Tradeoffs in Decision-Making Frameworks and Interaction Styles

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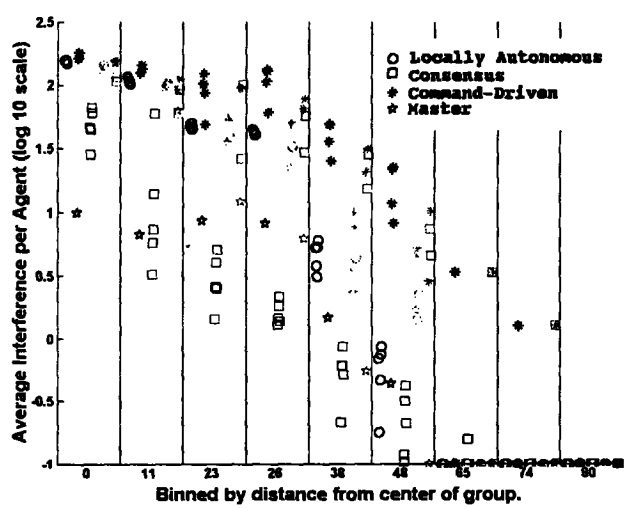
This research analyzes the performance of individual agents and groups of agents in different Decision-Making Frameworks across a variety of situations. A *Decision-Making Framework (DMF)* specifies how a set of agents interacts when determining how a set of goals should be achieved (Barber and Martin, 2001). A Decision-Making Framework is (1) the *decision-making control set* – which agents make decisions about the goals, (2) the *authority-over set* – which agents must carry out the decisions, and (3) the *set of goals* under consideration.

The experiment domain is naval radar interference management, where each agent has one goal, "Minimize system radar interference." Each agent controls the radar frequency on a simulated ship and attempts to choose frequencies that are not being used by other radars in the system. The performance metric is the mean interference of all agents in the environment.

The roles agents play in DMFs are *Decision-Making Interaction Styles*. *Master* agents decide how to achieve goals for themselves and *Command-Driven* agents; *Consensus* agents collaborate equally to decide for the group; and *Locally Autonomous* agents decide alone. The graph below reflects an analysis of how combinations of Decision-Making Interaction Styles and Decision-Making Frameworks affect the performance of individual agents and groups of agents in accomplishing an inter-dependent set of goals in a shared simulation.



Performance by Decision-Making Interaction Style, Framework

The graph shows the performance of agents in the system under one set of experimental conditions. The graph overlays the performance plots of agents and groups at different distances from the center of the group. The shapes of the data point markers represent different Decision-Making Interaction Styles and the columns within a "bin" represent different Global Decision-Making Frameworks. The Y-axis is a logarithmically plotted penalty function, so lower position indicates better performance. Thus, the graph shows how the performance of both groups and individual agents changes as the domain situation, their interaction style, and the organizational context change.

No Decision-Making Interaction Style dominates performance in all situations or organizations in this data. Even when the experimental parameters overwhelmingly favor one interaction style over the others, such as Consensus in the graph shown, that interaction style is not always preeminent, such as the Consensus agents in the mixed group furthest right in the bins. This is true both as the situation context changes and as the organizational context changes. For instance, in some situations when ships are close together, Consensus works best, but with more separation between ships, agents using other interaction styles perform as well or better.

Likewise, the relative performance benefits of different interaction styles change significantly as organizational context changes. As game theory has found, (Zlotkin and Rosenschein, 1996), the benefit of one interaction style is affected by the interaction styles employed by other agents. Some situations have network effects, where additional cooperating agents provide benefit to all, but in other situations, the fewer simultaneous actors the better. None of the interaction styles provides a universal advantage either within or across organizations. Overall, these preliminary results indicate that agents reasoning to form or alter decision-making organizations must consider the interacting performance effects of environmental attributes and the interaction strategies of other agents.

Barber, K. S. and Martin, C. E. 2001. Dynamic Reorganization of Decision-Making Groups. In Proceedings of the Fifth International Conference on Autonomous Agents (Agents-2001), 513-520. Montreal, QC, Canada.

Zlotkin, G. and Rosenschein, J. S. 1996. Mechanisms for Automated Negotiation in State Oriented Domains. Journal of Artificial Intelligence Research 5: 163-238.