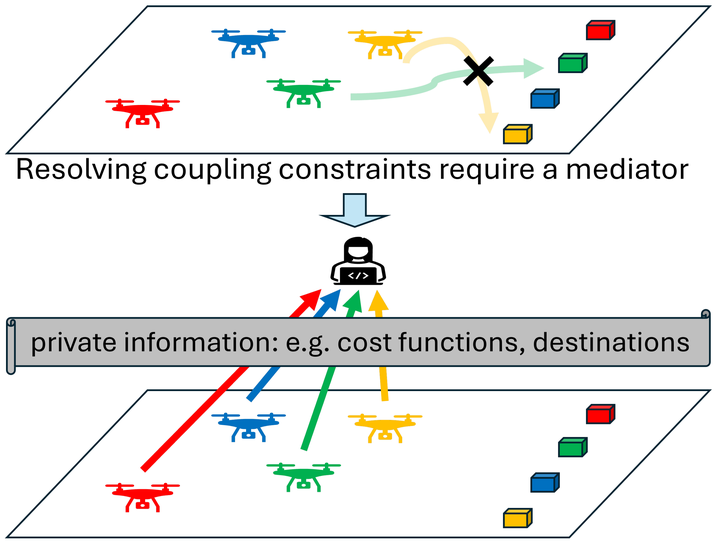
A Two-stage Mechanism for Prioritized Trajectory Planning in Multi-Agent Systems

Yu-Wen Chen Can Kizilkale Murat Arcak

Berkeley UNIVERSITY OF CALIFORNIA

Motivation



How to motivate agents to report truthfully?

Vickrey-Clarke-Groves (VCG) mechanism

- For each outcome x in set X, each of the N agents has its valuation $v_i(x)$, but may report the evaluation function as $\tilde{v}_i(\cdot)$.
- VCG mechanism maximizes social welfare and encourages truthfulness via selecting the outcome and imposing payments by

$$x^* = \arg\max_x \sum_{i=1}^{N} \tilde{v}_i(x) \quad \text{and} \tag{1}$$

$$p_i = \sum_{j\neq i} \tilde{v}_j(x^*) + h_i(\tilde{v}_{-i}). \tag{2}$$

- The additional payment p_i aligns agent-i's optimization goal with the planner's goal.

Main takeaways

- The VCG mechanism encourages truthful reporting but fails in settings where agents can refine locally.
- We propose a two-stage mechanism that incentivizes truthfulness while respecting agents' local decision-making.
- Our design prevents manipulation in priority weighting for prioritized planning.

Problem settings

Design a monetary mechanism s.t. agents are willing to report truthfully while selfishly minimizing their costs:

$$\begin{aligned} \arg\min_{y_i} \;& c_i(y_i, y_{-i}) + p_i(y_i, y_{-i}) \\ s.t. \;& g_i(y_i, y_{-i}) \preceq 0. \end{aligned} \tag{3}$$

- g_i includes agent dynamics and coupling constraints.
- c_i is the intrinsic cost; p_i is the imposed payment

Proposed two-stage mechanism

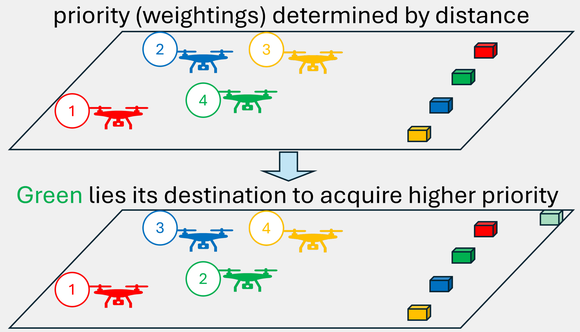
1. Based on the reported functions $\tilde{c} = (\tilde{c}_1, \cdots, \tilde{c}_N)$ and $\tilde{g} = (\tilde{g}_1, \cdots, \tilde{g}_N)$, the planner determines a reference signal:

$$\begin{aligned} \tilde{y}^*(\tilde{c}, \tilde{g}) = \arg\min_{y} \;& \sum_{i=1}^{N} \tilde{c}_i(y) \\ s.t. \;& \tilde{g}(y) \preceq 0. \end{aligned} \tag{4}$$

2. Once receiving the reference signal, **each agent decides its optimal y_i^* via (3)** and then pays $p_i\left(y_i^*, \tilde{y}_{-i}^*(\tilde{c}, \tilde{g})\right)$ where $p_i(s,t) =$

$$\sum_{j\neq i} \tilde{c}_j(s,t) + I_{\tilde{g}_j}(s,t) - h_i(\tilde{c}_{-i}, \tilde{g}_{-i}). \tag{5}$$

Extension to prioritized planning



Misreport manipulates the planner's optimization problem directly (via $\tilde{c}$) and indirectly (via weightings).

Case study: Linear-Quadratic-Regulator