Coordinated Deliberation Management in Multi-Agent CIRCA

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In multi-agent CIRCA, we extend real-time performance characteristics to a team of coordinating CIRCA agents, each controlling a separate member of a team of unmanned combat air vehicles (UCAVs). As illustrated in Figure 1, individual agents combine the adaptive mission planning (AMP) and automatic controller synthesis (CSM) modules with a plan executive (RTS) that is responsible for reactively executing these controllers. As also shown, CIRCA agents negotiate at all levels of the architecture to coordinate their activities.

The focus of this work involves managing the CSM's deliberation time. The AMP manages this resource in two ways: by determining which tasks to perform through negotiation with other cooperating agents (AMP-to-AMP), and by scheduling time to have its CSM generate plans (controllers) to address those tasks during mission execution (AMP-to-CSM).

CSM Deliberation: The overall team mission is composed of *phases*, which correspond to modes or time intervals that share a fundamental set of common goals, threats, and dynamics. For each phase, the set of agents must have coordinated plans that are custom-designed (either before or during mission execution) to achieve the goals and defeat the threats associated with that phase. Each CSM (Musliner, Durfee, & Shin 1995) is capable of automatically building these controllers, but it can be a complex and time-consuming process. The complexity (and hence duration) of the CSM process can be controlled by varying the *problem configuration* that is assembled and passed from the AMP to the CSM to describe the characteristics of the desired controller (Musliner & Krebsbach 2001).

Task Allocation: Using a Contract-Net-like arrangement (Smith 1980), the AMPs submit bids to handle the threats and goals of each phase. Currently the computation of bid values involves threat- and goal-specific costs and benefits that an agent expects to incur if it assumes that responsibility.

Dynamic Team Behavior: External contingencies can force reallocation of tasks between AMPs, or suggest a modified utility function for the AMP-to-CSM deliberation management function. For instance, if one UCAV is lost, its commitments must be re-announced and re-awarded to account for the lost asset. However, if the loss over-constrains the problem, each AMP agent may need to modify its utility (or cost-estimation) functions to prefer less goal-achieving, and more threat-avoiding behavior, to account for the more dangerous environment. Alternatively, updated intelligence reports disconfirming suspected threats in some phases could cause all agents to increase their preference for more goal-achieving plans in these less-dangerous phases. These modified preferences in turn dictate how the CIRCA agents estimate their costs when they bid for a threat or goal, and how they rank these tasks for selection on their deliberation agenda.

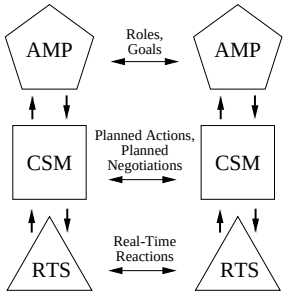

Figure 1: CIRCA agents negotiate at every level.

References

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