On the benefits of argumentation schemes in deliberative dialogue

(Extended Abstract)

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ABSTRACT

We present a model of argumentation-based deliberative dialogue for decision making in a team of agents. The model captures conflicts among agents' plans due to scheduling and causality constraints, and conflicts between actions, goals and norms. We evaluate this model in complex collaborative planning problems to assess its ability to resolve such conflicts. We show that a model grounded on appropriate argumentation schemes facilitates the sharing of relevant information about plan, goal and norm conflicts. Our results show also that this information-sharing leads to more effective conflict resolution.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multi-Agent Systems

General Terms

Experimentation

Keywords

Argumentation, Collective decision making, Planning

1. INTRODUCTION

Collaborative decision making among a team of agents is a complex activity, particularly when agents have different but interdependent objectives. When agents need to collaborate to accomplish a task, they must form an agreement on a plan to enact and coordinate together [3]. Agents may, however, have conflicting opinions on what to include in a shared plan due to differing commitments.

Argumentation-based models of dialogue enable agents to provide justifications for differing positions regarding a joint problem, which is useful in complex collaborative situations. Using such an approach, agents can identify conflicts in joint plans, and explore and identify alternative solutions that are more favourable for the team. Atkinson and Bench-Capon [1] present an argumentation-based dialogue for practical reasoning based on argumentation schemes focussed on finding a common plan for a joint goal. In related research, Toniolo et al. [4] present a formalisation of argumentation schemes appropriate for agents engaging in deliberative dialogue where conflicts may also arise due to differing objectives and normative constraints. A study of the benefits of using argumentation schemes for agents negotiating the allocation of limited resources is presented in Karunatillake et al. [2]. In existing research, however, the utility of using argumentation schemes is demonstrated through extended examples where the possible solutions are pre-established. How information shared during dialogue influences conflict resolution has not been rigorously assessed.

In this paper, we consider complex problems of collaboration where agents have differing objectives, norms and plan constraints. We empirically evaluate the model of argumentation schemes presented in [4] within symmetric and asymmetric dialogue systems and present some evidence for how such a model facilitates the identification and resolution of conflicts between interdependent plans.

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2. DIALOGUE SYSTEM

We consider agents that prepare plans to achieve individual objectives, but must collaborate to coordinate interdependent tasks or to inform the team about critical commitments. The dialogue system includes a language for discussing agents' plans, a model of arguments, a set of defeasible relations among arguments, and a dialogue protocol. The planning language is based on *situation calculus* extended for norms that define what an agent is obliged or forbidden to do. The structure of the arguments is grounded upon the argumentation schemes for practical reasoning presented in [4]. An action, described through its preconditions, effects and the goal that it contributes to, may be proposed by one of the parties. Agents can, then, formulate arguments that deal with potential conflicts between the proposed action and other actions, norms and goals through the use of critical questions including "**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 any conflicting norm that regulates actions or states of the world?", "**CQ4:** Is the goal justified?". The model defines an argumentation scheme for each of these conflicts and the critical questions identify defeat and support relations among arguments. A support relation justifies an agent's commitment, and a defeat relation describes

a conflict between a task of an agent and a task, a norm or a goal of the opponent's plan.

The dialogue system is built for two-agents discussions. Initially each agent creates an individual plan that is locally norm-consistent. The proponent starts the dialogue proposing an action from its individual plan to the other agent, and the dialogue progresses in a turn-taking fashion. When an agent passes, the proponent withdraws its proposal or the opponent accepts it and the dialogue terminates. On termination, agents may re-plan taking into account new information acquired during the dialogue. This, we claim, will lead agents to identify better collaborative plans. To test this claim, we consider three protocols for communication that correspond to different degrees of freedom in moving arguments. Protocol $\mathcal{P}_{ctrl}$ is a control condition where agents are not permitted to exchange arguments other than accepting or rejecting the claim. The argumentation-based protocols are symmetric protocol ($\mathcal{P}_{sym}$) where proponent and opponent may use defeat or support relations to form arguments, and asymmetric protocol ($\mathcal{P}_{asym}$) where the opponent explores its objections to the proposed action which are defended by the proponent.

3. EVALUATION

Design. The metric for evaluation is the feasibility of the resulting plans; i.e. the number of conflicts of different types between individual plans that can hamper execution of interdependent tasks. The agents' planning domain concerns operations of a local authority and a humanitarian organisation for evacuating people following a disaster. We ran 450 experiments for each protocol, starting from randomly generated initial plans. The conflicts were analysed before discussion to measure the total number of conflicts among the two plans (complexity of the problem) and post discussion for the conflicts solved.

Results. Figure 1.A shows that the number of conflicts solved is higher when argumentation schemes are used to guide the dialogue ($\mathcal{P}_{sym}$ and $\mathcal{P}_{asym}$) than in the control condition ($\mathcal{P}_{crtl}$). We plot here the percentage of solved conflicts as the complexity of the problem increases. In protocols $\mathcal{P}_{asym}$ and $\mathcal{P}_{sym}$ the conflict resolution trend stabilises (at around 33% and 45% respectively) showing an approximately linear relation between solved conflicts and plan complexity. In the control condition the trend falls, demonstrating that agents solve fewer conflicts as plan complexity increases. This result provides evidence for the claim that many conflicts can only be discovered through the exchange of arguments and, hence, sharing relevant information about existing plan, norm and goal commitments.

Although $\mathcal{P}_{asym}$ and $\mathcal{P}_{sym}$ show a similar trend, there is a difference in the performance of the two protocols. The total number of arguments exchanged in $\mathcal{P}_{sym}$ tends to be higher than with $\mathcal{P}_{asym}$ (Figure 1.B). However, the proportion of conflicts resolved with $\mathcal{P}_{sym}$ is more than 10% higher than with $\mathcal{P}_{asym}$ (Figure 1.A). The difference here is that $\mathcal{P}_{sym}$ permits additional information to be exchanged; i.e. justifications for an agent's commitment as well as identification of conflicts. This result provides evidence for there being a tradeoff in practice between the complexity of the dialogue and the number of conflicts that can be solved. We conclude that, although $\mathcal{P}_{sym}$ leads to more complex dialogues, it is more effective in resolving more complex interdependencies between agents' plans.

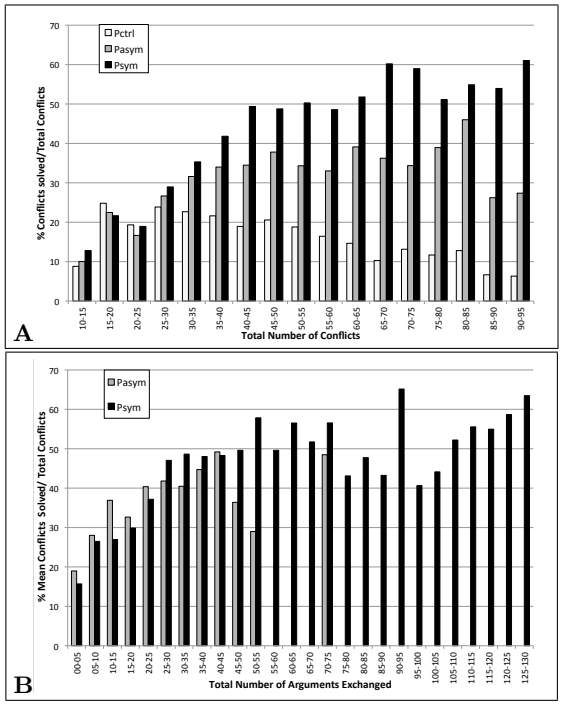

Figure 1: Results.

4. CONCLUSIONS

In this research we have considered problems where collaboration among agents is hampered by a wide number of conflicts related to individual objectives, norms and plan constraints. We have evaluated an argumentation-based model of deliberative dialogue grounded upon argumentation schemes that identify the causes of conflicts in collaborative planning. Our study has shown that the use of argumentation schemes leads to an effective exchange of relevant information. We have also demonstrated that focussed information sharing supports agents in creating more favourable collaborative plans.

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