Hybrid Decentralization for Multi-Robot Orienteering with Mothership-Passenger Systems

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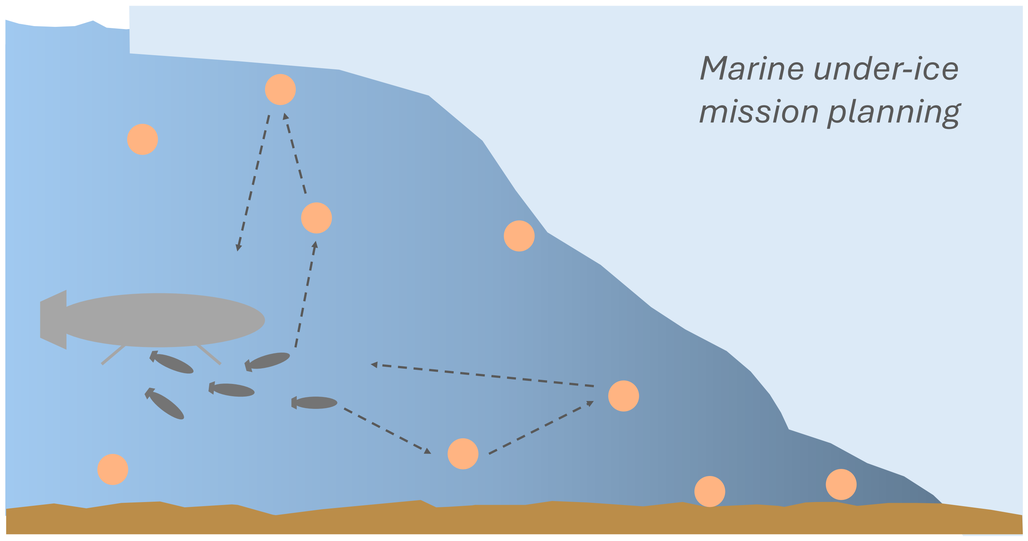
Multi-robot teams can efficiently explore **new environments.** If reaching the operational domain is itself a dangerous job, a **mothership** robot can **transport the team** to regions of interest.

Once deployed, the team must solve a challenging **Stochastic Multiagent Orienteering Problem** to 1) allocate tasks, 2) plan paths, and 3) return to the mothership for extraction within a travel budget in a stochastic environment.

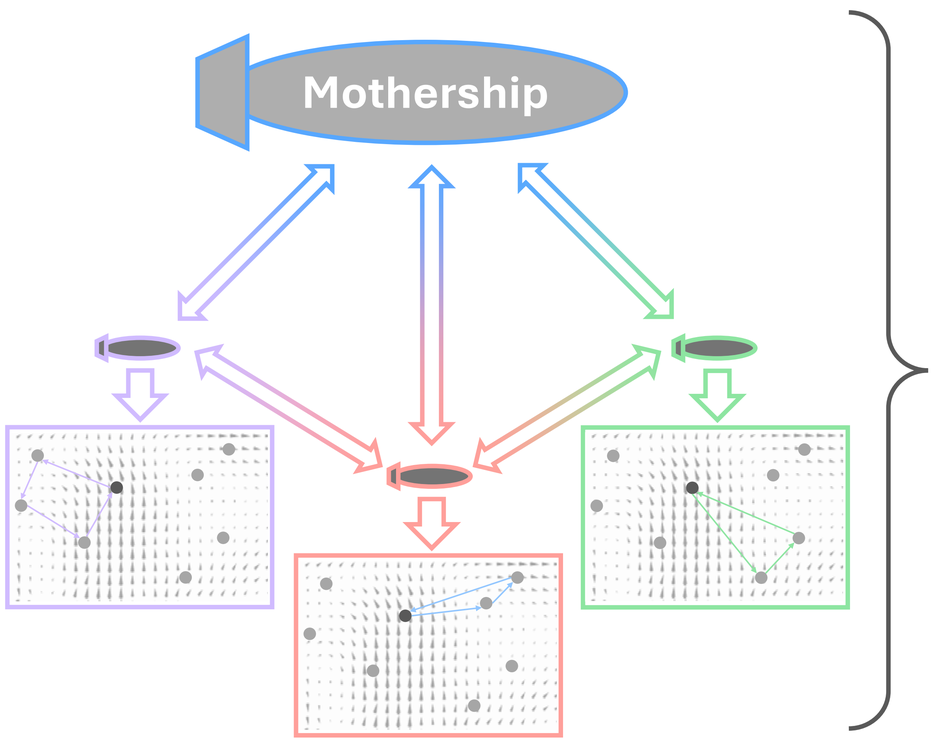
A multi-robot team solving this problem **fully decentralized** may **struggle** to produce globally-coordinated plans if **information propagates slowly** through the system.

Opportunity: How can we leverage a **hybrid centralized-decentralized** network available in Mothership-Passenger systems to **solve complex orienteering problems**?



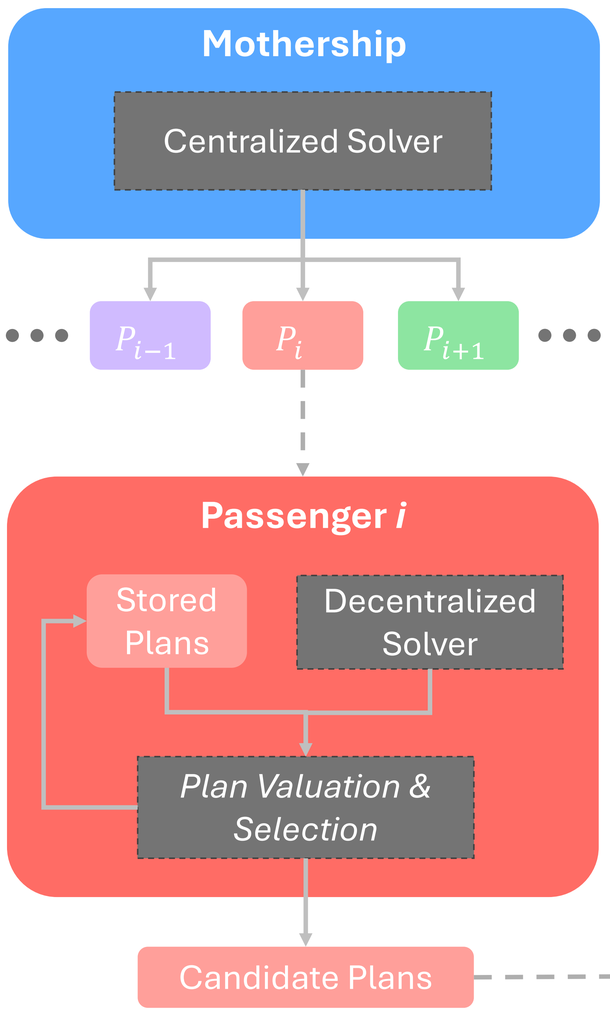
Hybrid Decentralized Mission Planning

We inject plans created by a powerful centralized planner onboard the mothership into passengers' decentralized planning routines to improve system-level coordination.



Passengers' decentralized planning routine supports coordination with neighbors in communication range.

Plans received from the mothership work to align passenger actions with distant robots.



1. **Aggregate observations** from connected passengers.
2. **Compute joint team plans** with centralized solver.
3. **Share solutions** with connected passengers.

Sampling-based solvers address environment stochasticity

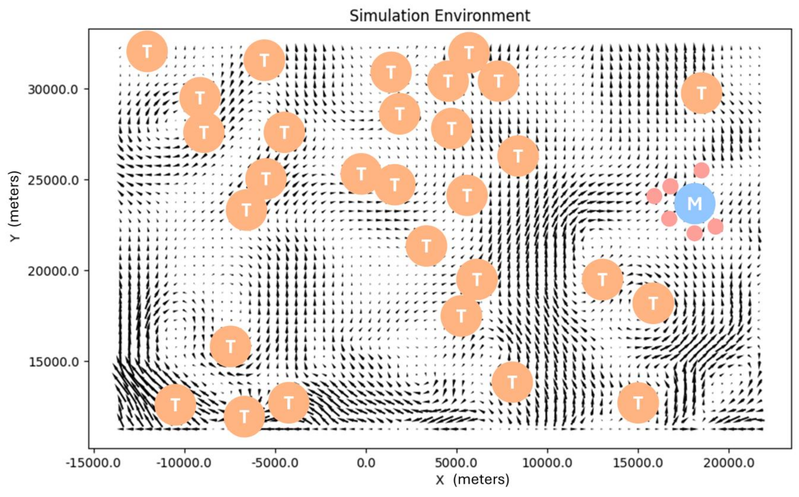
1. **Solve local plan** using observations & candidate plans from neighbors.
2. **Evaluate new plans** against stored high-value solutions (both solved locally & received from mothership).
3. **Store & share** distribution of high-value plans.

Experiments and Results

We evaluate our framework in a simulated underwater environment.

Tasks (T) and the mothership location (M) are distributed randomly.

Ocean currents from high-fidelity underwater simulator introduce stochastic travel costs.

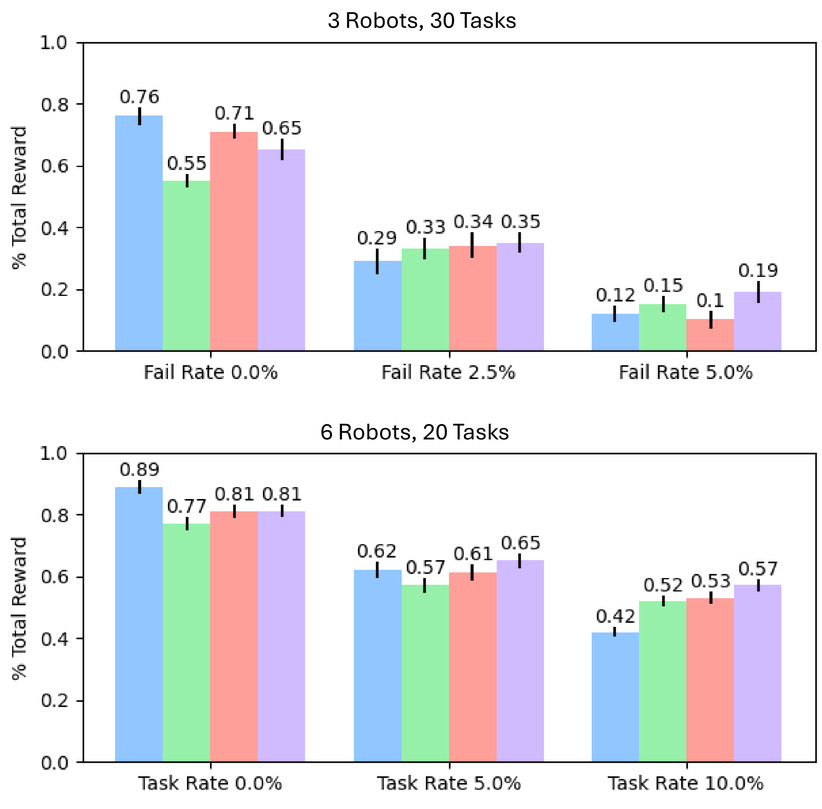


We compare four algorithmic variants:

- Offline, centralized solution only
- Decentralized planning only
- Offline + decentralized replanning
- Offline + hybrid replanning

We inject disturbances (robot failures, new tasks) at specified rates into the system.

These disturbances introduce heterogeneity in team observations and allow us to evaluate each method's replanning performance.



Our hybrid planning framework offers an initial performance boost from the mothership's centralized solver. Global coordination provided by the mothership improves system robustness in high-disturbance scenarios.

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