

iHERO: Interactive Human-oriented Exploration and Supervision Under Scarce Communication

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Motivation

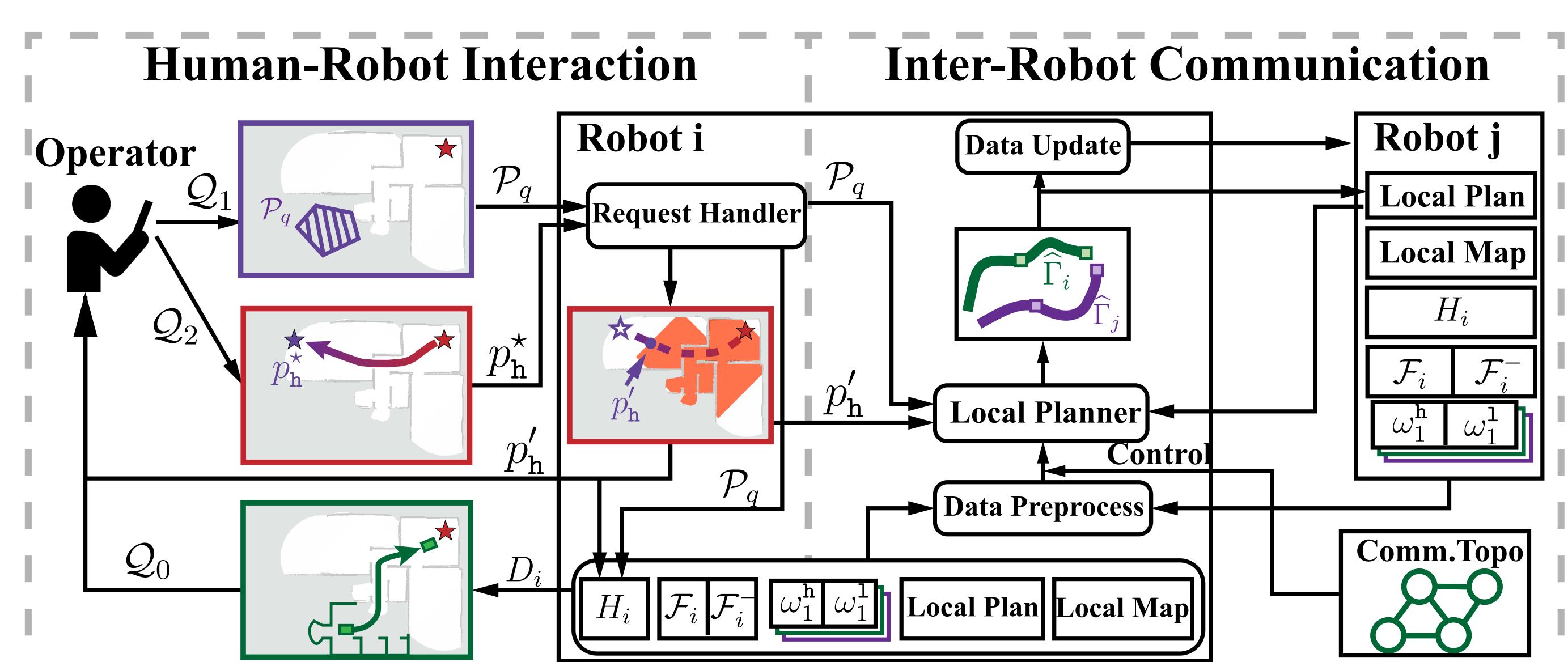
Multi-robot Exploration:

- limited communication
- crucial role of **human operator**

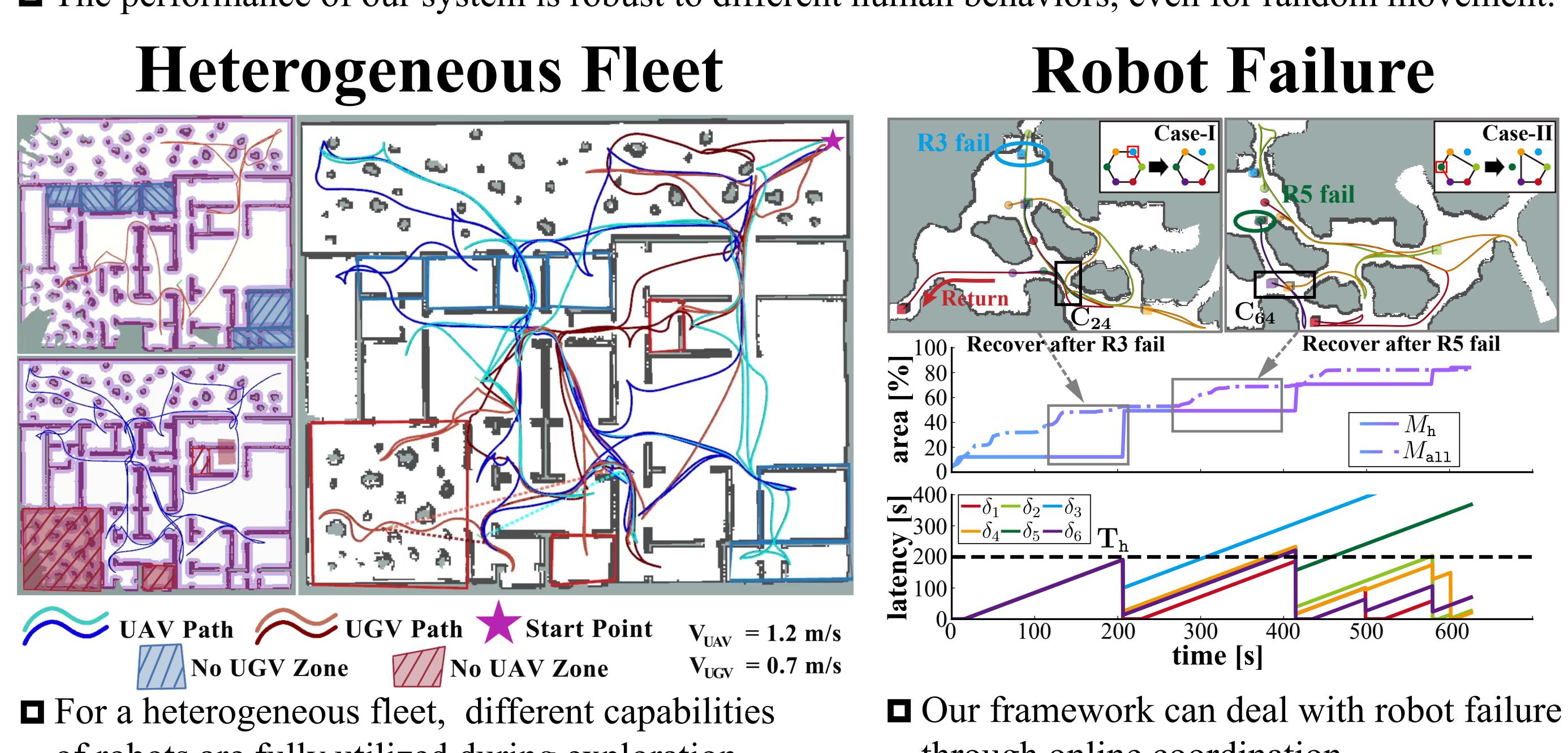
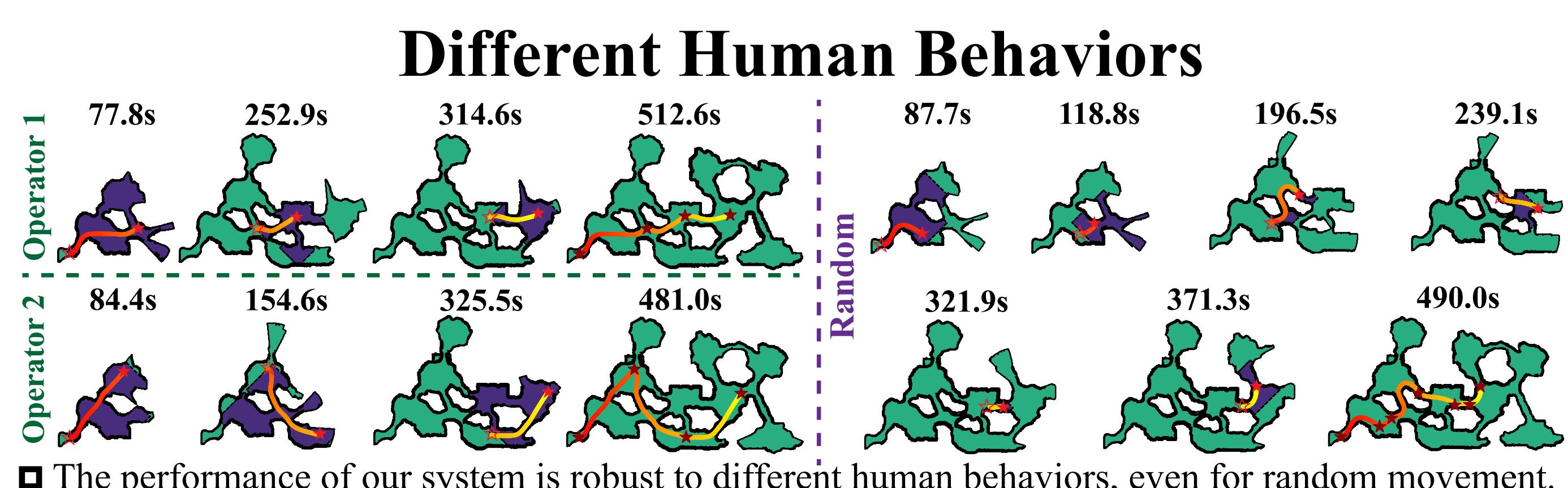
Human-robot Teaming:

- supervise exploration progress
- send **requests** to robot team
- operator may **move** in the environment

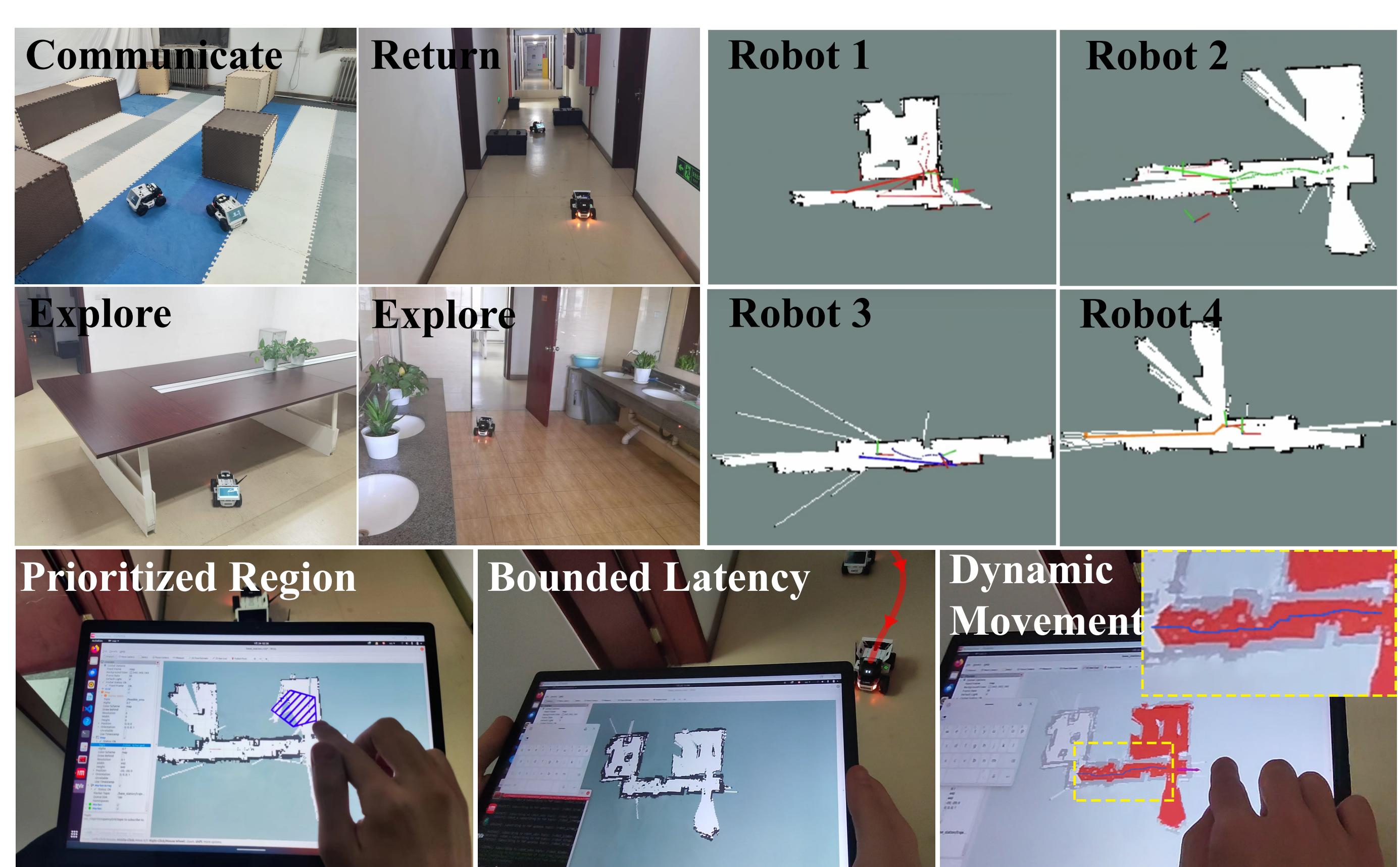
Overall Framework



Generalization



Hardware Demonstration



Problem Formulation

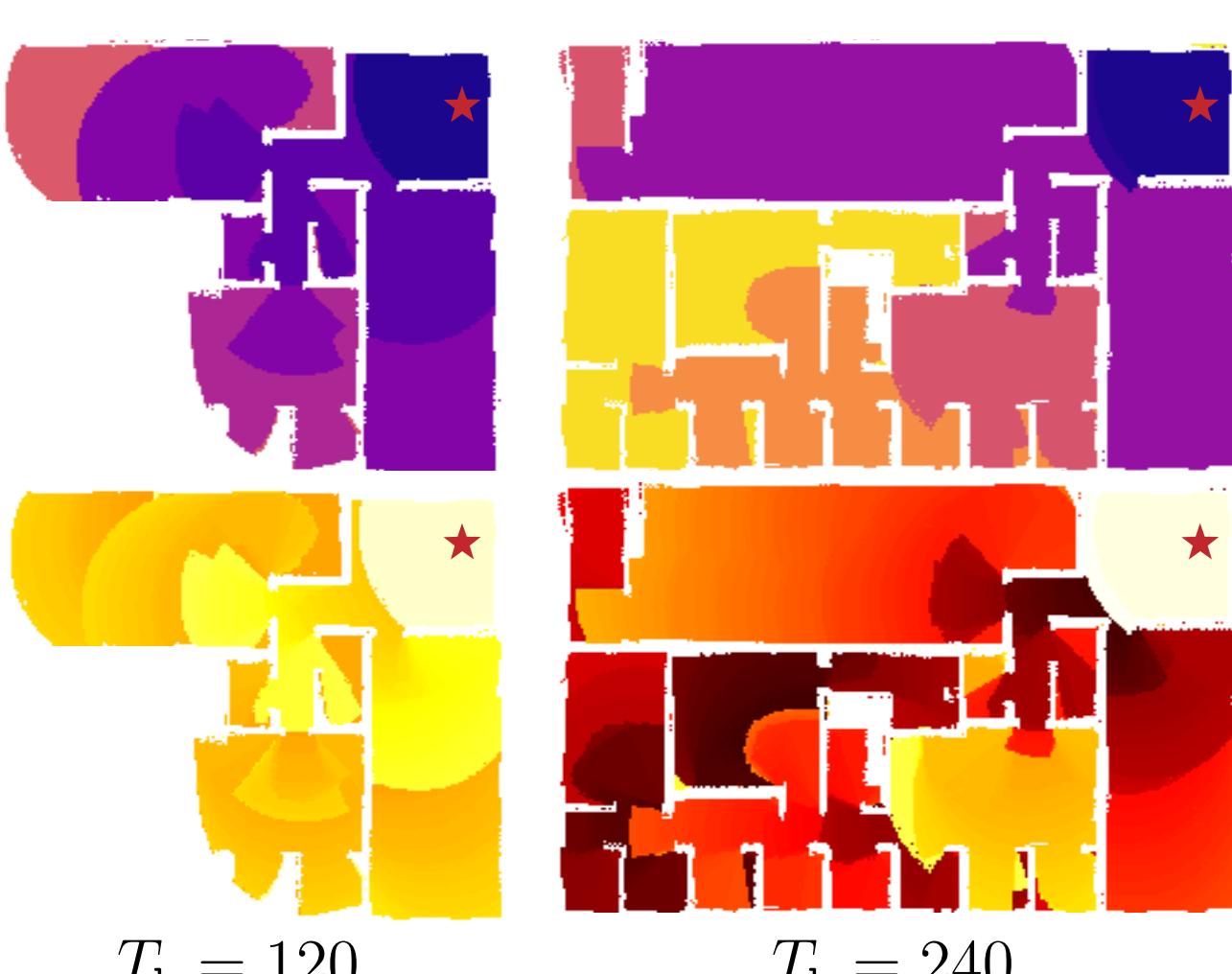
Human Requests:

- Q_0 : latencies should be smaller than bound
- Q_1 : prioritize the specified region
- Q_2 : specify operator's desired next position

Objective: minimize exploration time
subject to **human requests**

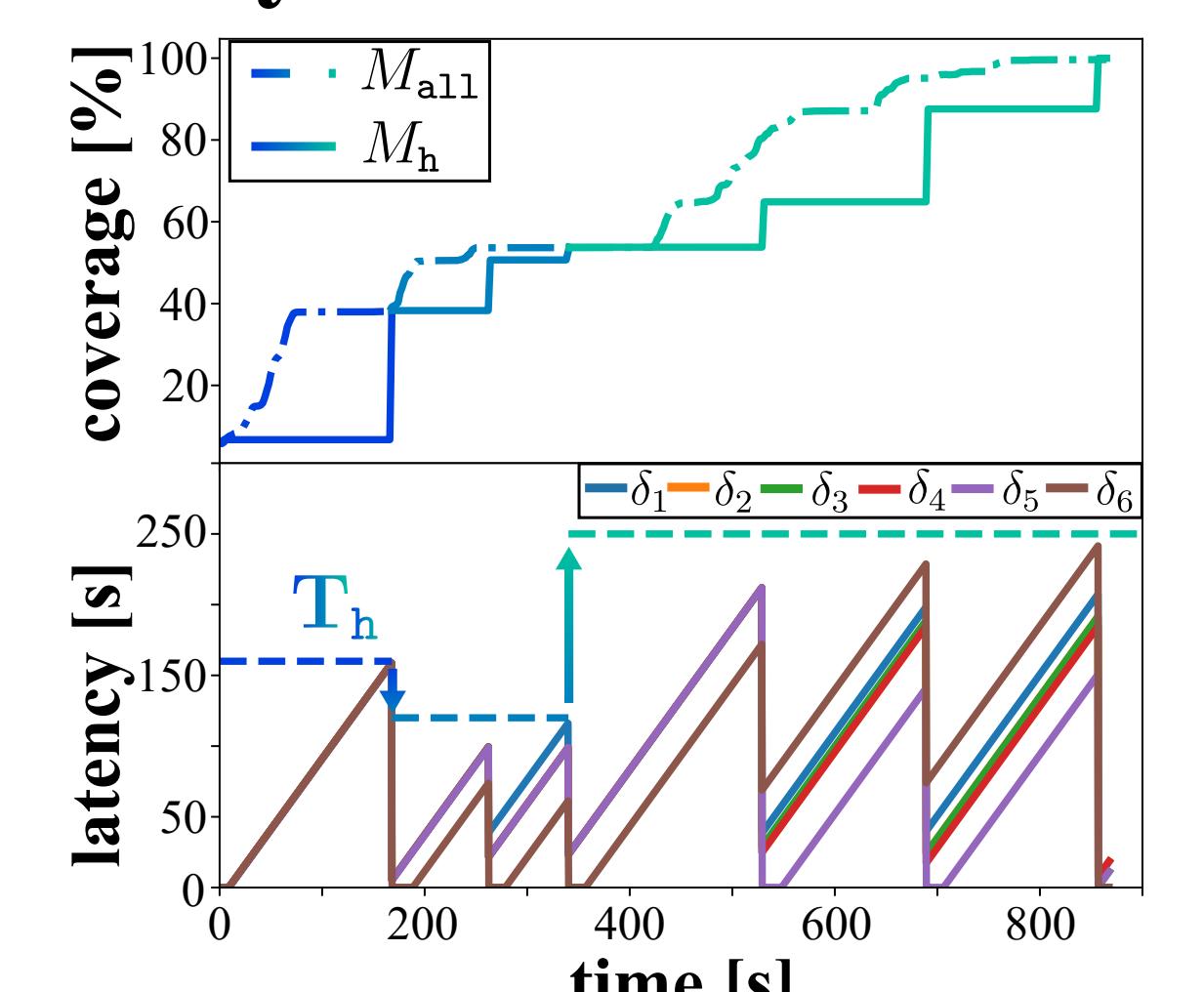
Experiments

Different constraints



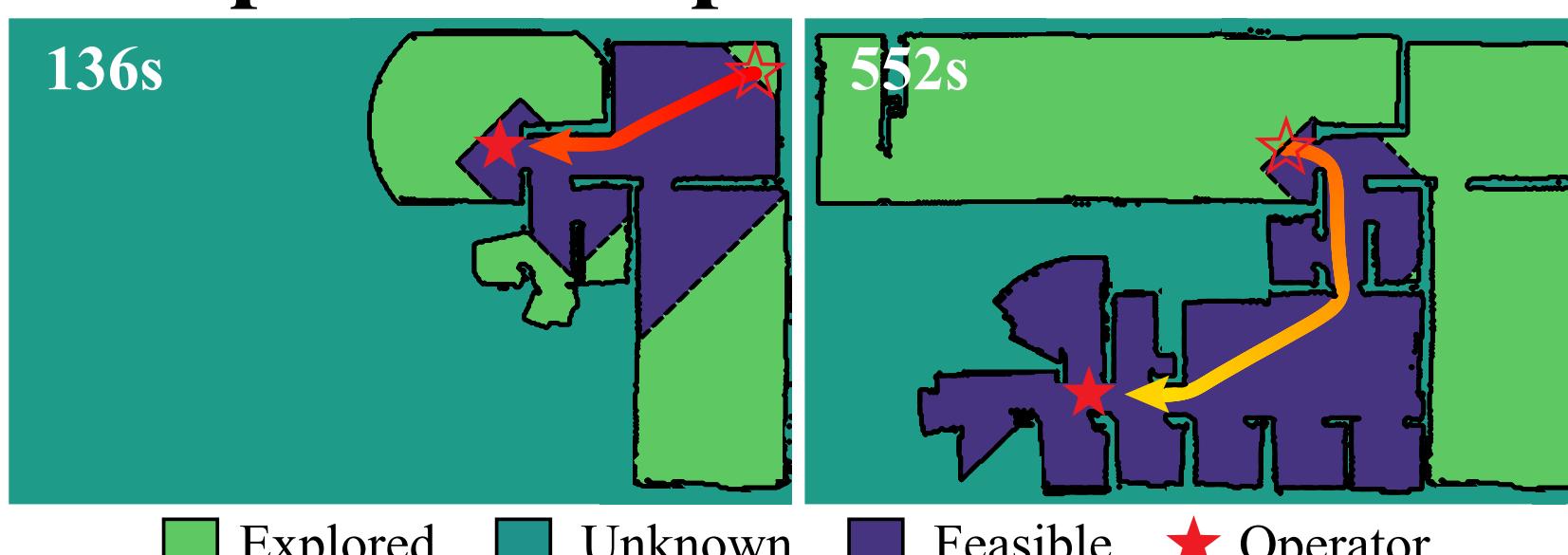
- Latency constraint is satisfied at all time.
- Small bound: frequent update, but small coverage.
- Large bound: complete coverage, but larger latency

Dynamic constraint

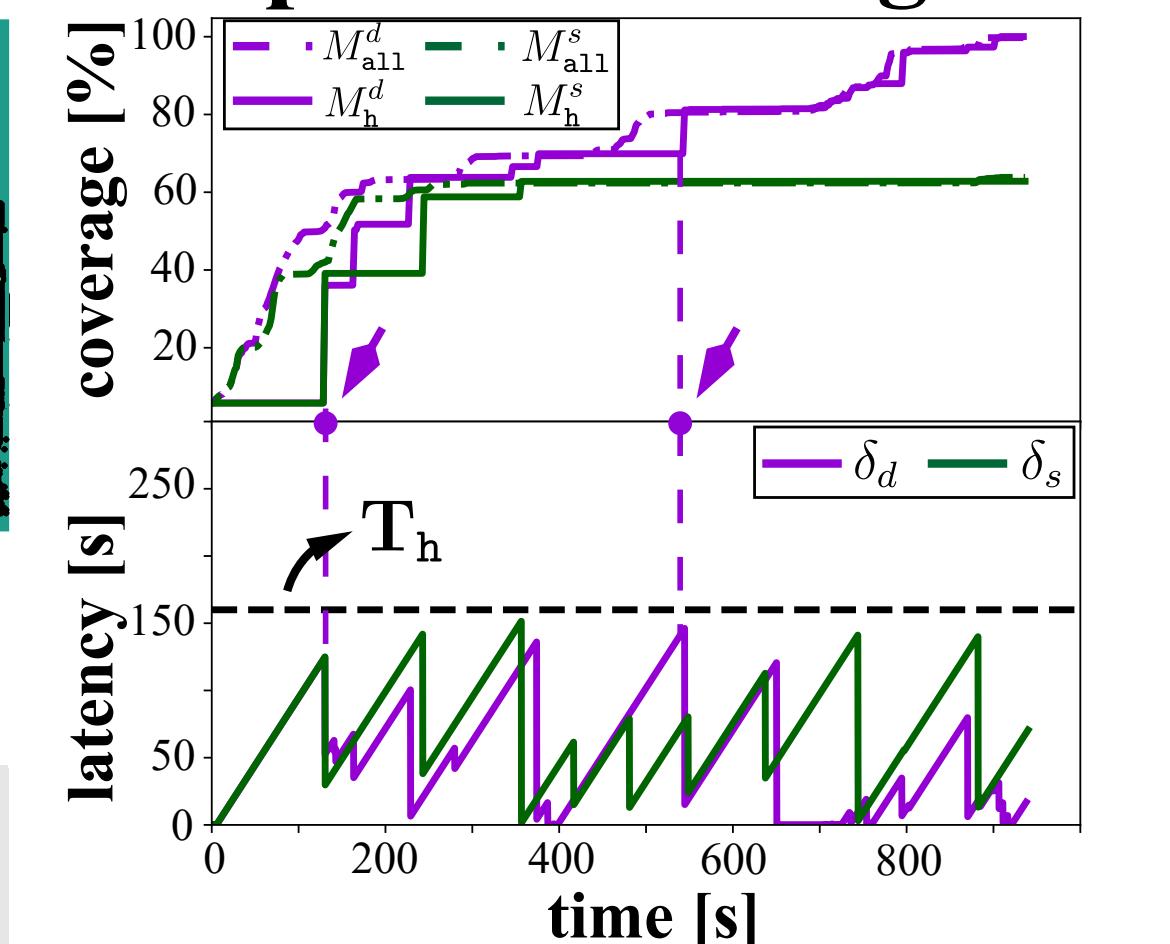


- The operator can change latency bound through online interaction.
- Latency and efficiency change accordingly.

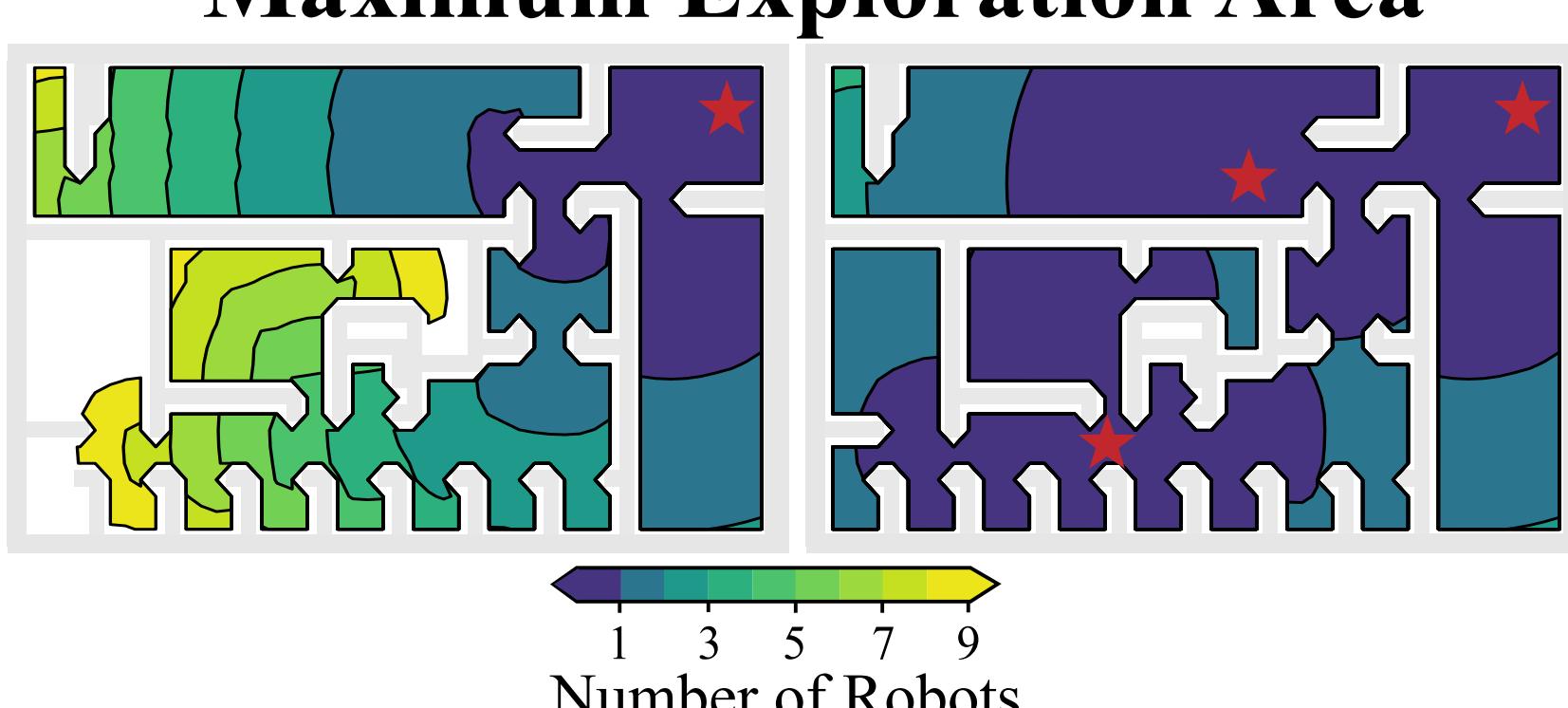
Snapshots of operator's movement



Exploration Progress

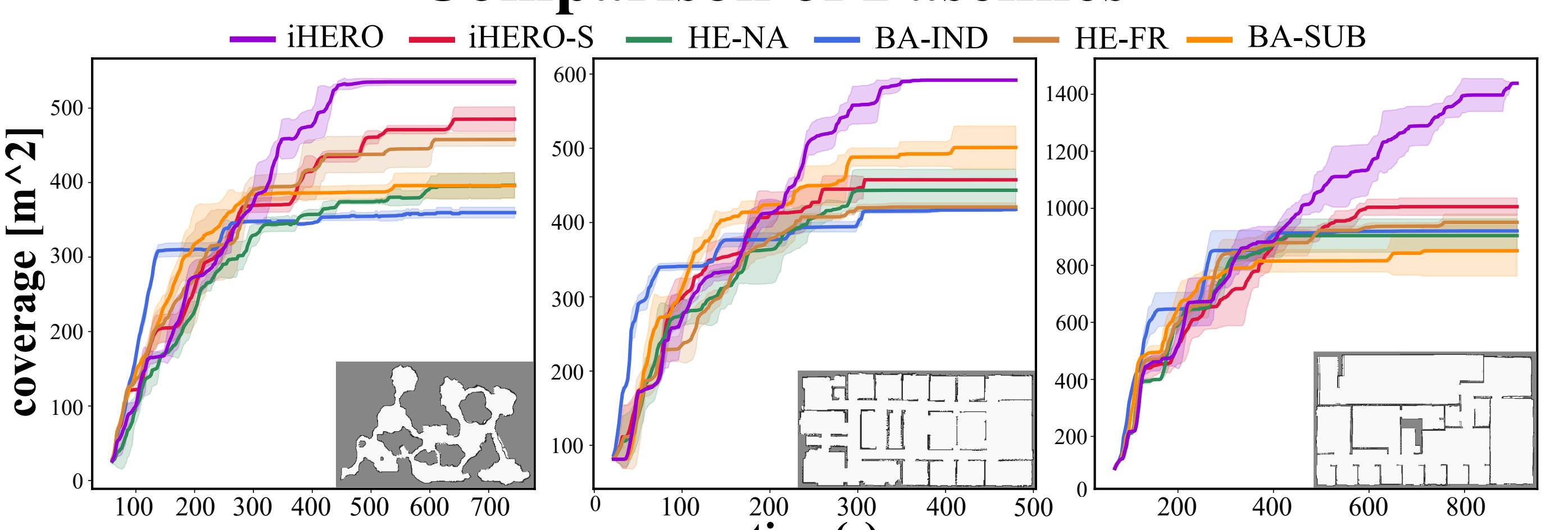


Maximum Exploration Area



- Due to latency constraint, operator can only move in **feasible region**.
- The maximum area is bounded if operator stays static, and dynamic movement extends this boundary.
- Movement yields **larger efficiency**.

Comparison of Baselines



- iHERO is the only method that (i) achieves **100% coverage** across all three scenarios; (ii) requires the **least number of return events** than all baselines; (iii) has the **highest efficiency** over all baselines across all scenarios; (iv) supports **online interactions** such as Q_0, Q_1, Q_2 requests.

Conclusion

- Intermittent communication protocol to ensure timely update to operator.
- Two explicit human requests:
Specify prioritized region & Dynamically move in the environment.
- Various generalizations.