Multi-agent System Architectural Aspects for Continuous Replanning

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Table of Contents

Table of Contents

Introduction

Contextualization

Figure: NASA's Perseverance rover. Source: NASA/JPL-Caltech.

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- Automated Planning (AP) is a potential solution for optimal plan creation and recovery in case of failures, especially in dynamic environments.
- In space robotics, multi-robot planning is vital for improving efficiency, reliability, and productivity in missions, allowing specialized robots to work together and ensuring continuity even if one robot fails.

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- There is ongoing research on coordination and planning in MRS, focusing on aspects like goal decomposition, task allocation, probabilistic and temporal planning, and interactive coordination of heterogeneous teams. [Cashmore et al., 2015, González et al., 2020, Bischoff et al., 2021, Martín et al., 2021, Lesire et al., 2022]

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- However, research that focus on plan recovery in dynamic environments are still scarce
- The main contribution of this work is the implementation of a MAS for simulating a robotic space mission, with code shared for open science.

Table of Contents

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- The Idea was to show details of the plan recovery process and test in other domains without ROS

Architectural Aspects

Design

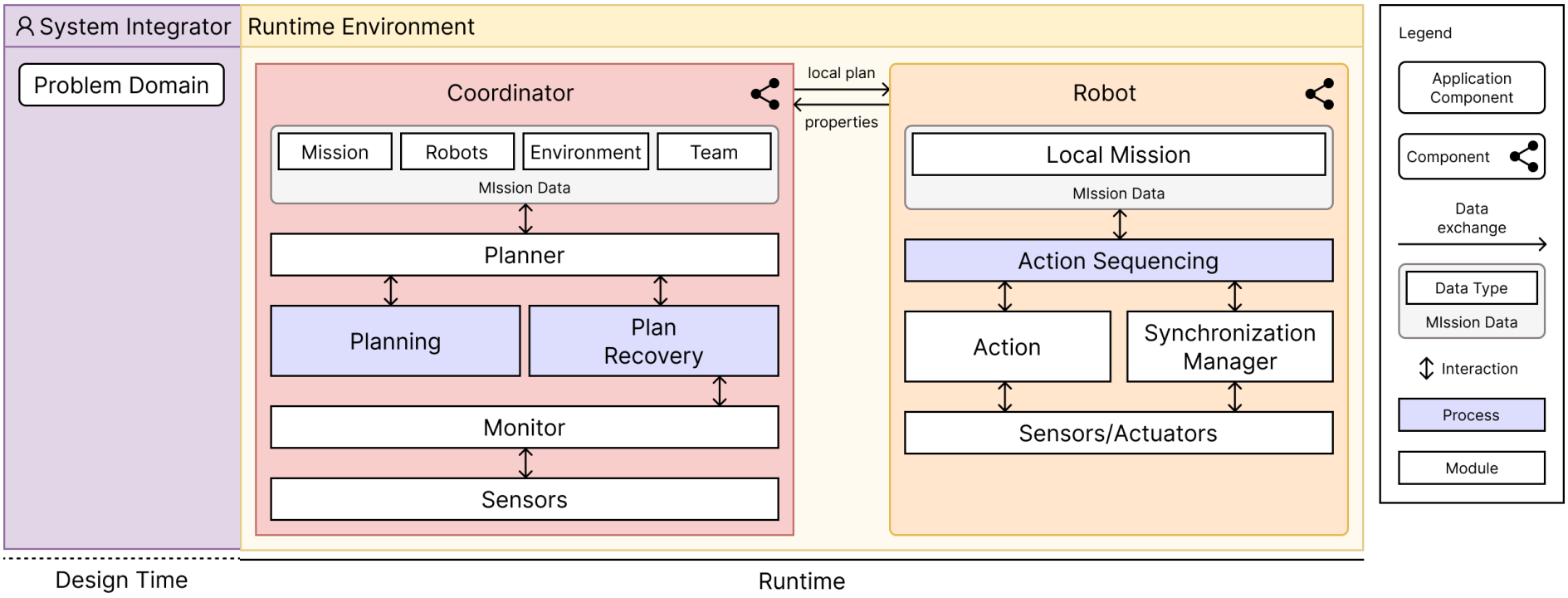

Figure: The high-level architecture.

Architectural Aspects

Plan Recovery

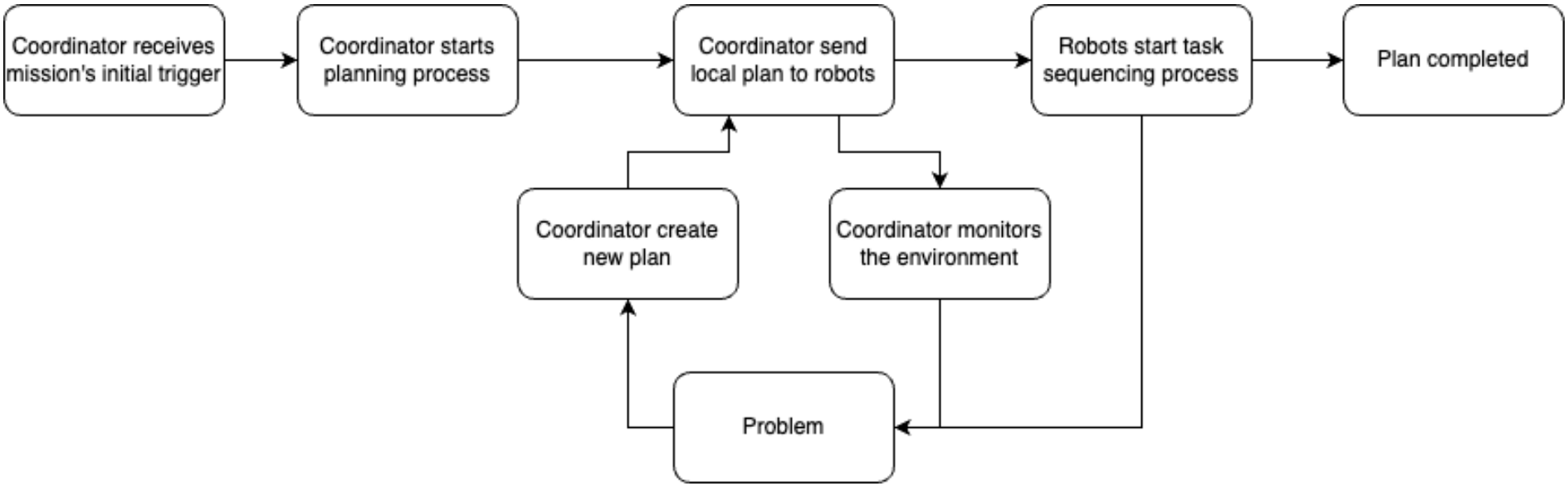

Figure: The solution's execution process.

Architectural Aspects

Plan Recovery

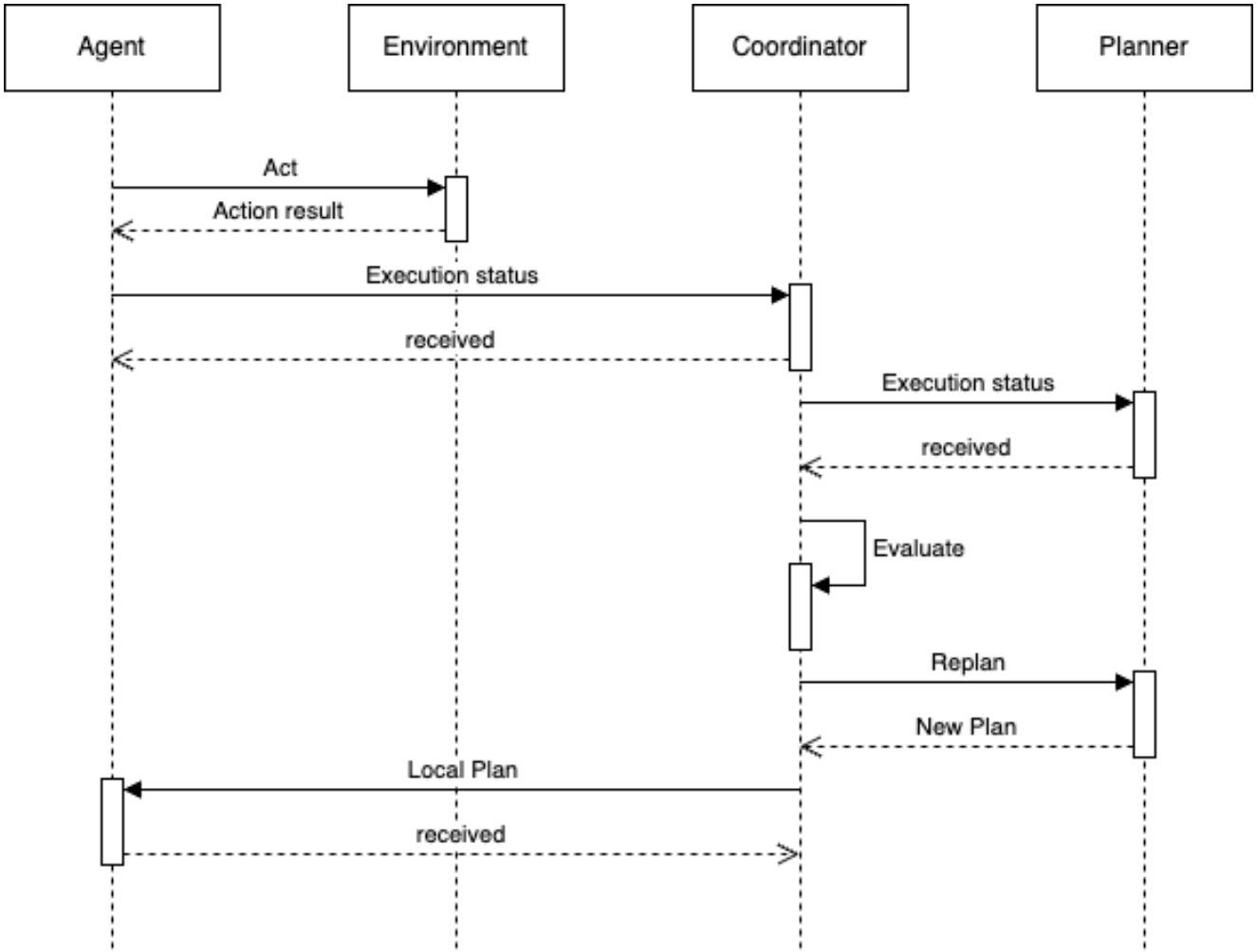

Figure: The architecture reactive replan sequence diagram.

Architectural Aspects

Plan Recovery

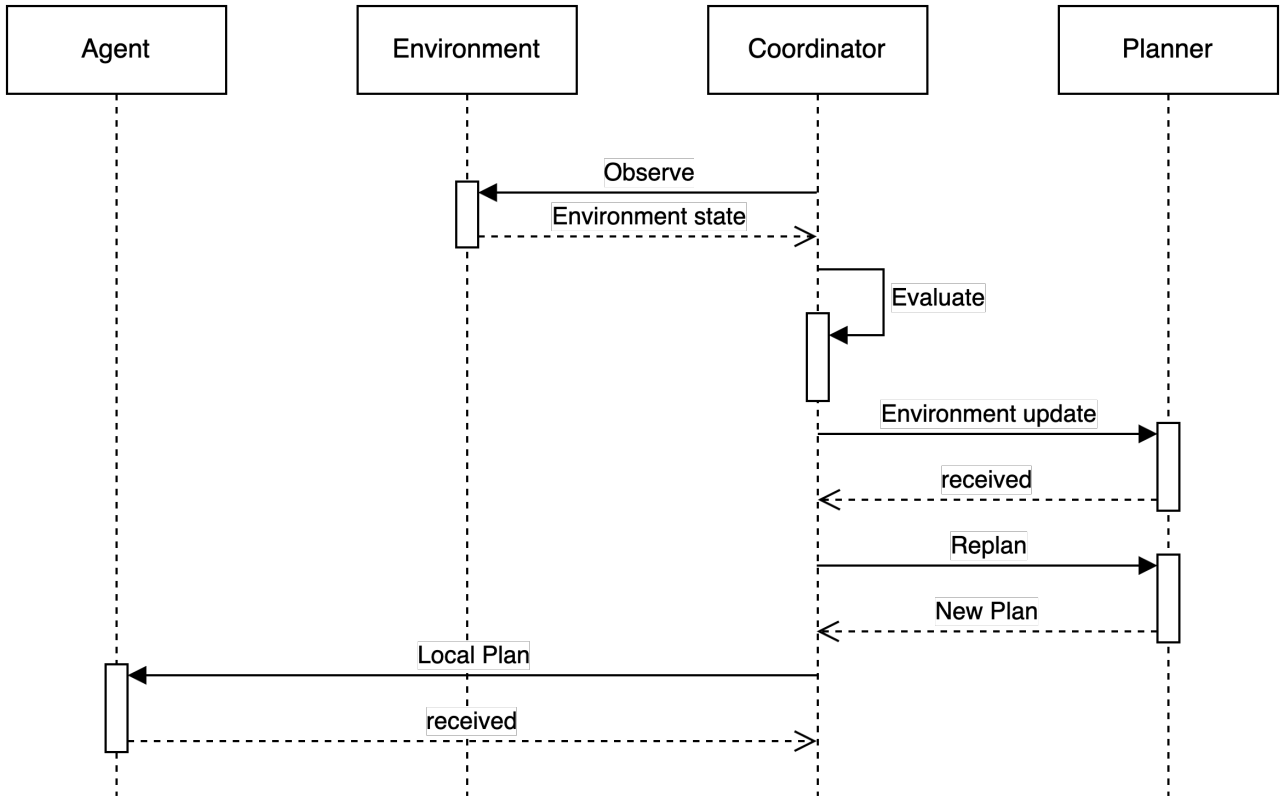

Figure: The architecture proactive replan sequence diagram.

Table of Contents

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Space Resource Gathering

- The main goal of the experiments is to describe and validate the strategy of the architecture's plan recovery process [da Silva, 2024]

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- This work uses the Space Resource Gathering (SRG) on planet exploration illustration example
- The SRG includes three robot types:
  - Scout: can map the environment looking for resources
  - Gatherer can collect the found resources
  - Remover can remove obstacles

Experiments

Space Resource Gathering

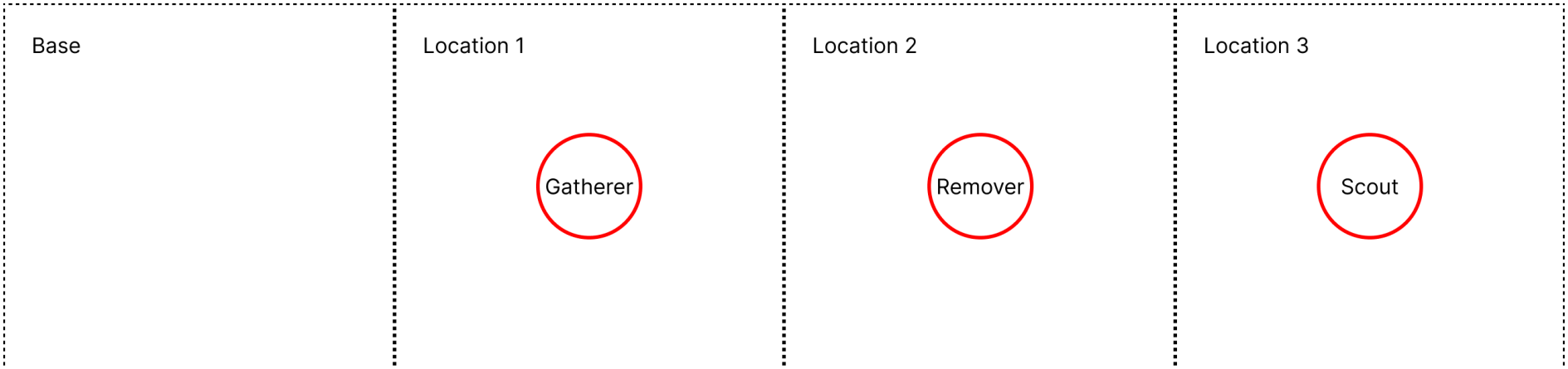

Figure: Example of a simulation map.

Experiments

Methodology

- 5 different scenarios (probability of problem occurring)
  - 10%
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- 30 executions each
- Metrics:
  - Number of executions that ended with success, replan, or failure
  - Execution time

Experiments

Experimental Setup

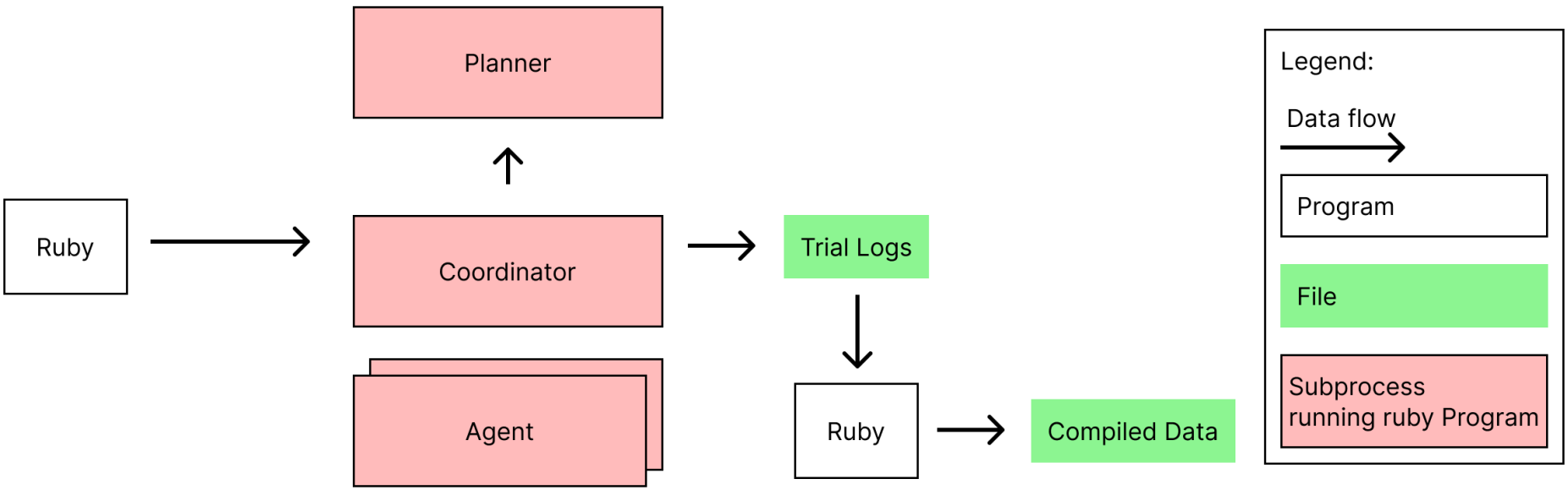

Figure: Experimental process.

Experiments

Results - # of execution results

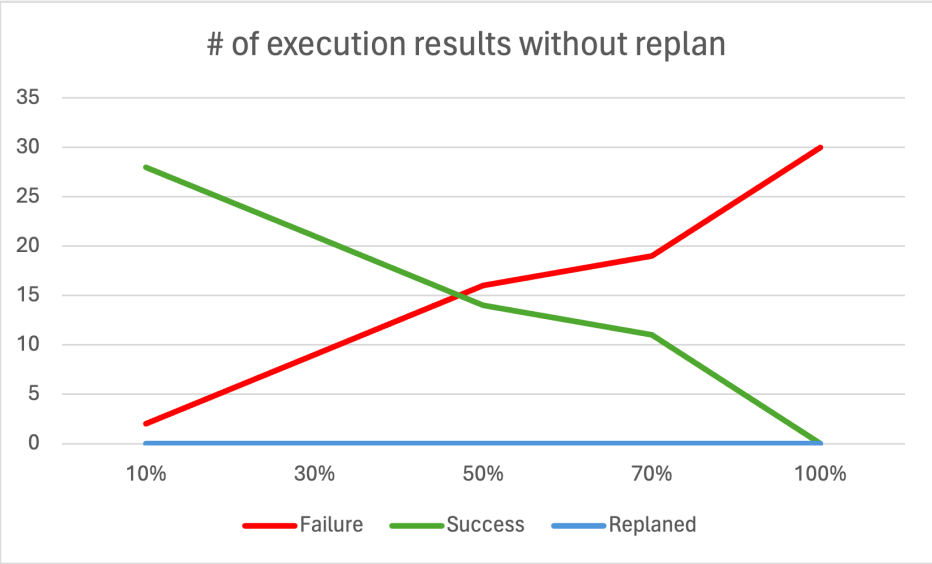

Figure: Without replan

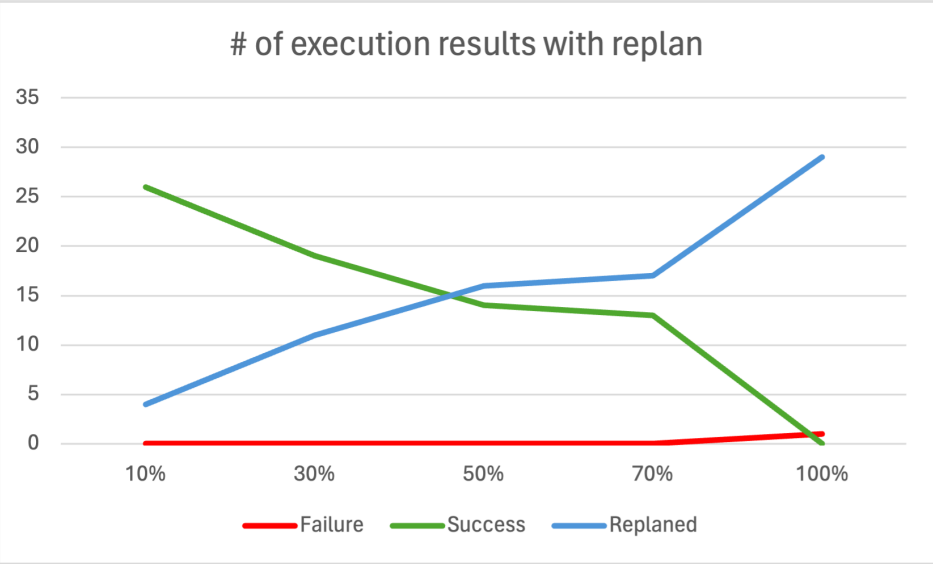

Figure: With replan

Experiments

Results - Execution time (s)

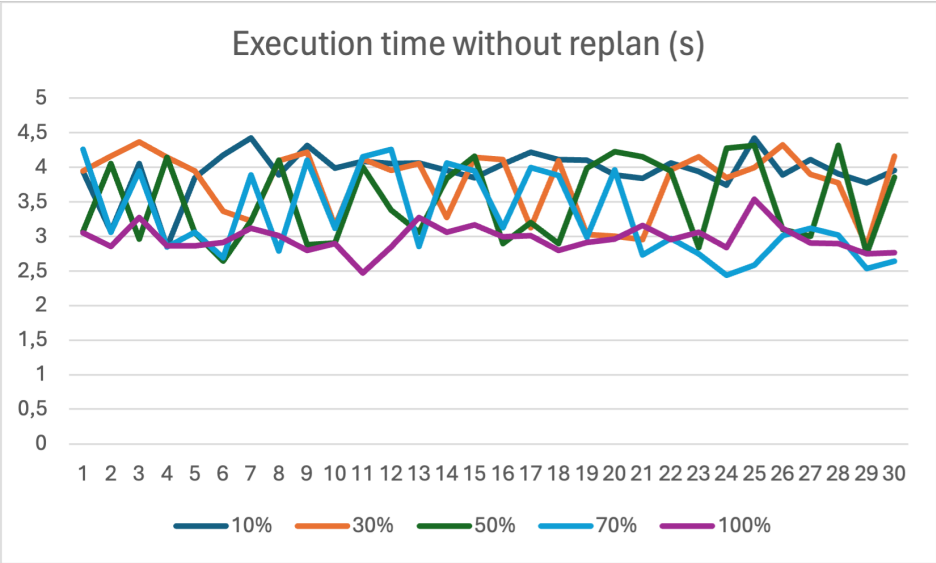

Figure: Without replan

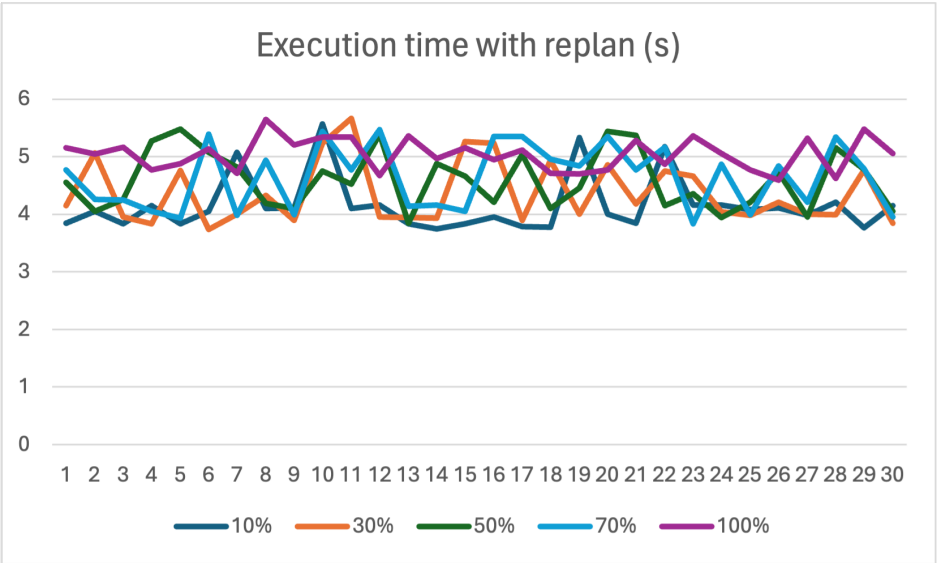

Figure: With replan

Table of Contents

Conclusion

- The experiments validate the proposed MAS architecture from [da Silva, 2024]

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Conclusion

- The experiments validate the proposed MAS architecture from [da Silva, 2024]
- The SRG example demonstrates the architecture's plan recovery capabilities in a simulated space robotics scenario
- Future work will focus on improving the architecture with sophisticated heuristic algorithms (BDI Agents, Team composition), decentralized Coordination, and experiments in other domains
- Future research will also involve experiments with larger numbers of robots, integrating advanced planning algorithms, and finding suitable benchmarks for multi-agent planning to compare with existing work.

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Thank you

Questions?
Suggestions?

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