Chapter 5

CONFLICTS IN AGENT TEAMS

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Abstract

Multi-agent teamwork is a critical capability in a large number of applications. Yet, despite the considerable progress in teamwork research, the challenge of intra-team conflict resolution has remained largely unaddressed. This chapter presents a system called CONSA, to resolve conflicts using argumentation-based negotiations. The key insight in CONSA (Collaborative Negotiation System based on Argumentation) is to fully exploit the benefits of argumentation in a team setting. Thus, CONSA casts conflict resolution as a team problem, so that the recent advances in teamwork can be fully brought to bear during conflict resolution to improve argumentation flexibility. Furthermore, since teamwork conflicts often involve past teamwork, recently developed teamwork models can be exploited to provide agents with reusable argumentation knowledge. Additionally, CONSA also includes argumentation strategies geared towards benefiting the team rather than the individual, and techniques to reduce argumentation overhead. We present detailed algorithms used in CONSA and show a detailed trace from CONSA’s implementations.

1. INTRODUCTION

Teamwork is a critical capability in a large number of multi-agent applications, such as virtual environments for education and training (Tambe, 1997), robotic teams (Kitano et al., 1997) and teams on the Internet. In these applications, agents must act together despite the uncertainties of their complex dynamic environment. Considerable progress has indeed been made in teamwork research. For instance, recent advances in teamwork models (Jennings, 1995, Tambe, 1997), which explicitly outline agents’ commitments and responsibilities in teamwork, have significantly improved flexibility in teamwork coordination and communication. However, this research has so far not addressed the challenge of resolving conflicts within a team.
Yet, as agent applications advance to meet the requirements of scale and autonomy, inter-agent conflicts become increasingly inevitable. For instance, while autonomously reacting to dynamic events, agents may unintentionally interfere in others’ actions, or faulty sensors may provide them with conflicting information or lead them to conflicting inferences. While such conflict resolution is difficult in general, it is even more problematic in teams if intrateam conflicts are not anticipated.

This chapter focuses on a system we have developed to resolve conflicts in agent teams, called CONSA: *COllaborative Negotiation System based on Argumentation*. In argumentation, agents negotiate by providing arguments (which may be justifications or elaborations) in support of their proposals to one another. CONSA builds on past work in argumentation (Chu-Carroll and Carberry, 1995, Kraus et al., 1998, Parsons and Jennings, 1996, Sycara, 1990), but advances the state of the art by fully exploiting the benefits of argumentation in a team setting. Thus, one key idea in CONSA is to cast conflict resolution as an explicit common team goal. As a result, the recent advances in teamwork models are brought to bear during conflict resolution, improving negotiation flexibility. For instance, if a team member privately discovers an event that renders the current team conflict irrelevant, it will be committed to informing its team members — it will not just withdraw privately from negotiations. Additionally, with an explicit common team goal, novel argumentation strategies emerge, e.g., agents may attempt to improve the quality of teammates’ arguments. Furthermore, since team conflicts are often rooted in past teamwork, CONSA enables agents to argue effectively about teamwork, by exploiting the teamwork models in a novel way, i.e., not only as a guide to agent behavior during conflict resolution, but as a source for reusable argumentation knowledge. Finally, CONSA is integrated within existing agent teams in complex environments, and has focused on practical issues, such as minimizing the resources consumed in negotiations.

This chapter is organized as follows: section 2. provides background and motivation. Section 3. provides details on STEAM which CONSA is based on. Section 4. describes the representation and evaluation of arguments in CONSA. Section 5. explains CONSA’s novel argumentation approach in detail. Section 6. shows how CONSA’s implementation works in a specific example. An earlier and shorter version of this chapter has appeared in (Tambe and Jung, 1999a). This chapter presents significant additional details, missing in that work.

2. **DOMAINS AND MOTIVATIONS**

The motivation for current research on negotiation is based on our previous work in complex, multi-agent domains such as real-world battlefield simula-