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

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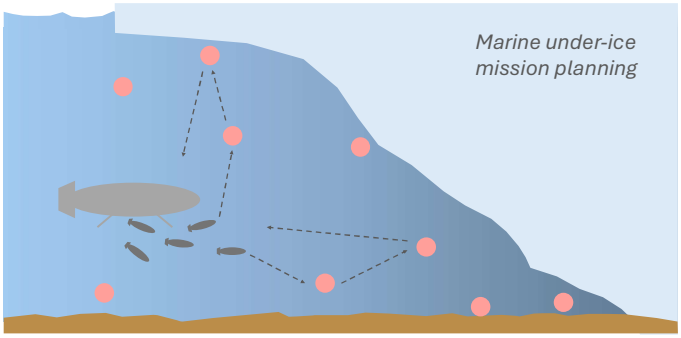
Multi-robot teams are useful for efficiently exploring **isolated, hazardous environments**.

If reaching the environment is itself a hazardous task, a larger **mothership** robot can be used to first **transport the team** to regions of interest.

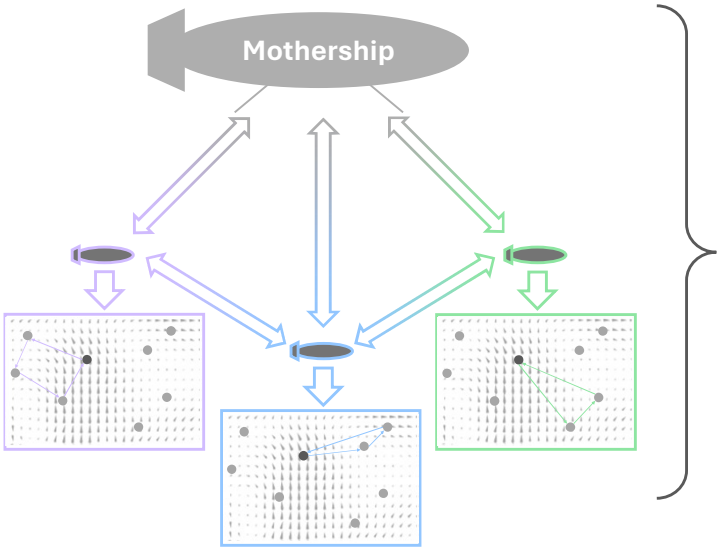
Once the team is deployed, passengers must solve a challenging **Stochastic Multiagent Orienteering Problem** to allocate tasks, plan paths, and return to the mothership for extraction within battery limits in a stochastic environment.

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

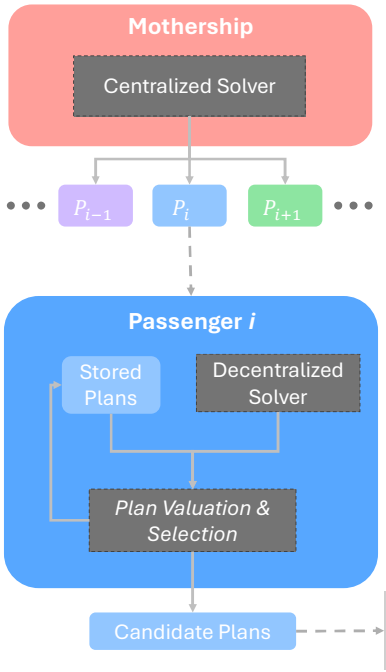


Hybrid Decentralized Mission Planning

We inject plans developed 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 align passenger actions with distant robots as well.



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

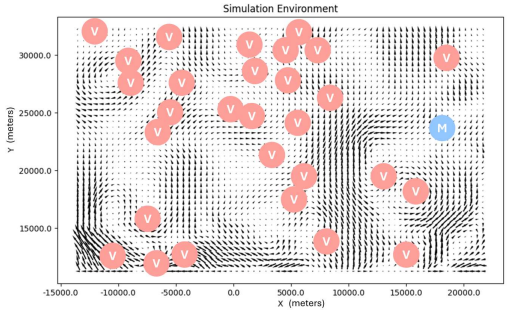
1. **Solve local plan** using observations & candidate plans from neighbors.
2. **Evaluate new plans against history** of high-value solutions (both solved locally & received from mothership).
3. **Store & share** distribution of high-value plans.

Experiments and Results

We evaluate our framework in a simulated underwater environment.

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

Ocean currents from high-fidelity underwater simulator provide stochastic travel times.

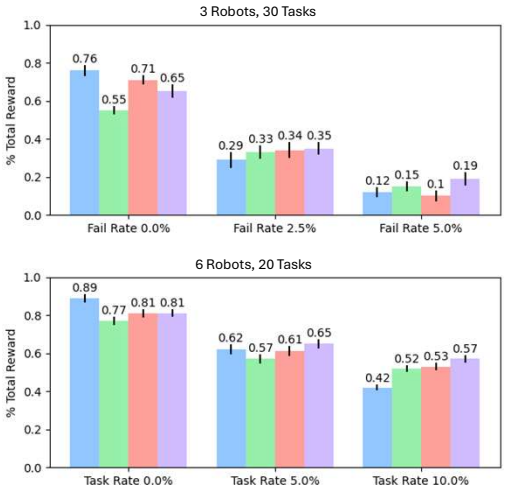


We compare four algorithmic variants:

- Initial, centralized solution only
- Decentralized planning only
- Initial + decentralized replanning
- Initial + 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 methods' performance in replanning.



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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