The Pocket Negotiator, synergy between man and machine

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1 Summary of research project

Negotiation is a complex emotional decision-making process aiming to reach an agreement to exchange goods or services. Although a daily activity, few people are effective negotiators. Existing support systems make a significant improvement if the negotiation space is well-understood, because computers can better cope with the computational complexity. However, the negotiation space can only be properly developed if the human parties jointly explore their interests. The inherent semantic problem and the emotional issues involved make that negotiation cannot be handled by artificial intelligence alone, and a human-machine collaborative system is required.

I propose to lead a team of people that will develop a new type of human-machine collaborative system that combines the strengths of both and reduces the weaknesses. Fundamental in these systems will be that user and machine explicitly share a generic task model. Furthermore, such systems are to support humans in coping with emotions and moods in human-human interactions. For this purpose we will contribute new concepts, methods and techniques. For integrative bargaining we will develop such a system, called a Pocket Negotiator, to collaborate with human negotiators. The Pocket Negotiator will handle computational complexity issues, and provide bidding- and interaction advice, the user will handle background knowledge and interaction with the opponent negotiator.

The Pocket Negotiator will enhance the negotiation skills and performance of the user by increasing the user's capacity for exploration of the negotiation space, reducing the cognitive task load, preventing mental errors, and improving win-win outcomes. We will devise a negotiation model that matches human cognitive representations of negotiation, and develop methods and tools to support humans in coping with emotions. Two negotiation domains, labour agreements and real estate acquisition, with associated experts provide the development ground for the Pocket Negotiator. We will validate the techniques and tools in training situations, and realistic experiments.
Keywords: Human negotiation support system, Shared generic negotiation model, Strategic bidding heuristic, Issue and preference elicitation, Emotive model for negotiation.

2 Description of the proposed research

2.1 Research topic

Negotiation is a prime example of a task for which the human mind is but partially equipped, and for which artificial intelligence can only provide partial assistance. Computational power, data storage, search techniques, computational heuristics to tackle exponential problem spaces, are among the good products of AI. However, AI has not solved the problem of the huge amount of knowledge necessary to cope with, and understand arbitrary conversations and problems. The complexity and the variability of the problems

humans wish to address are just too much to handle. My long term aim is to develop a new type of human-machine collaboration in which the human weaknesses are covered by the strengths of the machine, and the weaknesses of the machine are covered by the strengths of the human.

The team of the Pocket Negotiator project will contribute to this aim with a system development method that combines situated cognitive engineering (Neerincx, in press) with artificial intelligence. We deem the development of shared task models (Brazier, 2000) qualitative content models (Kraus, 1998), and the support of humans in coping with emotions due to human-human interaction fundamental for success. These models together properly reflect the way that humans represent problems and reason about them. The shared task models are essential for team work and serve as the backbone of the system; they form the basis of the explanation facilities and task division over user and system, and steer the content modelling process.

For integrative bargaining (Walton, 1965) we will develop the **Pocket Negotiator (PN)** to enhance the negotiation performance of human negotiators. This result is reached because the PN will increase the user's capacity for exploring the negotiation space, reduce the cognitive task load of the user by providing focus and structured support, and prevent mental errors, since the human-machine collaboration of PN and user supports corrective processes (Kahneman, 2003).

2.2 Negotiation, a brief introduction

Everyone is an experienced negotiator and everyone has an opinion about their negotiation skills. However, even professional negotiators can still improve their skills considerably. "*Most people are ineffective negotiators … Fewer than 4 percent of managers reach win-win outcomes when put to the test … Even on issues for which people were in perfect agreement, they fail to realize it 50 percent of the time*," writes Thompson (2005).

Fisher and Ury (1981, 2003), Raiffa (1982), Thompson (2005) and others emphasize that negotiation is not just about money, but also about good relationships, awareness of all issues (domain model), personal preferences (user and opponent model), knowledge of your alternatives (if no deal is reached), and reflection on your performance.

In integrative negotiation four major stages can be discerned: private preparation, joint exploration, bidding, and closing (see Fig.1).

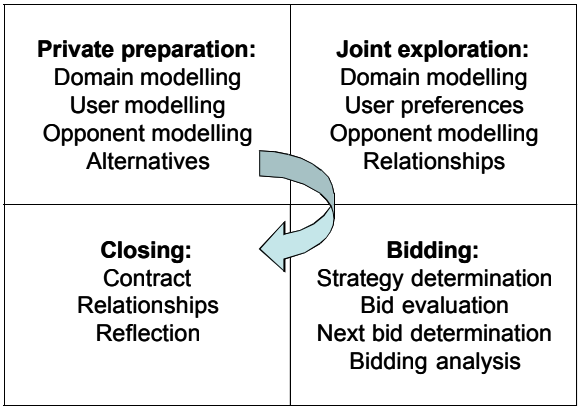

Fig. 1 Negotiation Stages

- **Private preparation** is predominantly a stage of information gathering and

reflection done before meeting the other party. The negotiator learns as much as possible about the negotiation domain (issues under negotiation, and hidden interests), the coming process, about his profile and about the opponent. Hidden interests are aspects that might not be mentioned, but that do have an impact, e.g., is one of the parties under time pressure?

Negotiation inherently has an aspect of conflict management (Blake, 1964; Fisher, 2003; Thomas, 1974, 1992; Kilmann, 1977; Pruitt, 1981, 1986). Having insight in their conflict-handling style and that of their opponent can help negotiators to predict possible sources of conflict, and ways to avoid or alleviate conflict; see the Dual Concern Model of (Pruitt, 1986) in Fig. 2.

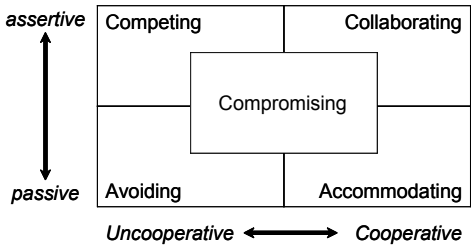

Fig. 2 Dual Concern Model

- **Joint exploration**: In this stage the negotiating parties talk to each other, but

don't place bids on the table. The aim of this stage is to check the information they gathered so far, to create a good atmosphere for the bidding that will follow, to make the negotiation space as big as possible, and to agree upon a protocol for the bidding, e.g., turn-taking by phone (often seen in real-estate).

- **Bidding**: During this stage both negotiators exchange bids according to some

protocol, typically a turn-taking protocol. For each incoming bid the negotiator has to decide, whether to accept (If he expects no more improvements can be made), to make a counteroffer (if he thinks he can do better), or to stop (if he thinks he has a better alternative elsewhere). The bidding ends when a party accepts a bid or stops.

- **Closing:** During the closing stage the outcome of the bidding stage is formalized

and confirmed by both parties. If confirmation turns out impossible, the negotiation returns to one of the previous stages.

Overall, negotiating is an emotional process, certainly for the novice negotiator (Ury, 1993, 2007). The more that depends on the outcome of the negotiation, the more intense the emotions. For example, buying a house for the first time, or negotiating about a job contract, can be intense (Deluca, 2007; Minden, 2006). This is partly caused by not feeling in control of the situation, not knowing what to expect, and fearing not to perform well enough (Folkman, 1990; Lazarus, 1984; Ursin, 2004).

2.3 Human problems with negotiation

In this section I address the most important problems from two perspectives: an outcome perspective, and a process perspective. I collected the remedies reported in literature to decide upon the support that I want the PN to offer.
The main outcome related pitfalls in negotiation are (Thompson, 2005):

- Leaving money on the table: when negotiators fail to recognize and exploit win-win potential. This means that a potential outcome exists that would be better for both parties.
- Settling for too little: a negotiator may make too large concessions thereby agreeing to a too-small share of the bargaining pie.
- Rejecting a better offer than any other available option happens when a negotiator ends a negotiation even though the offer provided by the opponent is better than other options available to the negotiator when no agreement is reached, and
- Settling for terms worse than alternative options happens when negotiators feel obliged to agree to an offer that is worse than other alternatives.

The pitfalls from the outcome perspective are caused by problems occurring during the negotiation process. In the literature, the following aspects are recognized:

- Lack of training (Thompson, 2005). Humans have difficulty in structuring

negotiation problems and thinking creatively about such problems. Moreover, just negotiating in practice does not alleviate these problems due to faulty feedback and self-reinforcing incompetence. Faulty feedback refers to the problem of not getting accurate, immediate, and specific feedback, which can only be solved through regular training. Self-reinforcing incompetence means not being aware of ones limitations, thus not seeing the need to improve ones skills.

- Lack of preparation, see e.g., (Thompson, 2005; Harvard, 2003). Preparation

is insufficient when it leaves the negotiator unaware of an important part of the bargaining pie and/or the preferences and circumstances of the parties involved (including himself).

- Structural barriers to agreement (Harvard, 2003). This refers to such problems as:

die-hard bargainers, a bad atmosphere (Mastenbroek, 1989), power imbalance (Mastenbroek, 1999), cultural and gender differences, disruptive people or incommunicative people at the table, and a lack of information. The last point can be caused by insufficient preparation, but also by communication problems.

- Mental errors (Harvard, 2003). Parties commit mental errors such as the

escalation error, biased perception, irrational expectations, overconfidence, and unchecked emotions. The escalation error is the continuation of a previously selected course of action beyond the point where it continues to make sense. Biased perception is the problem of perceiving the world with a bias in your own favour (Clancey, 1989; Harvard, 2003, Thompson, 2005).

- Satisficing (Thompson, 2005; Simon, 1955): Due to uncertainty of the future, the

costs of acquiring information, and the limitations of their computational capacities people have only bounded rationality, forcing them to make decisions by satisficing, not by maximization.

According to the literature, except for the satisficing problem, these problems are reduced by proper preparation, an effective negotiation style, a good dialogue with the opponent, timely interventions (such as introducing a break),

and training, see e.g., (Fisher et al., 2003; Harvard, 2003; Mastenbroek, 1989, 1999; Raiffa, 1982, 2002; Shell, 2006; Thompson, 2005). I intend to address all problems, including the satisficing problem by doing research and developing an human-machine collaborative system, the Pocket Negotiator (PN), that supports the user in all stages of negotiation. I intend the PN to work together with the user to create the content models, to prepare the user for the interaction with the opponent, to offer assistance if problems arise in the user-opponent interaction, and to offer bidding advice.

2.4 Negotiation from a technical perspective

Various negotiation systems created for specific negotiation domains have demonstrated that with respect to the satisficing problem significant improvements can be obtained (Bosse, 2005a; Gutman, 1998; Jonker, 2001, 2004; Klein, 2003; Luo, 2006). These systems are devised for specific domains, for which the negotiation space is known. Either the preferences of user are assumed to be known, or preference elicitation techniques are incorporated for that same specific domain. In the Althena project (www.althenasoft.org) users have to build all content models themselves. The support does not include predefined structures, repositories of content models, interaction support, selecting bidding strategies. Of course the introduction of technology in a process, changes such a process, as is the case for negotiation (Galin, 2007). To create human-machine collaborative negotiation systems for integrative bargaining a number of problems must be overcome.

To ensure optimal team work, user and system need to share a generic model of negotiation consisting of a task model and of a meta-model of the necessary content models. For negotiation, I presume that the content models are: Domain-, User-, and Opponent-model (DUO-models). The shared generic model of negotiation is a meta-model of the content models that describes the structure of these models and the underlying formal specification language. The generic model must be determined during the development phase of the Pocket Negotiator (PN). The negotiation space must be obtained during run time. The negotiation space depends on the DUO-models, and requires the negotiating parties to jointly explore their interests. A complete automation of this part of the process is impossible: the general world knowledge involved is too complex and the interests are human and not always explicitly known to the human in question. Furthermore, the preferences and hidden interests of the user and opponent must be elicited from the user.

I will make a task division between system and user that is based on the strengths and weaknesses of both. The system can be provided with a wealth of general knowledge about negotiation, about some specific domains, and is strong in avoiding the satisficing problem. The human has general world knowledge, and prowess in communicating with other humans. A complicating factor is the emotional aspect of negotiation; humans' negotiation performance is affected by emotions. So far only humans can interpret them in context; however, due to the emotions, they might find it difficult to cope. The advantage of the computer is that it won't be affected by emotions. The challenge is to develop a system that can assist the user in his interactions with the opponent; assessing the situation, regulating emotions, and coping with negative consequences of emotions.

The architecture (see Fig.3) is based on (Jonker, 2001) and consists of five components. During all negotiation stages the *DUO-modelling component* is responsible for the development of the DUO-models. The DUO-models can be inspected and adapted at all times. The history of these models, including the history of bidding is maintained as well.

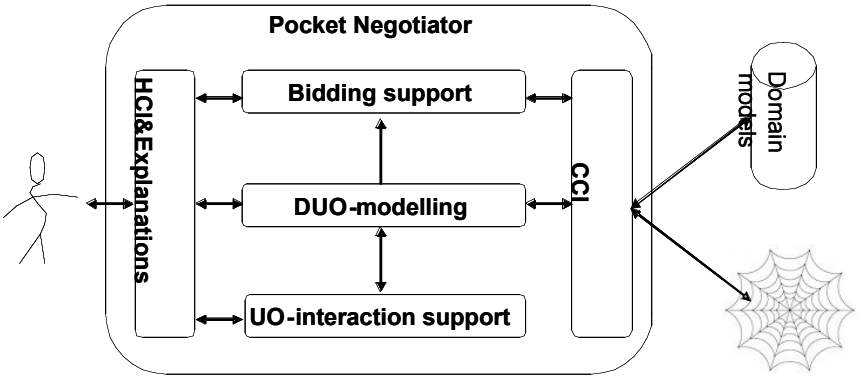

Fig. 3 Pocket Negotiator architecture

The *UO-interaction support component* assists the user in his interaction with the opponent; coping with emotions of user and opponent, offering suggestions for questions and remarks to prepare for this interaction.

The *bidding support component* provides support during the bidding phase: advising on bidding strategies, providing bid proposals, evaluating bids made by the opponent, and presenting an overview of the bidding history to get more insight in the progress (or lack thereof) of the negotiation.

Multi-modal interaction with the user for the benefit of all functionality of the PN is handled by the *HCI&Explanations component* according to his specific user requirements. This component is also responsible for offering a sophisticated explanation environment to explain the negotiation process and pitfalls, and the functionality of the PN. It also provides explanations to the user about negotiation- and conflict-handling styles, thus making the user aware of his conflict-handling style (Thomas; 1974), his mental model of negotiation (Boven, 2003), and what effects such styles can have on the other party.

Finally, interaction with other software, e.g., PNs, shared repositories of domain models, and other sources of domain information, e.g., Wikipedia, is handled by the *CCI (computer-computer interaction) component*.

2.5 Challenges

The research challenges (RC) addressed in this project are part of a long term challenge to research and develop human-machine collaborative systems to increase overall performance in which human weaknesses are covered by machine strengths, and machine weaknesses are covered by human strengths. The main research challenge addressed in this project is:

> *The research and development of human-machine collaborative systems in which the strengths of user and machine are combined, the weaknesses reduced, and the overall performance is improved. For this purpose we will devise new concepts and techniques to be integrated in a Pocket Negotiator (PN) that teams up with the user to enhance his negotiation performance.*

The main research challenges in this approach are the development of a shared generic model of negotiation, and system for user-opponent interaction support, a DUO-modelling, explanation, and, a bidding support. The shared generic model is to underlie the PN architecture and functioning, the other challenges correspond to PN components.

RC 1 Shared Generic Model of Negotiation

Our first challenge is to develop a generic model of negotiation that is shared by professional negotiators in the sense that it contains descriptions of the

negotiation process, and generic descriptions of DUO-models that correspond to human cognitive representations. We need to find techniques to construct such models by the cooperation of user and PN. Furthermore, the PN must be able to reason with qualitative specifications of the negotiation domain and preferences.

Existing negotiation support systems are based almost exclusively on quantitative models, see e.g., (Büttner, 2006; Faratin, 2001, 2002; Gutman, 1998; Hindriks, 2006ab; Hoogendoorn, 2006; Jonker; 2001, 2004; Oliver, 2005; Rahwan, 2005, 2007; Ros, 2006). Such models do not match human cognitive representations and are difficult to present to the user. The research and development of a shared generic model that is a meta-model of negotiation is expected to provide a major improvement in this regard (Brazier, 2000; Kersten, 1996). Protocols of negotiation will also have to be included in the generic model; various protocols can be found in (Rosenschein, 1994).

Existing negotiation languages and ontologies do not provide the required expressivity (Kersten, 1996; Kraus, 1998; Tamma, 2002, 2005; Wooldridge, 2000) and research on languages, such as the LeadsTo language (Bosse, 2005b) that combine qualitative and quantitative expressions needs to be continued. Furthermore, work like (Boutilier, 2004; Hindriks, 2007a) must be improved by allowing the user to determine the complete structure of the DUO-models: adding, changing, deleting parts of the qualitative and quantitative information structure, while still respecting the backbone specified by the meta-model. Finally, the reasoning involved in bidding heuristics has to be able to cope with incomplete information of quantitative and qualitative form (Meyer, 2004; Kraus, 2001; Lin, 2006; Section 4f).

RC 2 User-Opponent Interaction Support for Negotiation

Our second challenge is to develop a knowledge-based system as part of the PN to support the user in his interaction with the opponent. To meet this challenge a number of problems must be solved: user awareness of the role of emotions and conflict handling styles in negotiations, emotion elicitation, determination of conflict handling styles, and linking emotions to core concerns, and conflict-handling styles to produce advice.

Negotiators should be aware of the role emotions, moods, and interaction play in negotiation (Fisher, 2003; Kleef, 2004; Steinel, 2006; Thompson, 2005). The challenge is to devise a system that successfully makes users aware of this role. Since the literature does not agree on what the "best" way is to negotiate, see (Lewicki, 1992) for an overview, we need to research ways to effectively present the different models of conflict handling and interaction in negotiation to the user. The system needs to incorporate general knowledge about emotions, coping styles and mental models. Emotions or moods, for example, are triggered by a conglomerate of factors such as situation, context, interaction with other people, and physical state, see, e.g., (Frijda, 1993; Ursin, 2004). Successful behavioural responses grow into coping styles (Folkman, 1990; Lazarus, 1984) of that individual. The way people interact with each other and cope with emotions in a negotiation context depends on their mental model of negotiation, and their coping- or conflict-handling style. Regarding *mental* models (Gentner, 1983; Johnson-Laird, 1983) of negotiation, five distinct styles have been found (O'Connor, 1999; Thompson, 2003) that directly affect negotiation performance (Boven, 2003). Having one system in which all such knowledge resides, would already support the user in his corrective processes (Kahneman, 2003), thus preventing mental errors.

Another challenge is that the system needs to be able to elicit information from the user on the emotional state of both the user and the opponent. State of the art techniques in extracting emotion from visual images or spoken

dialogue (Chen, 2000; Devillers, 2003; Rothkranz, 2004; Truong, 2007) should be tested on their technical and ethical applicability for real negotiations, and for training situations. Furthermore, the user can use time-outs in the negotiation to reflect on the situation using emoticons (Desmet, 2002) to indicate his emotions and those of his opponent.

Tools and techniques need to be devised to elicit information from the user on the conflict-handlings styles of both parties (Thomas, 1974), and on the mental model of negotiation of the user (Thompson, 2003).

Finally, the system is to link emotions of the user and the opponent to core concerns (appreciation, affiliation, autonomy, status, and role), following Fisher and Shapiro (2005). This knowledge is to form the basis of a tool that provides general coping advice that fits the profile of the user and is relevant for the situation the user is in.

RC 3 DUO-modelling and Explanation for Negotiation

Our third challenge is the development of human-computer interaction tools and techniques to elicit the DUO-models of negotiation. Furthermore, a method needs to be researched and deployed to explain the negotiation process and PN's functionality.

The shared generic (meta-)model of negotiation of RC1 can be used to guide the process of elicitation, in such a way that the DUO-models match the individual's cognitive model of the negotiation. A model satisfying this requirement is called a shared model (Bosse, 2006a; Brazier, 2000; Swaab, 2002); shared by user and PN. State of the art elicitation techniques will be used and improved (Anthony, 2005; Boutilier, 2006; Brazunias, 2007; Chen, 2004; Dastani, 2005; Filatova, 2006; Fransella, 2004; Hao, 2002; Hindriks, 2007a; McTear, 2002; Miliner, 1996; Ludford, 2007; Reithinger, 2000; Wolf, 1996). Taking the frame of reference theory into account (Clancey, 1989), DUO-models need to contain descriptions from different perspectives, see e.g., (Albers, 2004; Easterbrook, 1993). Recommender technology will be used to present examples of models to the user that might already be close to his ideas (Burke, 2000; Chen, 2005; Linden, 2003; Queiroz, 2007; Schafer, 2001). The interfaces will be developed using state of the art techniques, see e.g., (Oviatt 2003; Preece, 2007; Shneiderman, 2005; Wahlster, 2001, 2006).

Existing literature on explanation systems and shared task models (Alessi, 2001; Bosse, 2006b; Brazier, 2000; Jonker, 1998) provides adequately guidelines and methods to develop the explanation component. The challenge is to integrate in one explanation component all aspects of negotiation, for example, also the elements developed to meet challenge RC 2 and RC 4. An associated research question is: Does the use of an animated character to do the explanations induce trust in the PN more than other techniques? The literature offers enough guidelines to set up experiments to answer this question (Bickmore, 2001; Castelfranchi, 2003; Chen & Pu, 2004; Lee, 2007; Pu, 2006; Reeves, 2003). The applicant's interest and experience in modelling trust will be put to good use; see Section 2.f.

RC 4 Bidding Support

To properly assist the user, the PN has to be able to give runtime advice on bidding strategies, on the quality of bids received from the opponent, on possible counteroffers that the user can make, on whether to accept an offer, to walk away, or to continue with the negotiation. Essential in this process is giving the user insight in the bidding history and a prognosis of future developments, see e.g., (Kersten, 1996; Monzani, 2004). Fundamental questions underlying these issues refer to the research into computationally efficient bidding

strategies that lead to win-win outcomes and cannot be exploited by the opponent (see e.g., Gutman, 1998; Jonker 2001, 2004; Klein, 2003; Ludwig, 2006), the research in this area is ongoing. Also techniques must be improved to reduce the complexity of the negotiation space while maintaining accuracy in bidding (Hindriks, 2006ab). Heuristics must be developed for runtime estimation of the Pareto-efficient frontier and efficient outcomes, such as Nash, Kalai-Smorodinski (Raiffa, 1982, 2002). So far, the computational complexity of these questions has not been tackled. Research and development of evaluation tools and techniques for the analysis of the dynamics of negotiations must continue (Bosse, 2005a, 2007; Hindriks, 2006b, 2007ab; Jonker, 2001, 2004, 2005ab; Kersten, 1996; Monzani, 2004). Through on screen visualisation the PN enhances the user's awareness of the negotiation space, potential strategies, and the interests of the opponent (Card, 1999; Dürsteler, 2002; Harris, 1999; Monzani, 2004; Spence, 2007; Tufte, 2001). Many questions remain in this area especially the relation between the bidding process and the negotiation outcome, still remains unclear. The random bidding strategy (Hindriks, 2007b) is socially unacceptable, but its outcome performance and its computational efficiency are rather good.

Any-time bidding heuristics need to be developed that can work with incomplete and quantitative and qualitative information. Exisiting constraint satisfaction techniques will be applied. Tools and techniques must be created to assist the professional user in selecting an appropriate bidding heuristic and to fine-tune that heuristic to his liking.

3 Approach

The approach to the PN follows an iterative process of research in which an artefact is specified in ever increasing level of detail and specifications are assessed and in a next iteration refined, tested, and adjusted or extended. Starting with the shared generic model of negotiation and the necessary studies for supporting user-opponent interaction in the context of the case studies, the basis is laid for an incremental development of the negotiation language and engine, the bidding support, and the elicitation techniques for DUO-models, emotions, and conflict-handling styles. Only by addressing these problems in conjunction can the necessary intelligent interaction of the PN be accomplished.

The basis of this approach originates in the 1980's to improve computer-supported task performance by increasing insight in the cognitive factors of human-computer interaction (Hollnagel and Woods, 1983; Norman, 1986, 1988; Rasmussen, 1986). Due to the adaptive nature of both the human and machine behaviour in human-machine collaborative systems, it is difficult to provide generic and detailed predictions on the overall human-machine performance. Therefore, Neerincx & Lindenberg (in press) developed a situated cognitive engineering method that adds a technological perspective to the classical human perspective in User Centred Design (Maguire, 2001). First, the technological perspective sets a focus in the process of specification and generation of feasible collaboration concepts. Second, the reciprocal effects of technology and human factors are made explicit and are integrated in the development process. Scenario-based design and test methods are being used to address actor's goals and the context of operation (Carroll, 2000). With Wizard-of-Oz techniques (in which a human "simulates" some machine functions), human-in-the-loop evaluations can be used to study design concepts in an early phase and to incrementally implement support functions in a cost-effective way (Neerincx, 2006). Game-based evaluation techniques can be used to immerse such users in a realistic usage context (Smets, 2007).

This way the PN will be developed and evaluated in the context of two case studies: labour agreements, and real estate (Deluca, 2007). Experts are available for interviews (both for knowledge elicitation, and validation purposes), see utilisation paragraph. Praction (consultants and trainers in negotiation) provides the training environment in which the PN is devised and used by trainees. The domain analysis of the case studies is shared amongst the four projects. The predominant case study of a project will serve to research theory and technology, the second case study serves as a fresh test bed for theory and technology. The scenarios collected in the various projects are available to all projects.

Strong emphasis will be placed on user empowerment by providing an intuitive user interface based on a direct manipulation interaction style, e.g., following as natural design metaphor the stages of Fig. 1, and using graphical user interface (GUI) elements, such as sliders, menus, spreadsheets, and graphs (see e.g., Card, 1999; Dürsteler, 2002; Harris, 1999; Monzani, 2004; Spence, 2007; Tufte, 2001). Users will be able to change default settings, which the PN will instantly process and afterwards feedback to the users in real time. Avatar technology will be tried to guide novice negotiators through the functionality of the PN (Dehn, 2000; Prendinger, 2003, 2005). As utility is paramount the PN's usability will be designed according to the ISO 9241-11 standard by following a user-centred design approach that actively involves potential end-users in the design of the PN's user interface. Especially the formative and to some extent the summative usability evaluation method will be applied to inform the development process and measure progress.

4 Innovation

The Pocket Negotiator project opens up a new line in intelligent support systems in which human weaknesses are covered by machine strengths and vice versa, in particular a Pocket Negotiator. For this purpose the project will contribute new concepts, techniques, and methods for the development of such innovative human-machine collaborative systems. Humans and computers have to some extent complimentary capabilities for negotiation. In my opinion this implies that tasks should be divided over humans and machines in a way that respects those capabilities. Humans understand the context and the emotional fluctuations in human-human interaction, they are capable of finding new relations between concepts, and they have the necessary background knowledge to interpret the domain of negotiation with respect to their own preferences. Humans can be troubled by emotions, and have difficulty with handling the complexity of negotiation spaces. For computers it is almost the other way around, although the computer can be provided with extensive knowledge on specific topics, and are capable of searching through huge amounts of data.

To allow human and support system to cooperate at the required level of competence, they need to share an abstract model of the task at hand (negotiation), and they need to share detailed models of the domain of negotiation (e.g., real estate), the user model, and the opponent model. Such models can only be shared if they reflect the cognitive models of humans. Research has shown that quantitative models do not reflect the cognitive models. The cognitive models are much more qualitative of nature. The models designed in the project will properly reflect the cognitive models including qualitative and quantitative aspects, and can thus be shared with the user.

An important innovation is that the Pocket Negotiator has the technology to share that generic negotiation model with the user. From then on, system and user share the responsibility to create shared content models of the negotiation at hand. The generic negotiation model prescribes the general structure of the

content models. The detailed structure of the DUO-models that are part of the instantiated models can change over time. This means the PN provides the technology with which the user can rearrange the relations within the model at any time. The technology to still analyse the ongoing negotiation and provide bidding advice will be new and set a trend in software negotiation literature.

The methods and technology developed to produce the PN is already set out to be used in other domains than negotiation. Some perspectives are presented in the utilisation paragraph.

The PN brings together decision theory and social and cognitive science in a PN on a hand-held device that supports human negotiators. The timing for such a device is right: the advance of internet, hand-held devices (organiser, palm computers, mobile phones), but also laptop computers is such, that practically every adult is equipped with several of such devices and Internet.

5 Plan of work

The four research challenges RC1 – RC4 laid out in Section 2a.4 are addressed in four projects: shared generic models of negotiation, user-opponent interaction support, DUO-modelling and explanation, and tackling the satisficing problem. The projects are cross-linked in terms of scenarios shared, joint responsibility for the design and execution of some of the experiments, and in the use in projects of tools and techniques developed in other projects.

The applicant's main task will be to guide and research the theoretical framework of the various projects and coordinate the activities of all projects.

Project 1: Shared Generic Model of Negotiation

Project 1 focuses on the development of a shared generic model of negotiation. The research challenges addressed are:

- **Negotiation Language** (Years 1, 2, and 3). The development of a qualitative and quantitative formal negotiation language – suitable for the specification of the partial DUO-models, the negotiation history, *constraints*, and the distinction between *negotiation issues* (negotiated at the table) and the *underlying interests* of the negotiator.

Approach: An incremental situated cognitive engineering design approach is followed that matches progress in the development of the negotiation engine and the progress in project 3 in the development of the elicitation techniques. The language will be designed using aspects of qualitative decision theory, existing work on the ontologies and models for negotiation, constraint satisfaction languages, and existing languages that incorporate both qualitative and quantitative aspects. The cognitive engineering approach including interviewing negotiation experts will ensure that the language contains all aspects with the cognitive representations of experts can be matched.

Deliverables: a formal negotiation language allowing for qualitative and quantitative information, and allowing for incomplete and uncertain information.

- **Negotiation Engine** (Years 3 and 4). Develop methods and techniques to be used by the PN to reason with constraints, and with incomplete and uncertain information specified in both qualitative and quantitative ways. Specifically for negotiation: The development of a negotiation engine that is able to process specifications made in the negotiation language to support all negotiation stages from a content perspective.

Approach: Incremental design of a negotiation engine that is able to compute with the (incrementally) designed negotiation language. The development of the system will be done in close cooperation with project 3 (DUO-modelling) to coordinate the implementation activities. The engine facilitates reasoning about the domain and preference elicitation process, suggests exploratory activities

with the opponent to fill in missing information, and proposes bids. Findings about typical profiles (cf. recommender systems) gathered experimentally in the real estate domain will also be used to predict user preferences. The adequacy of such techniques will be validated experimentally in the real estate domain.
Deliverables: a negotiation engine that underlies the content manipulation of the PN.

- **Effectiveness of the PN: Shared Model** (All years). The PN is designed with the aim of improving the quality of the negotiation process and outcome. Determine the effectiveness of the use of PN to explain the negotiation process and the effectiveness in creating shared model of negotiation between user and PN, and between user and expert. Research the criteria, methods, and techniques to answer these questions.

Approach: In close cooperation with project 2 the necessary criteria, methods and techniques are developed. Experiments are held to test the effectiveness of the PN. Subjects are experts and laymen, the domains vary over real estate, collective job contracts, and a new domain on which the PN has no prior information. Vary over including/excluding training sessions in the preparation stage.
Deliverables: an assessment of the effectiveness of the PN and its subsystems.

- Supervision: applicant and Dr. Hindriks.

Project 2: User-Opponent Interaction Support in Negotiation
The research challenges addressed in project 2 correspond to those laid out in RC2: the design of a knowledge-based system to support UO-interaction in negotiation.

- **Emotions: User awareness & Elicitation** (Year 1 and 2) Determine the emotions and moods that significantly influence the negotiation and its outcome. Determine what core concerns (sources) of the negotiation process can influence negotiation relevant emotions or moods. Develop techniques for the PN to make the user aware of the role of emotions in negotiation. Develop a suitable tool and technique to determine the User and Opponent emotions and sources thereof during and after negotiations?

Approach: The key emotions and their sources will be determined by literature review (see section 2a.2), observation of experiments, and interviews of laymen, experts, and trainers. Design and validate an emotive model for negotiation in which emotions are related to probable sources. By a review of the existing techniques in literature, and by first conducting Wizard-of-Oz experiments, develop suitable tools and techniques to ascertain User and Opponent emotions and their probable sources, and to explain them to the user.

All experiments will be designed and executed in the real estate domain in close cooperation with project 1 and 3. In the experiment a clear separation is made between expert negotiators in the domain of their expertise (realtors on real estate), experts for whom real estate is not their speciality, and laymen in negotiation.
Deliverables: an emotive model that relates negotiation relevant emotions to concerns and effects, a tool and technique to establish user's and opponent's emotions and sources during and after emotions, ways to make user aware of the role emotions as part of the explanation module of the PN.

- **Conflict Handling Styles: User Awareness & Determination** (Year 2) Design a successful way for the PN to make the user aware of the effect on negotiation of different conflict handling styles (Thomas, 1974; Kilmann 1977, Rahim, 1983) and mental models (Boven, 2003) in

negotiation. The Thomas-Kilmann Instrument (1974) is an excellent way to determine the conflict-handling style of the user, but it takes some time. In the context of negotiation: how can the PN assist the user in quickly estimating the conflict handling styles of himself and his opponent? Do we need the full Thomas-Kilmann Instrument?

Approach: To determine the best way to make the user aware of how his way of interacting and handling influences the negotiation a number of convincing and simple examples will be devised for each of the conflict-handling styles, and each of the mental models. Wizard-of-Oz experiments will be conducted to establish whether the user needs to be aware of both conflict-handling styles and mental models, and to establish the most effective way to present the examples to the user of the PN. Cartoons, see e.g., Fig 3, or a story-based approach are possibilities.

Deliverables: Instruments to estimate the conflict-handling styles and mental models of negotiation of both User and Opponent, tools for the PN to explain conflict-handling styles and mental models of negotiation.

- **Coping with Emotions** (Year 3 and 4) For the purpose of negotiation, what advice is applicable for the human negotiator to cope with his emotions and those of his opponent? On the basis of rough indications of the emotions and conflict-handling styles of User and Opponent, and User's estimation of the source of these emotions, develop a knowledge-based system to advice the user on a coping and interaction strategy.

Approach: By literature review, observation of training sessions and interviewing trainers a set of mappings is made from the emotions of User and Opponent, their conflict-handling styles, and the source of the emotions to a set of advices for coping and interaction. The results of the other subprojects are used here. The set of mappings will be ordered on the basis of their appropriateness. The appropriateness is established by interviewing trainers and measured and adjusted in experiments.

Deliverables: a knowledge-based system that advises on coping strategies and interaction for negotiation.

- **Effectiveness of the PN on U-O emotion and U-O interaction** (all years) The PN is designed with the aim of improving the quality of the negotiation process and outcome. Determine the effectiveness of the PN in this regard. Does it significantly reduce arousal? How does the user appreciate the PN emotionally? What is the level of engagement with and without the use of a PN? What is the social acceptability of the PN's functions? How does this depend on the social agreements, such as the protocol, made beforehand? Research the criteria, methods, and techniques to answer these questions.

Approach: Both objective and subjective measurements will be made. The quality of the negotiation process and outcome as far as rational aspects are concerned is established by and using the criteria and technology developed for the PN in project 4. To determine the effectiveness of the PN on emotional aspects the participants will be observed and video-taped. Afterwards the participants will be asked to look at the negotiation and assess their cognitive task load and their own emotions (Streefkerk, in press). The different assessment methods of the effectiveness of the PN will be applied in sets of experiments that will be designed and executed in close cooperation with all other projects. The experiments will be balanced with respect to use of PN, level of expertise of the participants, and both in the context of real estate and collective job contract negotiations.

Deliverables: Criteria, techniques, and methods for assessing objective and subjective effectiveness of negotiation support systems, an assessment of the

effectiveness of the PN and its subsystems.

- Supervision: applicant, Dr. Brinkman, and Prof. Dr. Neerincx.

Project 3: DUO-modelling and Explanation for Negotiation

Project 3 focuses on the development of techniques and tools to instantiate the general qualitative model with respect to the domain models, to explain negotiation, and to explain the PN functionality. The research questions addressed are:

- **Elicitation Techniques and Tools** (Year 2 and Year 3). Development of series of interactive techniques that enable the PN to create, in dialogue with the user, the negotiation model (consisting of DUO-models and negotiation history).

Approach: In close collaboration with project 1, user-centred design methods are applied to develop and compare a series of interaction techniques on their user experience and usability to determine which tools and techniques can best be implemented in the PN. Observations and interviews of expert negotiators and trainers, task analysis, and use-case analysis will provide the requirements for the elicitation techniques. By way of Wizard-of-Oz experimentation existing knowledge engineering and preference elicitation techniques will be tested for usability. The techniques should allow for a gradual integration of qualitative statements provided by humans. The emphasis will be on handling *incomplete or partial* negotiation information, since negotiators typically are able to express only incomplete information on issues and their preferences. Recommender technology will be used to speed up the elicitation process. Exploration of tools and techniques through Wizard-of-Oz experiments is done in Year 2. The best techniques are implemented and tested in Years 2 and 3.
Deliverables: evaluated elicitation techniques and tools for the PN.

- **Real-estate scenarios** (Year 3). Design of a set of real-estate negotiation scenarios to serve as test sets in experiments, and for creating the default settings in the DUO-modelling task covered together with project 3.

Approach: The set of scenarios is elicited by observation of training situations, and by interviewing realtors, and trainers in negotiation.
Deliverables: real-estate negotiation scenarios.

- **Explanation of Negotiation and PN functionality** (Year 4 and 5).

Approach: A user-centred approach will be used to design an animated character to explain to the user the negotiation process and the functionality of the PN. Conceptual designs will be tested in Wizard-of-Oz experiments. Implementation will be done in cooperation with the programmer.
Deliverables: An explanation component including an animated character

- **Effectiveness of the PN: DUO-modelling & Explanation** (All years). The PN is designed with the aim of improving the quality of the negotiation process and outcome. Determine the effectiveness of the PN with respect to the elicitation techniques. Develop criteria and methods to establish whether or not the models constructed models are shared by PN and user. Design criteria and methods to establish the effectiveness of an animated character to explain the negotiation process and the functionality of the PN induce trust.

Approach: In close cooperation with project 4 and according to the criteria, techniques and methods delivered by project 2 experiments are held to test the effectiveness of the PN. Subjects are experts and laymen, the domains vary over real estate, collective job contracts, and a new domain on which the PN has no prior information. Vary over including/excluding training sessions in the preparation stage.

Deliverables: an assessment of the effectiveness of the PN and its subsystems.

- Supervision: applicant and Dr. Rothkranz. The PhD candidate will spend the last half year on writing the PhD thesis.

Project 4: Bidding Support

Project 4 focuses on the satisficing problem (Simon, 2005) with an emphasis on overcoming the lack of computational power of humans when bidding in complex negotiation spaces. More detailed research questions addressed in this project are:

- **CAO-scenarios** (Year 2). Development of a set of collaborative job contract (Collectieve ArbeidsOvereenkomst in Dutch) scenarios to serve as test sets in experiments, and for creating the default settings in the DUO-modelling task.

Approach: The set of scenarios is elicited by observation of training situations, and by interviewing experts in collaborative job contract negotiations, and trainers in negotiation.
Deliverables: collaborative job contract negotiation scenarios.

- **Evaluation of Bids** (Year 2). Determine the best ways to visualize bid evaluations, and bid proposals. Devise methods, tools, and techniques for the PN to effectively provide explanations of this information.

Approach: A user-centred design strategy is used to develop techniques for visualization (Card 1999; Spence, 2007; Swaab, 2002; Tufte, 2001) of bid evaluations, and bid proposals (Bosse, 2005a; Hindriks, 2007; Jonker, 2004; Monzani, 2004, Raiffa, 2002). Wizard-of-Oz experiments are used to select the best options. The best options are implemented and tested in an experiment.
Deliverables: A set of tools and techniques for the PN for the visualization and explanation of bid evaluations, and bid proposals, and a first assessment thereof.

- **Negotiation progress** (Year 3). Develop a set of tools and techniques to visualize the negotiation progress in terms of negotiation history, and bidding progress with respect to estimated Pareto-Optimal frontiers, and well-known efficient outcomes, such as Nash Product, Kalai-Smorodinski Point. Devise methods, tools, and techniques for the PN to effectively explain of this information and the effect of the bidding process on the negotiation outcome. Research theories and formal properties to evaluate the bidding history in relation to the bidding outcome.

Approach: A user-centred design strategy is used to develop techniques for visualising the negotiation progress (Card 1999; Monzani, 2004; Spence, 2007; Swaab, 2002; Tufte, 2001). The existing formal analysis techniques of negotiation dynamics (Amgoud, 2005; Bosse, 2005a; Hindriks, 2007; Raiffa, 2002) are extended and combined with results on the effectiveness of mental models (Gentner, 1983, Johnson-Laird, 1983) of negotiation (Boven, 2003; Saba, 2002; Swaab, 2002). Wizard-of-Oz experiments are used to select the best options. The best options are implemented and tested in an experiment.
Deliverables: A set of tools and techniques for the PN for the visualization of negotiation progress, and a first assessment thereof.

- **Any-time bidding heuristics** to be used by the PN (Year 4 and 5). Devise or select existing any-time bidding heuristics for the PN that respect the requested negotiation style of the user, and that are capable of working with incomplete information, updates and qualitative models. Bidding heuristics are parameterised in several ways. Devise ways for the user to select appropriate bidding heuristics and fine tune these to his wishes.

Approach: Continue a tradition of work in the development of effective bidding heuristics (Büttner, 2006; Faratin, 2001, 2002; Gutman, 1998; Hindriks, 2006ab;

Hoogendoorn, 2006; Jonker; 2001, 2004; Oliver, 2005; Rahwan, 2005, 2007; Ros, 2006). For the best existing heuristics, adapt them for qualitative negotiation.

Test the acceptability and performance of the best strategies in experiments in which the PN assists the user in a negotiation against either a software agent or a human negotiator. Vary over expertise levels of the human negotiators.
Deliverables: A set of bidding heuristics, and a first assessment thereof, a negotiation test bed.

- **Effectiveness of the PN: Satisficing** (all years). The PN is designed with the aim of improving the quality of the negotiation process and outcome. Determine the effectiveness of the PN with respect to the visualization tools for negotiation progress, bid evaluation and bid proposals. Research criteria and methods to establish the effectiveness of the PN in terms of negotiation outcome and bidding process.

Approach: See project 3.
Deliverables: an assessment of the effectiveness of the PN and its subsystems

- Supervision: applicant and Dr. Hindriks. The PhD candidate will spend the last half year on writing the PhD thesis.

Supervision and coordination

The PN team will consist of the newly hired personnel, the programmer, the additional supervisors, and me. For the PN team I will organise weekly progress meetings, and literature meetings. I will form a larger team to include personnel from the contributing partners. To start the project I will organise a coordination meeting with the larger team. Such coordination meetings will be held at least twice per year. During these meetings the advances in information, theory, and technology of the previous period will be discussed and the work for the next period will be coordinated. The complete user committee will meet at least once per year.

To coordinate the programming activities, I will assign my group's programmer the task of integrating all results in one application that is incrementally growing into the PN. Furthermore, the programmer will design and implement an extension of the existing test beds (Bosse, 2005a; Hindriks, 2007) to form a negotiation test bed for simulated competition of bidding heuristics. He will add the case study domains to that test bed and integrate tools for negotiation analysis, and an interface to the PN allowing human players to play against software agents.

The proposed research will be conducted within the Man-Machine Interaction group, and in close cooperation with our partners (see utilisation paragraph), who will serve as advisors. My expertise in developing shared task models, modelling human reasoning processes, and developing design methods, and software environments will be essential for all subprojects. My experience in solving the satisficing problem for negotiation will be of the essence in subproject 4. My experience in teaching, promotional activities, and designing explanation systems will ensure that the complex concepts underlying negotiation will be translated effectively for the layman and the professional. My reputation and my international contacts in science and companies provide me with the backup from society necessary for such a project, see the utilisation paragraph.

The PN project is in the heart of the research interests of my research group. Its internationally renowned staff consists of Prof. Heynderickx (perception, experience evaluation), Prof. Neerincx (situated cognitive engineering), Dr. Brinkman (human-computer interaction, experience evaluation), Dr. Hindriks (negotiation, agent technology, decision support systems), Dr. Oomes

(perception, collaborative systems), Dr. Rothkranz (emotion detection, multi-modal interaction), and Dr. Wiggers (emotion detection, multi-modal fusion). The research fits within the EWI research focus DRC-ICT Intelligent Systems and the research school SIKS. The group is innovative in the combination of human-computer interaction, technical artificial intelligence, and cognitive science towards one common goal of engineering experience. There are some labs that combine some of these experts and methods (Prof. Nijholt's group in Twente, Prof. Bouwhuis' group in Eindhoven, and Prof. Stasko (at Georgia Tech), but few research groups combine all three lines of research.

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7 Utilisation paragraph

7.1 The problem

In all areas of life and business, whenever decisions have to be made for which one is dependent on others, negotiation is used to reach a common decision. With the development of information and communication technology these problems are no longer restricted to human-human negotiations, but can also encompass human-computer agent negotiations, and even pure computer agent – computer agent negotiations.

The problems of human – human negotiations and the need for systems to support such negotiations are discussed in section 2a. Aside from human-human negotiations that need support, the need for negotiation agents is growing with the advance of ICT and e-commerce. A shift is seen from pre-planned to on demand planning of production and logistics, and last minute formation of coalitions. This approach requires last minute negotiation, see e.g., (Hoogendoorn, 2006). Some of these negotiations are human negotiations, but most can and will be delegated to software agents. Delegation of negotiations to software agents requires additional research into strategic bidding heuristics. The software agents have to find good, if not optimal, solutions. They need to be robust against exploitation, meaning that their bidding strategy has to be effective against any strategy of the opponent.

All in all, to create intelligent negotiation (support) systems the following problems need a technical solution:

- Identifying, interactively constructing, and storing qualitative and quantitative negotiation models.
- Development of strategic bidding heuristics that
  - Can effectively use information on current emotions, cultural background, and conflict-handling styles of the parties involved.
  - Are robust for any strategy of the opponent.
- Developing adaptive interfaces for hand-held devices and laptops that effectively display to and elicit information from the user on:
  - The negotiation model (domain, user, opponent, dynamic model).
  - Negotiation progress: bidding trajectory placed in the estimated negotiation space with respect to the Pareto-Optimal frontier, efficient outcomes (such as Nash, and Kalai-Smorodinski).
  - Bid proposals and evaluations.
  - Emotions and interaction styles of the user and opponent.
  - Closing aspects of the deal.

Some visualisation ideas for the PN are presented in Fig. 4 and 5.

Fig. 4. Visualisation ideas for aspects of the user model. On the left: the objectives of the negotiation (house with issues: price, transaction date, and things to take over), and the relative importance (part of the preference profile) of those issues. On the right: for one issue, i.e., price, how to specify the value type and preference information for that issue.

At the end of the project the PN *can* assist in negotiations of which the domain is prior unknown to the PN. However, where possible the Pocket Negotiator will make use of (and add to) open and growing repositories of domain models. The repositories of the IntegNeg project (see end-users) will be studied and, if possible, a dedicated wrapper will make them available to the PN.

The PN can operate in two modes: Wireless Communication, or Manual. In Wireless Communication mode, applicable if both negotiators have a PN, the bids decided upon by the users will be exchanged directly between the PNs. In Manual mode the user has to manually enter the counteroffers into his PN. Depending on the number of issues at stake, an overview of the whole negotiation space is offered on one screen, or in a layering of screens that corresponds to the natural hierarchical nature of the issues (as some are more important than others).

The complexity of the negotiation domain can also require the PN to contact a more powerful machine to handle the necessary computations in time. For negotiations of the complexity of the NCF/SARA negotiation on the purchase of a supercomputer, the PN will be installed on a machine that offers more options to display material to the user, e.g., a laptop.

To qualify the effectiveness of the PN controlled experiments will be set up. These experiments will run with three groups: in the first group everyone has a PN, in the second group per pair of negotiators only one party has a PN, and in the third group no one has a PN. The usual evaluation techniques of interviewing, measuring physiological effects, as well as formal analysis will be used to ascertain the effectiveness of the negotiation and the experience of the negotiator. Logs will be made of all experimental negotiations, to extract data that can inspire new bidding strategies.

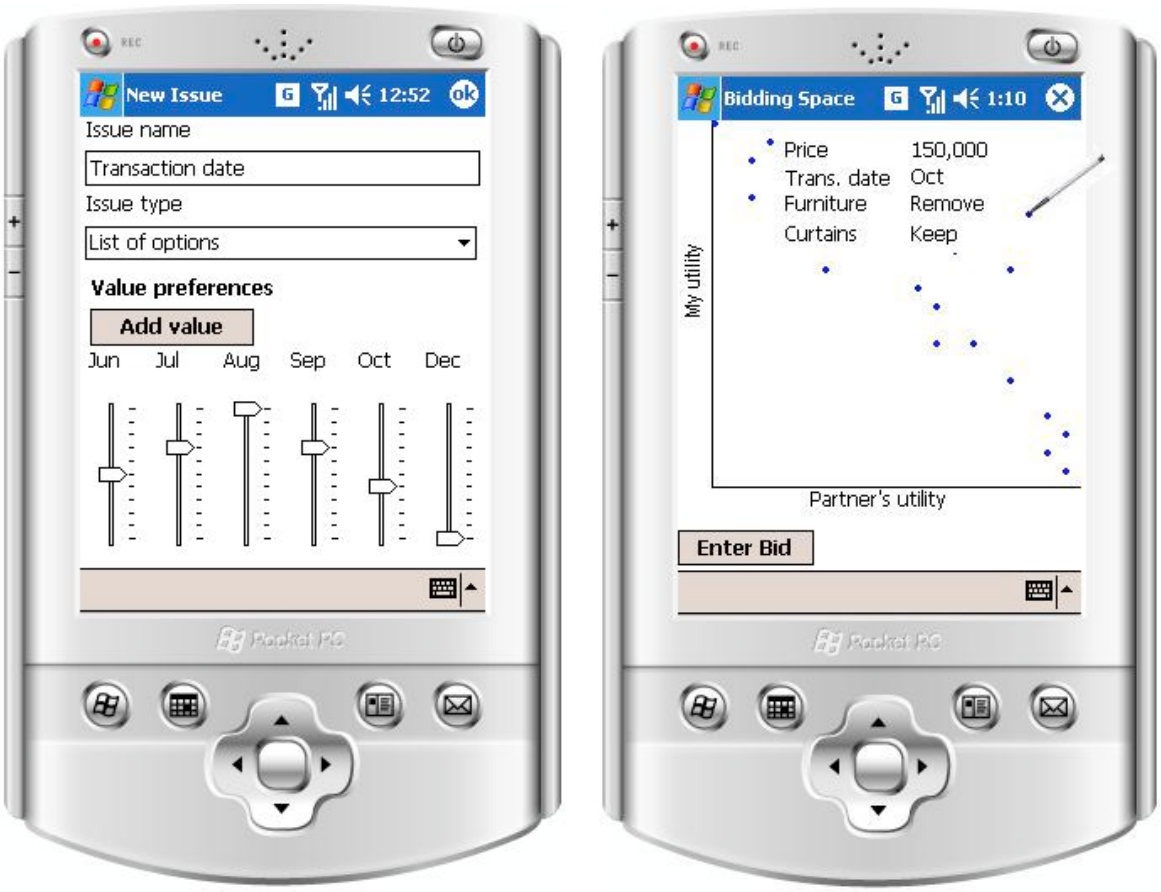

Fig. 5. Visualisation ideas for the PN. On the left: aspects of the user model; the issue transaction date, with type and values (months) and the preference for those values. On the right: the contents of a potential bid and its location (denoted by the pen) in the negotiation space (picture on the right).

To achieve effective utilisation of the new technology a number of steps have to be taken. The first is experimentation on the case studies of the project with the help op our partners (see user section). Different aspects of the PN (interactive modelling, strategic bidding heuristics, human-computer interfaces, and so) all have to be validated on standard examples for which the solution can be computed analytically, or for which detailed refined evaluation methods are available.

The next step is to try the PN on various realistic examples. The industrial partners connected to this project are capable of providing us with such examples and assisting us with their evaluation. Foremost amongst the industrial partners Almende and DECIS will support us, as they are willing to invest considerable manpower in a joint effort to get maximum results out of this project. In addition, also Seldon Systems, KPN, Thales, ForceVision, TNO, Getronics PinkRoccade, and LogicaCMG are willing to help in this phase. During this phase, the PN will be applied not only to support human-human negotiations, but also to support humans in human – computer agent negotiations, and to autonomously conduct computer agent – computer agent negotiations.

7.2 Proposed utilisation approach

Hence, the utilisation process needed will consist of the following related components:

- Validation of the various elements of the PN and of the PN as a whole on prototype test cases and realistic cases from real estate and labour agreements (NIO, Praction, FNV Bondgenoten, NCF, KPN Arbeidsverhoudingen, and the real estate brokers). The focus will be on human-human negotiations only. Human negotiations without support are logged and analysed. The same negotiations with PNs are logged and analysed. The results of the two groups are compared.
- Validation on two additional industrial test cases (negotiation to support decision making in critical situations, and negotiation in the logistics domain) provided by our collaborating industrial partners (Almende, DECIS, Seldon Systems, KPN, Thales, ForceVision, TNO, Getronics PinkRoccade, LogicaCMG). Considering human – human, but also human – computer agent, and computer agent – computer agent negotiations. Fully balanced and controlled experiments will carried out to compare results and establish the effectiveness of the PN.
- Testing on various realistic non-industrial examples for human – human negotiations (NIO, Praction, FNV Bondgenoten, the real estate brokers) and on realistic industrial examples for human – computer agent, and computer agent – computer agent negotiations (Almende, DECIS, Seldon Systems, KPN, Thales, ForceVision, Getronics PinkRoccade, LogicaCMG).

7.3 New applications

Although the main objective is to support humans in their negotiations, various interesting applications of the proposed PN technologies are envisaged for the industrial partners. The techniques developed for the PN are relevant not only for negotiation, but also for all kinds of applications involving demand and supply and decision making. Interactive modelling is necessary to elicit user and product models (demand) and to identify and model available products (supply). After matching demand and supply and selecting partners, negotiation is used to accomplish trade. Trade networks are of interest because of the repeated negotiations in such networks, in which good relationships are of the utmost importance. Repeated negotiations thus emphasize the importance of high quality opponent models and robust and adaptive strategic bidding heuristics. Specific domains that the industrial partners find of interest are: decision making in critical situation (DECIS, Thales, ForceVision, TNO), logistics (Almende), broadband communication (Seldon Systems), fast Internet access in public places (KPN), trade and business processes (Getronics PinkRoccade and LogicaCMG).

7.4 Societal effects

The PN will substantially improve the quality of the deals made in negotiations in which it is involved. This improvement is induced by the improved quality of preparation of the negotiator and the added value of proposals for offers that the PN will suggest to its user. The PN is capable of effectively searching through the negotiation space, and based on the quality of the opponent model, will suggest solutions that are to the benefit of all negotiation partners without leaving money on the table. Interestingly enough, research shows (Bosse, 2005a) that this is already the case if only one partner is equipped with a negotiation support system. The effect is more significant if both use one. The economic value is thus directly related to the number of negotiations in which the PN is involved.

From another perspective, the technology developed for the PN is key to new developments in wireless communication and the idea of a 24/7/365 economy. The capability of forming ad hoc coalitions to bring down production and transaction costs and thus prices of goods adds a new dimension to possibilities and applicability of make to order production systems. The careful and in advance modelling of domains, user profiles, and opponent profiles allows for rapid action on the dynamic opportunities brought to our attention by the ongoing implementation of the knowledge economy. This will be studied in additional case studies with our partners interested in negotiation in commercial and business processes (see below). The societal impact of this development might be more radical, since it could change the market place.

7.5 The users

The project is supported by both direct users and end-users, a complete list with addresses and other contact information can be found at the end of this section.

7.5.1 Direct users

Direct users are companies that have an interest in the technology developed in this project from their own business perspectives. End-users are grouped together according to their interest in this project: Negotiation to support decision making in critical situations, negotiation in commercial and business processes, and researchers in negotiation.

Negotiation to support decision making in critical situations

A substantial subgroup of the direct users is particularly interested in applying negotiation to support decision making in critical situations. Their combined support makes it possible to conduct an additional case study and extend the team with additional researching manpower. The additional case study will be in the security domain. The partners are DECIS, Thales, ForceVision, and TNO. The group offers:

- Researcher(s) for the additional case study, together approximately 1.4 fte* per year for the duration of the project.
- Testing our technology in the context of other projects.
- Evaluating the results of the research in terms of technical functionality and performance.
- Being members of the user committee.

• DECIS (contact: Dr. C.H.M. Nieuwenhuis)

DECIS is a research consortium that develops new concepts and technology for decision-support in multi-stakeholder processes. The contribution of DECIS will add up to approximately 1 fte per year for the duration of the project, a great contribution that enables us to perform the additional case study.

• Thales (contact: Ir.M.H.Menninga and Dr. M.A.W.Houtsma)

Thales develops high-tech Command and Control systems for security applications in which decision support systems play an important role. Thales would contribute domain knowledge and their expertise in decision support systems for the additional case study, for an estimation of 0.1 fte per year for the duration of the project.

• ForceVision (contact: MSc. R. Duell)

ForceVision develops real-time mission critical systems for security applications in which decision support systems play an important role. The contribution of ForceVision will be approximately 0.2 fte per year for the duration of the project.

• TNO Human Factors (contact: Hans Godthelp)

* Dutch term for financial technical unit for manpower

The business unit Human Factors of TNO performs research into and develops systems for decision support of humans in cognitive demanding situations. TNO would contribute their expertise in human decision making and the security domain for the additional case study, for an estimation of 0.1 fte per year for the duration of the project.

Negotiation in commercial and business processes

- Almende (contact: Ir. P. van Tooren)

The main areas of interest for Almende are the facilitation of networks (especially logistics networks), and of communication. Almende runs quite a few critical projects in logistics and incident management. We see Almende as one of our main technological partners. Almende will participate by:

- Offering a PhD student (MSc. Duco Ferro) to study the formation of coalitions through negotiation in the logistics domain.
- Offering technical assistance to optimize communication from the PN to other software and hardware devices.
- Evaluating the results of the research in terms of technical functionality and performance.

The contribution of Almende would add up to approximately 1 fte per year for the duration of the project.

- KPN (contact: Prof. dr. ir. Nico H.G. Baken)

KPN is currently investing in the future of communication and services through projects such as the Streetlights project (an initiative of the consortium Streetlight of KPN N.V., Lucent Technologies and Tyco Electronics). The consortium is convinced that offering fast Internet access in a public environment, through specially adapted electronic devices on the street (such as streetlights) is the way of the future. Our technology would enable them to offer ad hoc commercials and services that are tailored to people passing by. The interactive modelling approach of this project is an enabler of getting the user models necessary for this. Furthermore, the negotiation technology would allow the potential client to directly negotiate about the goods or services of interest.
They will contribute by:

- Testing our technology for ad hoc and personalised advertisement of goods and services and testing the PN to purchase selected goods and/or services.
- Evaluating the results of the research in terms of technical functionality and performance.
- Being a member of the user committee.

More substantial cooperation in the exploitation and commercialisation of the PN for the civilian user is being considered.

- LogicaCMG (contact: M. Konijn)

LogicaCMG Offers ICT services, consultancy, and software systems to support business processes. Negotiation is a major activity for all her clients. They will participate by:

- Evaluating the results of the research in terms of technical functionality and performance in a real-life situation for one of their clients.
- Being a member of the user committee.

Their contribution would add up to several man-months during the project.

- Getronics PinkRoccade (contact: Dr. T. Chang)

Getronics PinkRoccade develops ICT solutions in which markets and business processes take a central place. From this perspective GetronicsPinkRoccade value the development of the PN and all enabling technology as a facilitator for the coordination of business processes and to support trade for their clients. They will participate in the user committee.

- Seldon Systems (contact: J. L. Burgett)

Seldon Systems provides software products and services used by more than a hundred cable, DSL, and wireless communication operators along with millions of their subscribers. They aim to use our technology in the management of complex emergency and standby power requirements across operational networks. They will contribute by:

- Testing our technology for management of power requirements.
- Evaluating the results of the research in terms of technical functionality and performance.
- Being a member of the user committee.

Researchers in negotiation

- InterNeg Research Centre (contact: Prof. Dr. G. E. Kersten)

The centre is an international research group for the development of negotiation support systems. It consists of researchers having a keen interest in this project. Their contribution lies in discussing and commenting on our work. The budget has an entry for travelling and subsistence that enables us to go to and/or organise workshop in which the progress can be discussed.

7.5.2 End users

End users are those individuals or institutions that can use the PN in their line of work or for their own ends as civilians. End-users are grouped together according to their role in this project: negotiation trainers and negotiators for various domains, specialists in labour agreement negotiations, specialists in real estate negotiations, and non-specialists in negotiation.

Negotiation trainers and negotiators for various domains

- Praction (contact: M.A.M. van Gurp)

Praction is a company specialised in management, commercial, and communication training. Praction would contribute by offering:

- Practical training cases and an environment to perform controlled experiments.
- Trainees to test the PN in training situations.
- Their expertise in negotiation, thus contributing to the development and design of the PN.
- To serve as a member of the user committee.

The contribution of Praction would add up to approximately 0.2 fte per year for the duration of the project.

- The Stichting Nederlands Instituut voor Onderhandelen (NIO) (Contact: Mr. J. Meijer)

The NIO supports research on negotiation and asked me to share the applicant's expertise and research as their primary knowledge partner. NIO sees the development of negotiation support systems as a fundamental contribution to their first objective, i.e., the development of knowledge, insight and skills in negotiation. A dynamic system based on behavioural as well as cognitive insights will increase our understanding of the role that various factors play in reaching a negotiation outcome. The PN would be a useful tool for anyone entering negotiations. Given that the PN would lead to more efficient outcomes for both parties, the economic and societal impact will be very significant.
The NIO contributes by offering experts in negotiation that would:

- Lend their expertise in the development of the PN and test it.
- Evaluate the results of the research in terms of functionality and performance from a human perspective.
- Be a member of the user committee.

- Rechtbank Rotterdam (Contact: Mr. F.A.M. Veraart). Judge Veraart would appreciate a tool such as the PN to assist in finding the settlements for conflicts appearing in court. She is willing to give advice and serve on the user committee.

Experts in negotiation about labour agreements

- Julicher en Meijer, solicitors (contact: Mr. J. Meijer)

This company is specialised in judicial aspects of labour agreements and will share their expertise in these matters. In their experience negotiation solves most conflicts.

- FNV Bondgenoten (contact: A. Jongbloed)

FNV Bondgenoten is specialised in negotiating collective labour agreements. They offer to provide the project with a practical case for the evaluation of the PN and will serve as a member of the user committee.

- KPN Arbeidsverhouding (contact: R. van Hattem)

As managers of human resources for KPN, they are often involved about negotiations for labour agreements, both on the individual level as well as for the collective. They are willing to serve as a member of the user committee.

Experts in negotiation about real estate

- Hans Janssen Makelaars (contact: J.H. van Kampen)
- 2VM Makelaars (contact: Bernd Rottgering)
- De Witte Garantiemakelaars (contact: Ferry Nefkens)

As real estate brokers these companies negotiate on real estate property on a daily basis. They are willing to serve as members of the user committee.

Non-specialists in negotiation

- National Computing Facilities (contact: Dr. P.J.C. Aerts)

The National Computing Facilities (NCF/NWO) and SARA suggested that the applicant would assist them during their negotiations for a new supercomputer with some computer manufacturer. The domain, user, and opponent models created by the applicant, her team, and NCF/SARA were instrumental during various points in the negotiation. The complexities of the domain are such that negotiations without some form of computer support are out of the question. The models were created manually. It was interesting to see that both parties (NCF/SARA versus computer manufacturer) regularly consulted with their laptops before replying on bids. Furthermore, the negotiation took several months, enabling both parties to adapt their models and do their computations.
NCF is interested in continuing this cooperation by contributing:

- Practical cases from their area of expertise (such as negotiating about a supercomputer)
- As a member of the user committee.

7.6 Implementation

The implementation of the PN will be platform independent and based on Java, Jess and the agent platform JADE. Current versions of our negotiation bidding engines are based on Java and DESIRE (Vrije Universiteit Amsterdam). De implementation process will be largely performed by the scientific programmer of the MMI group in about 50% of his time. The PN will be developed for use on hand-held devices, and other computers (laptops included).