Agent Support for Collaboration in Complex Deliberative Dialogues. (Extended Abstract - PhD Thesis)

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1. INTRODUCTION

Organisations often form collaborative teams for sharing knowledge and resources in order to accomplish complex tasks. For example, a team involving non-governmental organisations, civil and military institutions may be formed rapidly in response to humanitarian crisis. In another context, a company may collaborate with a team of service providers in fulfilling its requirements. Collaboration enhances the capabilities of individuals. However, working in a team requires a great effort from the individuals to overcome to differences in, for example, knowledge, instruments, and culture. Incompatible objectives in addition to internal policies increase the complexity of cooperation in decision-making. For effective teamwork, team members engage in discussion to agree on a common plan of activities, but often positive outcomes are hampered by conflicts of opinion among partners on the way to proceed. Software agents, employing mechanisms that support a discussion regarding a shared plan, have the potential to facilitate conflict resolution among partners. We believe that the use of argumentation-based models to support dialogues would aid team members to identify effective justifications and more favourable agreements.

Recent work on argumentation for deliberative dialogues in multi-agent system has shown that argumentation is a promising approach for generating consistent collaborative plans [1, 2]. On the other hand, some earlier research has exploited agent support for policy advice in producing more cost/time efficient plans within a team planning context [7]. This existing research, however, does not adequately address the requirements of applications where agents are concerned with agreeing interdependent plans. For example Atkinson and Bench-Capon [1] present an argumentation-based dialogue for practical reasoning based on argumentation schemes where agents focus on the discussion of what is possible and justified in a shared plan with a common objective, according to values or costs. In contrast, in this research we explore what is possible when agents elaborate individual plans for achieving different objectives where only some activities require cooperation. Furthermore, plan constraints are not sufficiently expressive for describing the reasons for adopting a certain plan. A team member may have internal regulations such as norms which will forbid (or oblige) them to perform an action in the plan. Argumentation for norm adoption has been considered in Oren et al. [5], but in our research the goal is to bring together norm and plan-constraints within a single coherent model. Thus, we propose in this research a model of team dialogue for multi-agent systems grounded upon argumentation schemes focussed on identifying relevant conflicts about plans, norms and goals when establishing agreements on interdependent plans.

Furthermore, very few approaches have conducted an evaluation of the benefits of using argumentation-based models in deliberative dialogues (i.e. [3]). In different types of dialogue it has been shown that argumentation has the potential to lead agents to an effective conflict resolution; for example in negotiation, argumentation enables a more efficient reallocation of resources [4]. In existing research, however, the utility of using argumentation schemes is demonstrated through extended examples, but how information shared during dialogue influences conflict resolution has not been rigorously assessed. Thus, in this research we propose a model of arguments that captures conflicts among interdependent plans with the aim of evaluating how this model, embedded in a multi-agent dialogue system, leads agent to share more focussed information about plan and norm constraints. Furthermore, we aim to show that agents employing this model are able to support human team leaders in planning by suggesting arguments that facilitate the resolution of conflicts.

2. APPROACH

In this research, we focus on the question of how software agents can support human collaborative planning in complex deliberative dialogues. In order to address this question, we will concentrate our efforts on two main objectives: *(i)* the formalisation of an argumentation framework for multi-agent deliberative dialogues that allows agents to clarify the nature of the conflicts in a joint plan; *(ii)* the development of a system where the model would be embedded for evaluation in order to prove that these applications may effectively enhance collaboration among teams by supporting members to identify effective justifications.

The dialogue system that we propose includes a language for discussing agents' plans, a model of arguments, a set of defeasible relations among arguments, and a dialogue protocol. The underpinning planning language is based on *situation calculus*, a second order language designed for representing dynamic domains. We adopt an extension for tem-

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poral applications adapted to consider norms [6]. The argumentation framework involves different forms of argument focussed on identify plan, norm and goal conflicts among agents' plans. The formal structure of the arguments is based on argumentation schemes. These schemes capture patterns of arguments that commonly occur in human dialogue and they can be used as heuristics for structuring dialogue concerned with practical reasoning [1]. These schemes are also suitable in our context since we aim at presenting the arguments in a way that looks familiar to human users.

The dialogue protocol considers the debate among two agents in a team. The dialogue commences when one agent informs the team about its intention to perform an action or requests a particular action to be performed by others. In engaging other agents in the discussion, the proponent describes the action with preconditions, effects and the goal that this action will help to achieve. The opponent, having a wider set of information about the action under discussion, can select new arguments according to possible conflicts with its commitments and norms. In order to formulate such arguments, an agent follows these critical questions: "**CQ1:** Is the action possible given other concurrent actions in the plan?"; "**CQ2:** Is the action possible according to causal plan constraints?"; "**CQ3:** Is there conflicting norm that regulates actions or states of the world?"; "**CQ4:** Is the goal justified?". A different argumentation scheme is defined for each of these questions. The formalisation of this model is presented in [8]. The critical questions are used to define defeat relations describing a conflict between a task of an agent and a task or a norm of the opponent's plan, and support relations used to justify an agent's commitment. Agents proceed in the discussion using various instantiations of these schemes. Since each argument shares new information about actions, states or goals that parties intend to achieve or to perform, an agent is able to counterattack the proposal using the critical questions to formulate new arguments. If agents find an agreement, the action is included in the shared plan. If agents disagree, the proponent withdraws the proposal and re-plans with an alternative that would not conflict with the information acquired during the dialogue.

3. EVALUATION

In our work we consider a domain where the collaboration among agents is hampered by a wide number of conflicts among plans related to individual objectives, norms to follow and plan constraints. The argumentation-based model has the potential to enhance the collaboration among team members. In order to evaluate this notion we developed a system where agents, employing our model, mimic the human practical reasoning dialogue. Agent planners are provided with goals, norms and plan rules to prepare individual plans. Agents discuss about collaborative actions in the plan, generate arguments and choose the appropriate ones during the dialogue. The agents' planning domain concerns operations of a local authority and a NGO for evacuation of people after a disaster.

In the first phase of the evaluation, we consider feasibility of the plans as indicator for qualitative plans. The measure of feasibility is represented by the number of conflicts existing between two interdependent plans. The evaluation is focussed on the number of pre-existing conflicts are solved after the discussion. The results show that this model leads to an effective exchange of relevant information about conflicts between the plans enabled by the use of argumentation schemes. Furthermore, experiments using a restrictive and a flexible protocol provide evidence for how this focussed information sharing leads to a more effective resolution of goal, norm and plan conflicts.

In a second phase, we will focus on how the dialogue evolve when agents perform a quantitative analysis of the costs and benefits of the commitments. Agents will distinguish among conflicts that must be solved because they cause a significant loss of utility in the plan and the ones that can be ignored if a better solution cannot be found. We also plan to run experiments with human subjects where personal agents will be aware of the individual plan and norm constraints. In this context agents will identify and present possible arguments for users to exchange during the discussion. Using the quantitative approach, agents will help users to identify more crucial conflicts that can hamper the execution of joint plans. Experiments with human users will produce evidence about the effective aid that agents can provide during the discussion about collaborative plans.

4. CONCLUSION

In this work we present a model for arguments that contributes in deliberative dialogues based on argumentation schemes for arguing about norms and actions in a multi-agent system. Our study shows that the use of argumentation schemes supports agents to effectively exchange relevant information and leads agents to create more favourable collaborative plans. Further studies are planned to consider utility of commitments and human planners. In future research, we may focus on identifying more effective strategies to convey information during the deliberative dialogue.

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