DUO meta-model for knowledge elicitation and bidding support in NSS

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ABSTRACT
Negotiation support systems (NSS) help users in the complex process of reaching agreements about exchange of goods or services. A difficult issue in the development of NSS is how to extract knowledge from qualitative real-life data and embed it into the system. We present a meta-model for modeling domain, user and opponent (DUO) in NSS with focus on four main concepts: issues, preferences, interests and objective domain knowledge. We claim that (a) these concepts are essential in extracting data from unstructured sources, and (b) these concepts can be a basis for formal reasoning about user preferences and bids. We ground our meta-model in negotiation literature and data gathered with case studies and interviews. Finally, we formalize parts of the meta-model as a step towards a computationally-oriented model.

Keywords
Meta-model, Negotiation, Expert Knowledge, Interviews, Case Studies

INTRODUCTION
Negotiation is a complex process aimed at reaching agreement about the exchange of goods or services. Although a daily activity, few people are effective negotiators [23]. Existing Negotiation Support Systems (NSS) can improve the human performance in negotiations and increase the number of win-win outcomes if the negotiation space is well-understood [11]. However, to develop the negotiation space properly, both negotiation parties have to jointly explore their interests.

Humans and computers have complementary capabilities for negotiation. Humans are better equipped to understand context, finding new relations between concepts, and having the necessary knowledge to interpret the negotiation domain with respect to their own preferences. However, people have problems handling emotions and the complexity of outcome spaces. Computers provide computational power, data storage and search techniques to handle outcome spaces. However, they still have problems with handling huge amounts of background and context knowledge necessary to handle arbitrary conversations and problems.

We are developing a new kind of human-machine collaboration system supporting one party in negotiations. To allow the human and the NSS to cooperate at the required level of competence, they need to share a model of the negotiation process (Figure 1), a detailed model of the particular negotiation domain (D), negotiator (user (U) and opponent (O)). Together we call the latter 'DUO models'. To share these it is important that they reflect cognitive models of users and are based on accurate real-life data. The negotiator models (UO) can only be entirely elicited through user-system interaction during the negotiation process with the opponent and need to be revisable and adjustable. This does not mean that we have to create new models from scratch with every negotiation. Based on literature and real-life data we can implement domain-independent meta-models[1] of the negotiators.

Negotiation literature [7, 8, 9, 19, 23] gives insight into negotiation processes and also important concepts such as issues, preferences and interests valid for any negotiation domain. State of the art NSS are usually built upon some model of the negotiation process. However, these models are often implicit. Furthermore, most systems do not incorporate a meta-model of the negotiation domain which is validated by real-life data. To our knowledge, there are no ready-to-use formalized domain models available for NSS that can be incorporated by system engineers and instantiated for a particular domain. The negotiation literature emphasizes that besides the above mentioned concepts the following play an important role in the process

[1] By meta-model we mean an explicit description of concepts that are independent from the negotiation domain. This model can be instantiated by feeding in expert knowledge to represent a model of a concrete domain.

and success of a negotiation: emotions, social aspects, negotiation styles, and mental models. While there have been attempts to persuade NSS-developers of the importance of social aspects [1, 22], most of the named concepts are not represented in models used by current systems. They focus rather on technical aspects. Another problem developers face, is the elicitation and embedment of domain knowledge from experts and users. Our goal is to provide a meta-model that underlies both the knowledge elicitation process and the bidding support. We ground our meta-model in the negotiation literature and validate it with real-life negotiation data from expert interviews and user case studies. The resulting DUO meta-model can represent any domain involving bilateral, integrated negotiations and instantiated by feeding in expert knowledge of a particular domain.

RELATED WORK

In a recent review, Kersten and Lai [13] give a detailed overview of NSS and E-negotiation systems. Among other things they give a categorization of software systems (Figure 2) and a structure of key constructs used in NSS. An NSS developed by Kersten and used mainly for training and teaching is the Inspire system [12]. The system employs a 3-phase model including pre-negotiation, negotiation and post-settlements. Concepts like objectives, preferences and issues are present in the model, but relationships are implicit. Kersten and Lai conclude that rather few systems were successfully used for real negotiations. We believe that one particularly important reason for this concerns the validity of the models which are typically not based on real-life data.

If the systems' models do not comply with the mental models of the users or cannot handle information used for taking decisions in real-life negotiations, it seems likely that the usefulness and real-life applicability of the system is limited.

A single research framework is needed to study and compare E-negotiation systems. An important part of such a framework is a well-defined meta-model that provides a basis for incorporating real-life data.

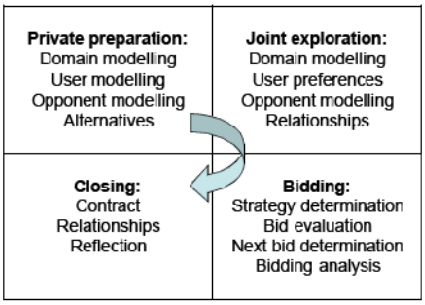

Figure 1: Negotiation phases [23]

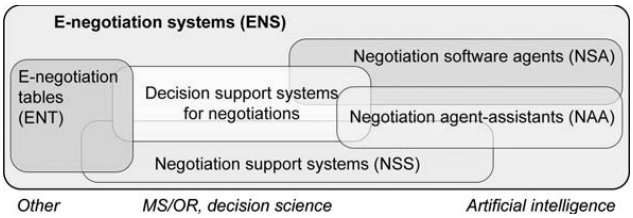

Figure 2: Overview of ENS [13]

Especially eCommerce and Artificial Intelligence have been interested in supporting or automating negotiations involving humans and/or software agents. Negotiation models are essential for systems developed in those areas. Köhne et al. [14] give an overview and analysis of models used in different approaches to electronic negotiation: the bargaining school, the auction school and the agent school. They show the large diversity of models used and point out that "most of them concentrate on special aspects of the negotiation process". They offer different views based on decision support, communication or document management. Within the bargaining school models have been developed for legal documents created by negotiation [4], relating documents, messages and partners to a negotiation [18], combining organization and communication [21], for business negotiation support [5] and an abstract negotiation protocol [12]. Köhne and colleagues argue for a meta-model, that combines these views to be the basis for the development of customizable NSS. Their approach involves comparing and analyzing existing models. It does not include a validation of the model with real-life data.

Ermolayev and Keberle [6] created a generic negotiation ontology (GNO) to facilitate negotiation among software agents. Their work presents a very detailed UML model of negotiation and a number of important definitions needed for a common basis to describe negotiation. Focusing on the domain, they have modeled a negotiation set which includes a number of negotiable issues with dependencies between them. The negotiators have beliefs which influence the utilities of considered issues. This is similar to our own approach. What is missing in their model is the important relationship between preferences and interests. Furthermore, instead of using utility functions we are interested in qualitative input of preferences.

META-MODEL

The proposed meta-model is shown in Figure 3. Parties in a negotiation are called negotiators. For a bilateral negotiation we specify two: our system's user and the opponent. Depending on the domain, negotiators have different roles, e.g., buyer and seller in the real estate domain. An issue (also commonly called *attribute*) is a concrete, negotiable aspect such as monthly salary, number of holidays, full-time equivalent (FTE). Every issue has a set or range of possible values. The value of an issue in a given instance can be objectively determined (e.g. 2400 euro, 30 days, 0.7 FTE). Issues and their possible values typically depend on the domain. A possible outcome has a

specified value for every issue. All bids made during a negotiation are possible outcomes. A negotiator's bids are determined by his strategy, which depends on his preferences and the negotiation protocol. An agreement is a bid accepted by all parties. Each negotiator has preferences. People have preferences over values within a particular issue (value preferences), e.g. prefer a high over a low salary, over the issues (issue ordering), e.g. prefer part-time work over salary or over complete outcomes (outcome preferences), e.g. prefer job offer A to B. In our model all preference types are classified as sub-concepts of an abstract preference concept. Preferences are often influenced by the negotiator's interests. The role of a negotiator can determine some of these interests. Other interests are individual based on the negotiator's characteristics.

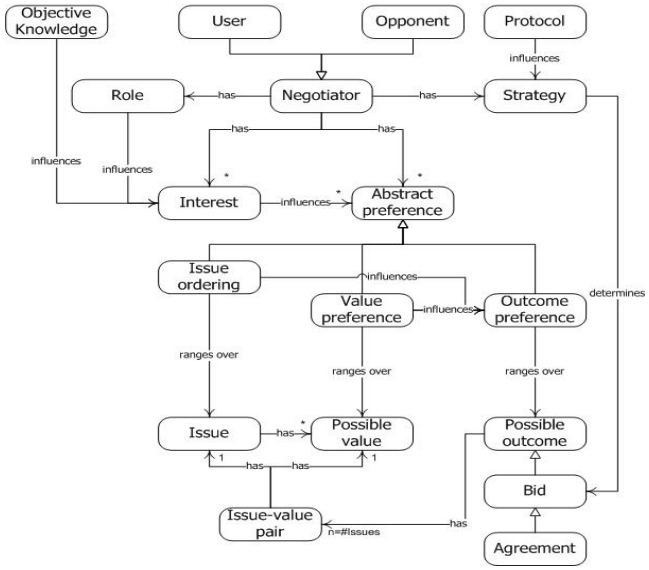

Figure 3: DUO meta-model

The need for underlying interests

It is common practice in NSS to define a negotiator's preference over possible outcomes in terms of issues. The set of issues differs per negotiation, but they are typically drawn from a pool of issues that are given by the domain. Although this seems straightforward, it is difficult to define the issues that objectively belong to the domain.

Consider creativity in a job. Is that an issue, or an interest of a person relating to issues of freedom to start new projects and new product lines? Some issues do not belong to the domain but reside in the user. To deal with those, we propose to not only define a negotiator's preference in terms of issues, but to base it on her interests. There are different terms to indicate interests (e.g., underlying values[2], fundamental objectives) used in literature. We define an interest as a party's basic need, want, or motivation that is potentially at stake in a negotiation. The measure of success in a negotiation is how well your interests are met [15].

The importance of the discovery of interests during negotiations has been pointed out in the literature on interest-based negotiation [7]. By understanding one's own and the other party's reasons behind a position, people are more likely to find more creative options and by that reach a mutually acceptable agreement easily.

In literature on behavioral decision-making [16] the emphasis has shifted from stable to constructive preferences. In this view people do not have predefined preferences over issues, but construct them as the negotiation goes along. Preferences might then also change again when a negotiator receives new information. Underlying values are mostly seen as stable. For a differentiation between preferences and values see [20].

Value-focused thinking advocates the specification of fundamental objectives before identifying possible alternatives [11]. Carenini and Poole [3] have looked at these concepts in detail and pointed out the implications for AI research on building preference models. It becomes clear from the literature that the relationship between interests and preferences over issues in a negotiation domain is essential to model.

While an interest is not negotiable, an issue is. In our previous job example, creativity would be an interest, while the freedom to start new projects is an issue. One has to identify which issues can serve an interest. Chosen issues influence the degree to which interests are met, but it is not always a one-to-one relation. An applicant with childcare responsibilities has the interest that the children are taken care of after school. This interest, childcare, can be met by various issues, e.g. part-time work, working from home, a childcare refund, childcare facilities, salary that will cover childcare expenses. One issue may also contribute to multiple interests. Many issues that deal with money do so, because the interests people have for using the money will be different. But also the hours that you can work at home can be linked to different interests like taking care of children, less commuting or liking to work in this environment.

Including interests in the model provides a clear separation between aspects that are negotiable (usually the same set of issues for every negotiator) and aspects that not negotiable (these might be different per negotiator). In the next section we show that this separation greatly facilitates analyzing the data from cases and interviews.

DUO MODEL VALIDATION: CASES AND INTERVIEW ANALYSIS

A challenge in the development of NSS is embedding rich real-life data into a model that can be incorporated in an NSS. We show that the DUO model, in particular the (relation between) issues, interests and preferences, can be used to extract knowledge from real-life data. We first describe our data gathering methods and then how the data

[2] This should not be confused with a possible value for an issue (see Figure 3)..

from these sources can be structured using the DUO meta-model. In the same way the meta-model can be instantiated for different domains.

We have two example domains: real estate and job contract negotiations. These domains were chosen because (a) most people are familiar with them and (b) they constitute important negotiations in people's lives involving emotions. To elicit domain knowledge (objective knowledge) one can choose from a long list of elicitation methods [2]. We used expert interviews and layman use cases. From the expert perspective we aimed at getting an accurate account of how negotiations in a given domain typically work. This includes the process and common issues, but also expectations towards the opponent and how the opponent is perceived. We used interviewing techniques to acquire that knowledge. We were also trying to get an account of how the laymen understand negotiation processes and what their interests are. Therefore, we conducted several case studies investigating real-life negotiations.

Since our focus lies on evaluating our meta-model with respect to the validity of the abstract concepts, we are not looking at specific preferences or issues that came out of data, but at how well the meta-model helps us understand the user and the experts with respect to issues, interests, default preferences and domain knowledge. Obviously, we will mention concrete issues and interests to explain the process of evaluation.

Elicitation Method: Expert Interviews

Participants and Procedure

We conducted five semi-structured interviews with experts, three professionals for the job domain and two for the housing domain. For the job domain the first person was a recruiter for experienced professionals at an international information technology company with 4 years experience on the job. The second person was a recruiter at a medium-sized international consulting company with 1.5 years experience. The third person was a Human Resource employee at a Dutch research company. For the housing domain the first person had been a real estate agent for eight years. The second person was the founder and director of a Dutch organization offering real estate services over the internet.

Four interviews were arranged at the participant's workplace to ensure the participants feel comfortable. The interviews were based on a number of questions created beforehand serving as a guideline. The interviewer first created a personal atmosphere and asked the participants to talk about themselves and a typical negotiation in their jobs. Then the interviewer either chose to pose a prepared question or a spontaneous one emerging from the interview. We had three researchers observing and taking notes.

Elicitation Method: User Case Studies

We gathered 8 user case studies, three as diary studies (in the job domain), and 5 as detailed interviews about the process of the negotiation (3 in the housing domain, 2 in the job domain).

Participants and Procedure

Participants were in the process of buying a house or switching jobs. They were either asked to keep track of the process in a diary, or to participate in an in-depth interview if the negotiation had taken place. The diary study presented the subjects with a blank page with topical and situational suggestions to write about. The participants sent the diaries to the researcher when the job contract was signed. The real estate diary studies were not completed yet, so housing data will come from in-depth interviews only.

DUO MODEL VALIDATION

We validate our DUO meta-model with real-life data. We show that in order to interpret the data gathered from the expert interviews and user cases we need the four main concepts interests, issues, preference and objective domain knowledge. We do so by presenting and analyzing representative examples of text from the studies. The text snippets are statements by experts or users about what people negotiate about, how and why. We start with the analysis of the expert interviews in both domains.

Experts on Job Domain

Expert_1: "When talking to the candidate I try to find out whether the person fits the company. The candidate has to fill in a form with wishes for salary, position, lease car, reimbursement of internet costs etc. We check whether it fits the level of the candidate and is in line with our team."

From this excerpt we can clearly see a differentiation between issues and interests. Issues are "salary", "position", "lease car", and the "reimbursement of costs", because these are matters to negotiate about. "Fit to the company", and "self-image" are subjective non-negotiable matters the company is concerned about. Therefore, they are interests. In this example the interests define the extent to which the issues are negotiable: the level of salary is limited by the candidates' skills and the rest of the team. It is not possible to fit this relationship into an NSS model that only consists of issues. Therefore, it is important to model interests.

The following snippets emphasize the importance of the management of expectations between the parties:

Expert_1:"I want to get the candidate on board but I also want to keep him. Therefore it is important to manage expectations."

Expert_2:"My expectations for the candidate are that he is informed about the company, prepared about the content of the function he is applying for and asks questions during the interview."

Expert_2:"If the candidate only talks about money, I wonder whether he is really interested in the company or will leave soon. Money is important, but does not count for everything."

These quotes express expectations from the employer. Expectations can be managed but hardly ever negotiated. Therefore, we cannot model them as issues. We can, however, fit them into the concept of interests, since they represent some aspect of the future collaboration that one is concerned about. If the data is typical for a certain domain, e.g. that commonly employers want to keep their new employees, we can model this data also as 'objective domain knowledge'. This knowledge can influence whether a deal will be made or not. In extreme cases the bidding might not even start because it becomes clear earlier that the interests of one party will not be met. An NSS's model that only focuses on entering issues and not this kind of crucial knowledge is of limited value.

The experts we interviewed also mentioned what most candidates want:

Expert_1:"Most important concerns for the candidates are salary, work-life balance and pension regulations."

Expert_3:"For the candidate salary is most important. For the company the fit is most important**."**

In this example we would also have problems fitting work-life balance into the concept of issues. It is not negotiable per se but needs to be translated into issues like "holidays", "flexible work hours" or "part-time work".

"Salary" on the other hand is an issue. "Pension regulations" could be an issue if the company offers to negotiate about them.

Experts on Real Estate Domain

Expert_4:"Concerning the transaction date: The buyer first wants to sell his own house. Is there already a buyer for it? Is the asking price appropriate?"

The snippet reveals a relation between the transaction date and the wish of the buyer to sell his own house first. The transaction date is negotiable with the seller but it is influenced by a wish that is not part of the negotiation. In order to represent this in a model we need to fit the wish of the buyer into the concept 'interest', which in turn influences the 'issue' transaction date.

The following quote shows the importance of objective domain knowledge for the reasoning about an offered bid:

Expert_4:"Evaluating a bid depends on the situation. E.g.: Are there other people interested?"

In case of other people being interested in the same house, there is a higher risk that you might not get the house. Therefore the next bid has to be decided carefully. This kind of information needs to be incorporated in the advice to the user with respect to the evaluation of offers and the proposals of counteroffers.

Expert_5:"Buyers often do not understand that it is important for the seller to know that the buyer can finance the house."

This snippet reveals an interest of the seller, i.e., "get my money". If the buyer is not aware of this worry, he misses out on an opportunity to influence the negotiation process. If the demand for houses is high, the seller might prefer dealing with another prospective buyer. If it is a buyer's market, the buyer can play with worries of the seller, thus trying to reduce the price.

Other issues that the experts provided like repairs, guarantees (e.g., soil test), transaction date, and movable property (e.g., furniture) give a lot of opportunities to create new options in the negotiation. Knowing the interest of the opponent, e.g. that he might want to get rid of some things inside the house is a chance for the buyer to expand the deal. Therefore, it is essential to model also the opponent's interests and remind the user of their importance.

Users on Job Domain

User_1: "The dilemma is whether I will search for a career oriented job (with or without mentioning my planned world trip in 8 months) or just any job, not necessarily supporting my CV that is close by my home and allows me to earn money."

User_1: "To be honest, I'm more and more doubting the possibility to find a job that is both an intellectual challenge and for a period of 7 months if I mention my planned world trip."

User_1: "What I like about the job is that it is close. The salary sucks as well as the content, but planning my world-trip is priority."

Again, in these snippets we can clearly see the difference between issues and interests. Interests are "world-trip", "career-oriented job" and "supporting my CV", "intellectual challenge", "close to home", while issues are "money" and "contract length". In an approach relying only on issues, things like "world-trip" cannot be modeled, as this is not a negotiable aspect of the job. Still it is critical to be able to model the relation between interests and issues because the interests influence the user's choices over issues such as "contract length". Interesting to note is that the subject notices a potential incompatibility between the "world-trip" interest and the "intellectual challenge". 'Potential' because it depends on telling the other party that the world trip is planned. This aspect is important as it shows that we need to be able to model background knowledge about how interests are tied together. What we also see is that the subject expresses a clear priority: the world trip comes first as an interest and as a result the subject wants to work close to home (less travel time means more trip planning time) and have a certain salary in the next 8 months. This reveals the candidate's preferences.

Several other snippets from other users in the job domain reveal possible interests and issues:

User_2: "the work is diverse (*interest*), it is for 2 years (*issue*), R&D and industry are involved as well as research (*issues*); it is a good opportunity to figure out what I want to do further (*interest*)."

User_3: "...make my desires explicit such as working closer to home, no irritating colleagues, travel time, diversity and

change". All of these desires are expressed as interests, although for some it is possible to define relevant issues (e.g., travel time translates to working from home or having clients close to your home town).

Users on Real Estate Domain

In the following snippets we show how users buying a house think about the process.

User_4: "...wanted to live close to the centre (of Rotterdam), with a diversity of people cultures and social class."

User_4: "...my bank thought it would be possible to get a mortgage. Normally this was easy but I started my own company and therefore I had no fixed salary. Normally one has to produce figures over the last three years, but I could not do that as I just started. The bank was also ok with the figures of this year and a prognosis for the next. They gave me a mortgage, if I kept the extra cost for renovating the house as low as possible"

In these snippets we see two things. First, some interests do not easily translate to issues. For example, living close to the centre is an interest that strongly influences what houses to consider, but it is never negotiable between the buyer and the seller; it is a property of the house. Only if the negotiation is between two partners deciding on a house, it becomes an issue reflecting interests such as close to facilities and entertainment. This again shows the need for explicit modeling of interests and their potential relation to issues. An exclusive focus on modeling issues would exclude "living close to the centre" as information usable by the system. Second, some issues have to do with a complex set of other issues or interests. The issue of the size of the mortgage finally depends on whether an interest of the bank (solvability of the house owner) is being met. This interest depends on the financial prospects of the house owner, in this case translated into the negotiable issues "low extra cost" and "showing financial results of this and next year". The distinction and the link between issues and interests are important: the bank needs to be convinced that the owner can pay the mortgage.

User_5: "We searched for a location between work and friends, not in too small a village, facilities close by and well maintained." Here, all aspects relate to interests that are difficult to translate into issues because they are attributes of a house. Only the "level of maintenance" is translatable to an issue like "repairs" that could be negotiated with the current owner. The next and last quote shows typical issues for evaluating a house.

User_5: "We valued the house based on the price asked, the moment we could move in and the money needed to renovate."

We argued that NSS which only model negotiable issues and their preferences, but leave out underlying interests and crucial domain knowledge, cannot take all influencing factors into account when evaluating bids or offering advice. From the data we have seen that often the interests of both parties influence which issues will be negotiated and to what extent. Knowing interests of the other party helps to generate more room for negotiation. An NSS should be able to give users hints about issues and interests to think about based on objective domain knowledge; also from the opponent's point of view. A lot of the data that is used by people to take their decisions does not fit into existing domain models. We showed that the data we gathered from experts and users about negotiations in the job and house domain fit into the meta-model we proposed previously based on negotiation literature.

TOWARDS A FORMALISM FOR NSS

In this section we show some first ideas for how the DUO meta-model can be used as a basis for a formal approach to reasoning within NSS. One way to apply the models is as input to the underlying reasoning framework of the NSS; (1) to infer a user's preferences over possible outcomes from the information that was elicited from the user, (2) to suggest a next bid, based on the preferences, the bidding history and a given negotiation strategy, (3) to explain to the user why such conclusions were drawn.

We present some examples of qualitative rules as part of a qualitative framework for negotiation. We focus on the relation between issues and interests. Formalization of other concepts will be the focus of future work. There are several formalisms available that can be used to express preferences, e.g. utility functions [9] or logical expressions. We have chosen to formalize key concepts that are part of the meta-model using Reiter's [17] default logic. Default logic provides a tool to represent knowledge that is qualitative in nature and not precise enough to uniquely characterize a utility function. A default theory is a pair <D,W>. *W* is a set of logical formulae, called *the background theory*, that formalize the facts that are known for sure. *D* is a set of *default rules*, each being of the form: $P:J_1,J_2,\ldots,J_n/C$. Informally this means that if we believe that P is true, and each J_k $(1 \leq k \leq n)$ is and stays consistent with our beliefs, we are led to believe that C is true. For the formal semantics, see [17]. As soon as there is information to the contrary, the default rule is no longer applicable. For example, the typical value preference of a buyer for a low price may be expressed as:

issue(price) ∧ price(X) ∧ price(Y) ∧ X<Y:
value_prefers(buyer,price(X), price(Y)) /
value_prefers(buyer,price(X), price(Y))

The issue ordering of preferring part-time work over salary is not a default ordering; it is negotiator specific. Therefore, we do not formalize this as default knowledge. However, if over time we learn that a substantial percentage of negotiators have such an issue ordering, it is possible to store this knowledge in the system to be used for improving the preference elicitation process. The knowledge can, e.g., be expressed as a constraint over the possible utility functions, or as a logical relation. In both cases the system labels such knowledge as holds_for_some negotiator or role. For example, let C(A) be the constraint for some negotiator

A, then holds_for_some(A, C(A)). For the example about part-time work in terms of utility functions we would get:

C(candidate) ≡ issue(part-time work) ∧ issue(salary) ∧ part-time work **>** salary.

The holds_for_some predicate is applicable to any logical statement (constraint, preference, default rule).

Similarly, outcome preferences can be formalized in terms of constraints on utility functions, or in a logical relation. Let b1 and b2 be possible outcomes for which the negotiator A prefers b1 over b2. As constraint on the utility function U_A, the constraint is $U_A(b1) > U_A(b2)$. As a logical relation, where outcome_prefers is the predicate used to express outcome preferences: outcome_prefers(A, b1, b2).

Given these basic relations, it is now possible to add the concept of interests and define relations between interests and issues. Preferences directly relate to the issues that are negotiable, but often these are influenced by a negotiator's underlying interests [7]. For example, a negotiator may have a preference for part-time work, because he wants to spend more time with his children. Which interests are important, and the degree to which a possible outcome addresses an interest, are subjective and influenced by the role of the negotiator. Interests thus provide a reason that motivates why certain issues are more important than others. We reuse basic defaults from default theory to model this relation, in order to avoid the need to introduce a defining semantics for 'reasons'. Then the given example may be formalized as: interest(candidate, child_time): issue_order(candidate, part-time work, salary) / issue_order(candidate, part-time work, salary)

where interest(candidate, child_time) represents the fact that the negotiator wants to spend as much time as possible with his children. These formalizations provide formal input that can be computed by a machine. Additional formalizations may be added, to provide a formal representation of the meta-model. For example, the knowledge that the real estate domain knows at least the two roles seller and buyer may be represented by the logical statement:

domain(real_estate) → ∃A,B role(A, seller) ∧ role(B, buyer)

Extensions and a more extensive discussion of these formalizations are outside the scope of this paper.

CONCLUSION AND FUTURE WORK

Interests and their relation to issues are hardly taken into account in current NSS. There are at least three reasons why they should be. First, it is known that awareness of the opponent's interests stimulates the creative process of finding new options for negotiation [7]. Second, preferences over issues are based on interests. Third, addressing interests in the preference elicitation process can help identify the right issues. Due to a lack of existing models in NSS that consider interest and also default domain knowledge we designed the DUO meta-model. This model can serve as a starting point in the development of NSS and as a framework for the comparison of NSS. The model, which is grounded in negotiation literature, explicitly differentiates between negotiable issues and interests that underlie the preferences of a negotiator over issues. We have argued that such a distinction is necessary to ensure the applicability of NSS. We validated our meta-model by structuring real-life data gathered from case studies and interviews. Finally, we have shown how the model can be a basis for formal reasoning about preferences. In the future we will extend this formal model to support the bidding process and create a formal language for handling qualitative statements of preferences using argumentation [24].

ACKNOWLEDGMENTS

We would like to thank our interview and study participants. This research is supported by STW, applied science division of NWO and the Technology Program of the Ministry of Economic Affairs.

REFERENCES

1. Bui, T. Evaluating Negotiation Support Systems: A Conceptualization, in *Proceedings of HICSS'94* (Hawaii, January 1994), IEEE Press, 316—324.
2. Burge, J.E. Knowledge Elicitation Tool Classification. www.cs.wpi.edu/~jburge/thesis/kematrix.html.
3. Carenini, G., and Poole, D. Constructed Preferences and Value-Focused Thinking: Implications for AI research on Preference Elicitation, in *Proceedings of AAAI-02 Workshop on Preferences in AI and CP: symbolic approaches*, (Edmonton, Canada, July, 2002).
4. Chiu, D.K.W., Cheung, S.C. and Hung, P.C.K. A Meta-model for Contract Template Driven e-Negotiation Processes, in *Proceedings of PACIS '02* (Tokyo, Japan, September, 2002), 854–868.
5. De Moor, A. and Weigand, H. Business Negotiation Support: Theory and Practice. *International Negotiation 9* (2004), 31–57.
6. Ermolayev, V. and Keberle, N. A Generic Ontology of Rational Negotiation, in *Proceedings of ISTA'2006* (Klagenfurt, Austria, May 2006), 51–66.
7. Fisher, R. and Ury, W. *Getting to Yes: Negotiating Agreement Without Giving In*. Penguin Books, New York, USA, 1983.
8. Harvard Business Essentials, *Negotiation*, Harvard Business Press, 2003.
9. Keeney, R.L. and Raiffa, H. *Decisions with multiple objectives: preferences and value trade-offs.* Cambridge University Press, 1993.
10. Keeney R.L. *Value-Focused Thinking: A Path to Creative Decision Making*. Harvard University Press, 1992.
11. Kersten, G. E. and Lo, G. Aspire: an integrated negotiation support system and software agents for ebusiness negotiation. *International Journal of Internet and Enterprise Management 1,* 2 (2003) 293 – 315.
12. Kersten, G.E., E-negotiation systems: Interaction of people and technologies to resolve conflicts. InterNeg Research Papers INR 08/04. (2004) 1–21.

13. Kersten G.E. and Lai, H. Negotiation Support and E-negotiation Systems: An Overview. *Group Decision and Negotiation 16*. (2007) 553–586.

14. Köhne, F., Schoop, M. and Staskiewicz, D. A Meta Model for Electronic Negotiations-Comparison of extisting approaches. In *Proceedings of RESEEM'05* (Amsterdam, the Netherlands, September, 2005) 19–33.

15. Lax, D.A.,Sebenius, J.K.. *3-D negotiation: powerful tools to change the game in your most important deals*. Harvard Business School Press. Boston, Mass., 2006.

16. Payne, J.W., Bettman J.R. and Johnson E.J. *The Adaptive Decision Maker*. Cambridge University Press, 1993.

17. Reiter, R. A logic for default reasoning. *Artificial Intelligence 13* (1993) 81–132.

18. Schoop, M. and Quix, C. DOC.COM: a framework for effective negotiation support in electronic marketplaces. *Computer Networks* (2001) 153–170.

19. Shell G.R. *Bargaining for Advantage: Negotiation Strategies for Reasonable People*. Penguin Books, 1999.

20. Shiell, A. Hawe, P. and Seymour, J. Values and preferences are not necessarily the same. *Health Economics 6, 5* (1997) 515–518.

21. Ströbel, M.: Design of Roles and Protocols for Electronic Negotiations. *Communication Research 30* (2003) 147–177.

22. Swaab, R., Postmes, T., and Neijens P. Negotiation Support Systems: Communication and Information as Antecedents of Negotiation Settlement. *International Negotiation 9* (2004) 59—78.

23. Thompson, L.L. *The Mind and heart of the Negotiator*. Prentice Hall. 2005.

24. Visser, W., Hindriks, K.V. and Jonker, C.M. Argumentation-based preference modeling with incomplete information. In *Proceedings of CLIMA-X* (Hamburg, Germany, September, 2009). 156–171.