Decision models
Framework one	X	X	X
Framework two	X		
Framework three	X – time		
Framework four			X – learning

four frameworks.

The first framework covers all elements that can appear in the negotiation process. In this framework, the description of the elements is kept abstract, in contrast with the second framework. The second framework is closer to the implementation level and proposes languages for describing and specializing the protocols. The third framework can be viewed as an extension of the first two. It proposes to attach time attributes to protocol messages. The first framework has a notion for negotiation object and decision models. They represent the objects that are subject of negotiation and the prescriptions for choosing a future action. The first framework covers the decision making model from argumentation-based, heuristic and game theory approaches. The fourth framework proposes a decision model based on the Case Based Reasoning approach with elements of learning. The ability to learn is only present in the fourth framework.

4 CONCLUSION

In many cases, information systems for e-commerce need to be able to negotiate automatically with other information systems. Such information systems operate in domains that differ with respect to a number of factors, such as the number of participants in the negotiation. In this paper, a systematic investigation of these factors has been presented.

In the past few years, a number of general frameworks for automated negotiation have been published. In this paper, four of these frameworks have been reviewed and compared according to a meta-model that describes the frameworks in terms of negotiation protocols, negotiation objects and decision models. A relation between this meta-model and the factors that constitute the negotiation domain has been sketched as well. This relation may be used to assess applicability of a specific framework in a specific negotiation domain.

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