Cooperative Transport of Objects using Heterogeneous Robots

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Object Manipulation

Transport and manipulation of objects is a basic task in other actions:

Transport

Construction

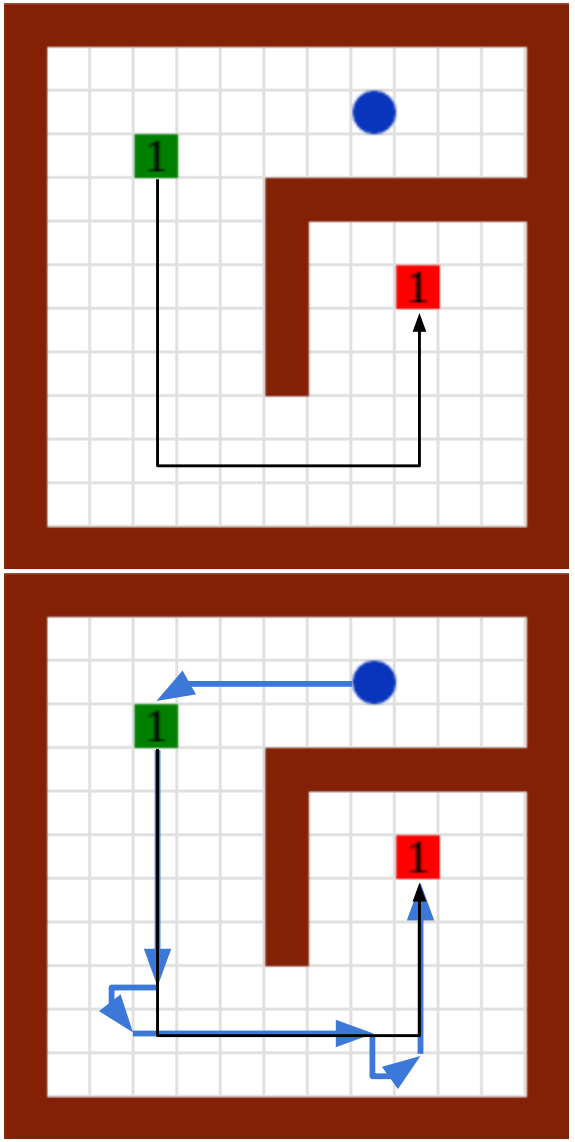
Tools

Household Usage

Problem Definition

Problem 1 *Object Path Planning*

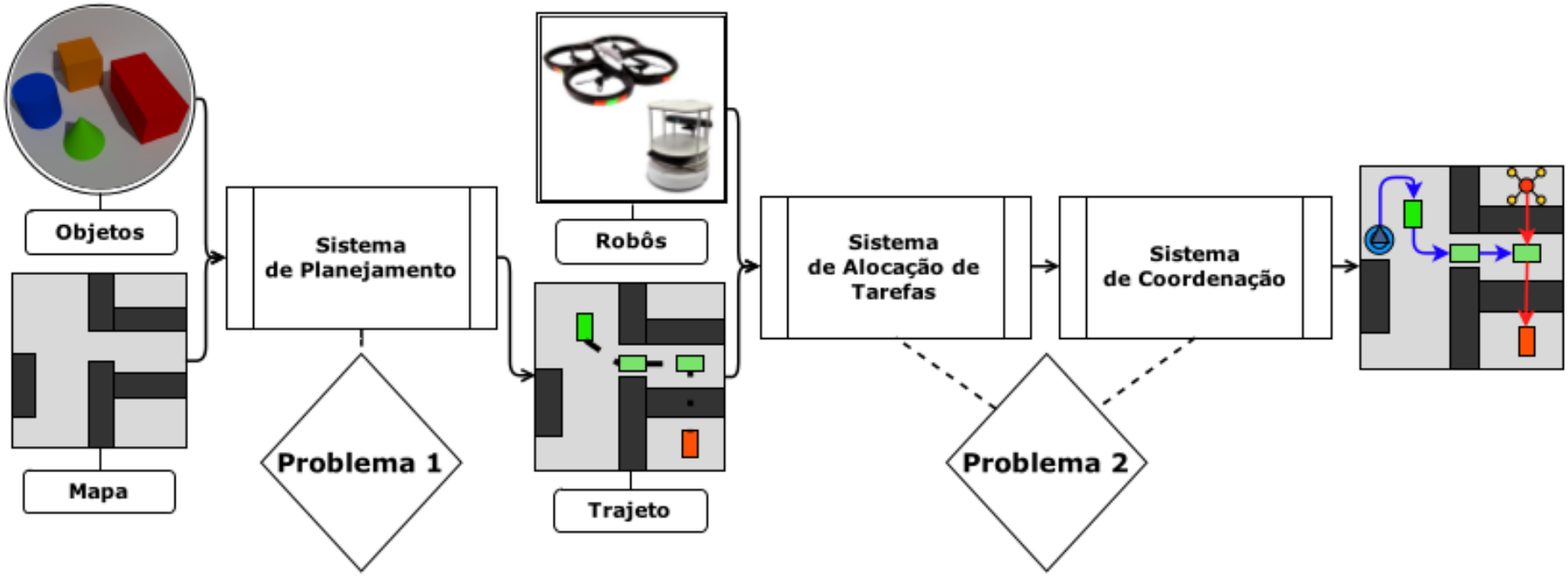
Find a feasible path inside the workspace to each object, starting from its initial position until a desired end position.



Problem 2 *Agents Coordination*

Allocate and Coordinate agents to accomplish each required path of the objects.

Metodology



Metodology Diagram

Utility Function

Quantifies the quality of a plan based on the energy and the drive time of a robot.

$$\Theta(S, r_i) = \beta \times \Upsilon(S, r_i) + \gamma \times \Psi(S, r_i). \quad (1)$$

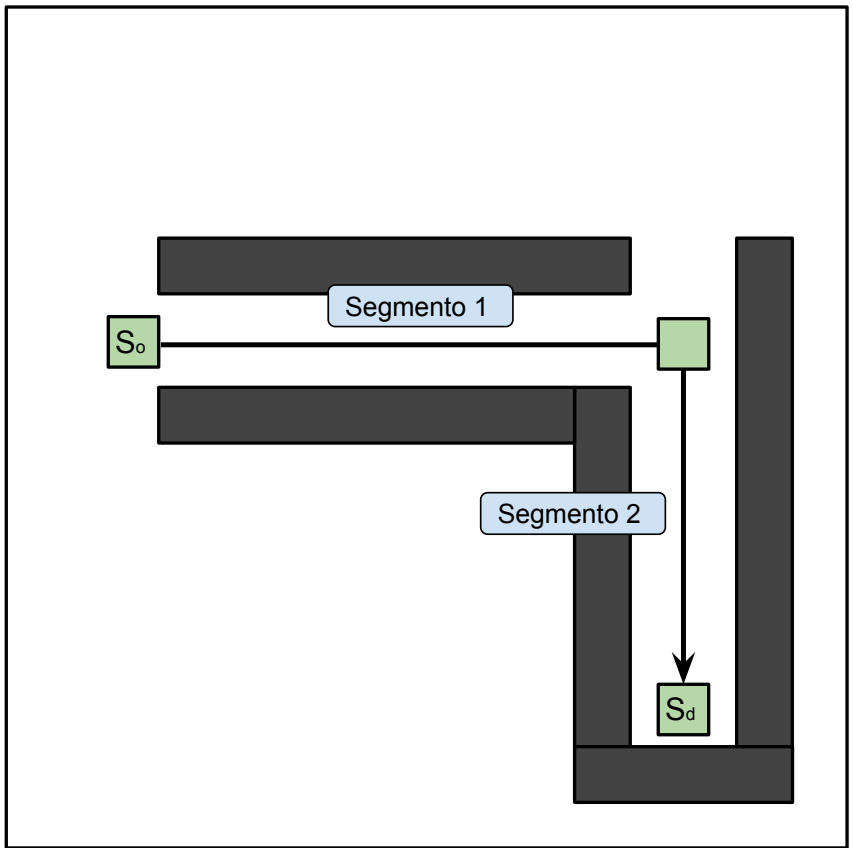
$$\Theta_p(\mathcal{P}) = \sum_{i=1}^{q} \Theta(n_i) \quad (2)$$

S: current state, r_i: robot, $\mathcal{P}$: plan

Path Planning - Object

Planning for a object from set $\mathcal{O}$ has two phases:

1. *Planning*: a travel plan is created;
2. *Segmentation*: the plan is splitted into sub-plans.



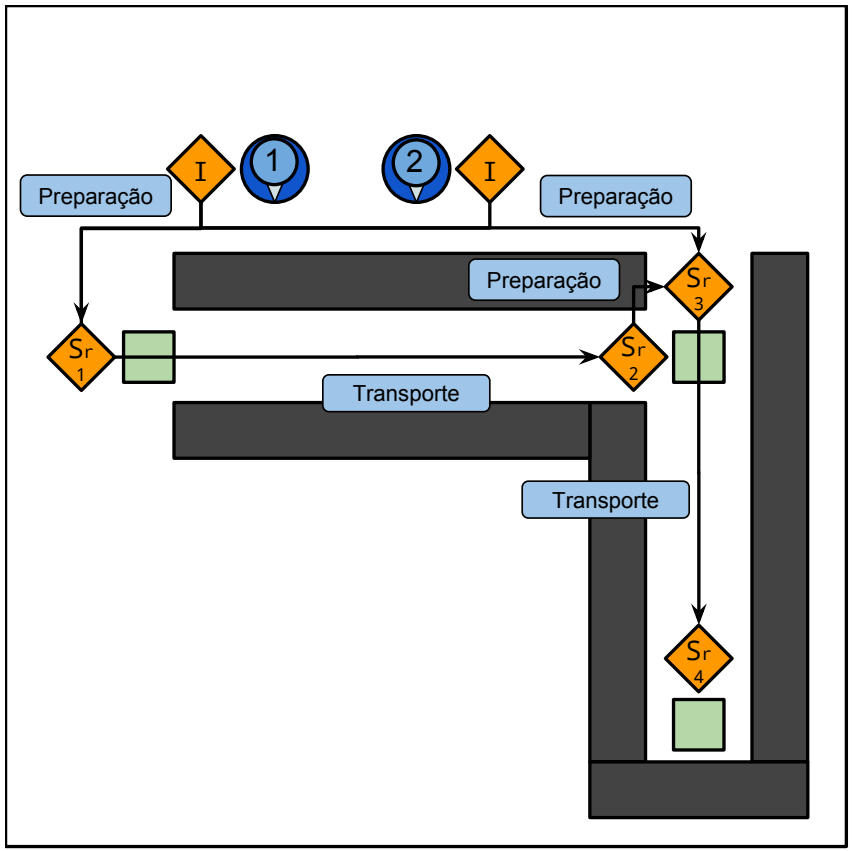
Object Plan

S_o: initial state, S_d: end state

Path Planning - Agents

Based on segments created from the object's plan, for each agent r_i, movimentation plans are created, of two types:

- *Preparation*: plan in which the robot approaches the object to be transported;
- *Transport*: plan used to transport the object.

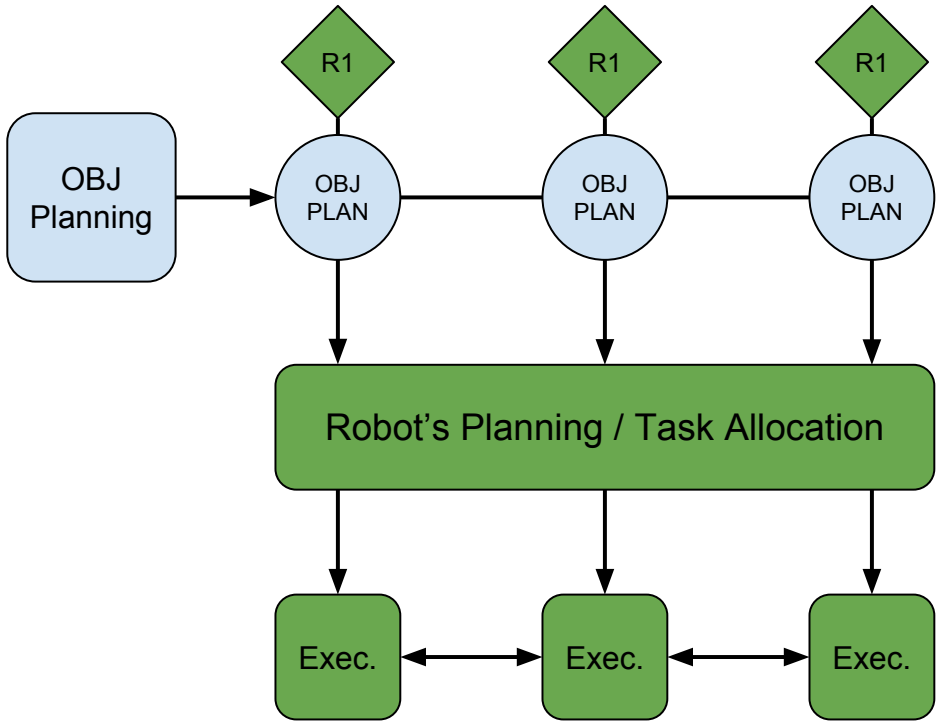


Agent's Plan

Task Allocation

Task Allocation Process:

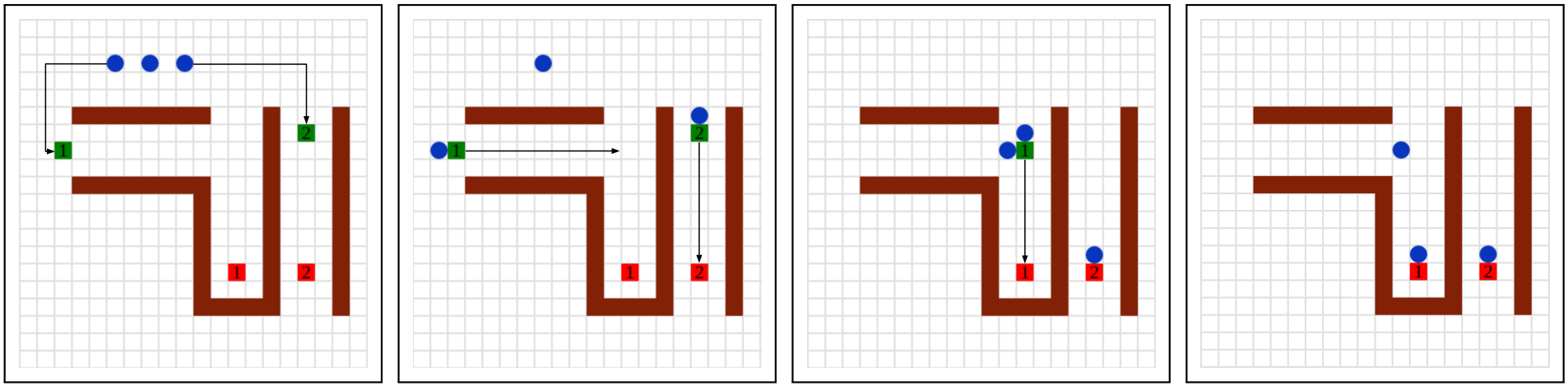
1. Based on the object's plan, each robot create its own plan to transport it;
2. The robots exchange its cost plans, and apply the Hungarian Method the know which robot will do each plan;
3. Repeat the process until all object's plan are allocated.



Allocation Process

Coordination

The coordination process occurs with the exchange of information about the current task that each robot is executing.
When a object is transported by multiple robots, they inform each other to wait until it's possible to execute their tasks.



Experiments