

TREASURE HUNT PROBLEM

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INTRODUCTION TO MULTI-AGENT SYSTEMS

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MASTER IN ARTIFICIAL INTELLIGENCE

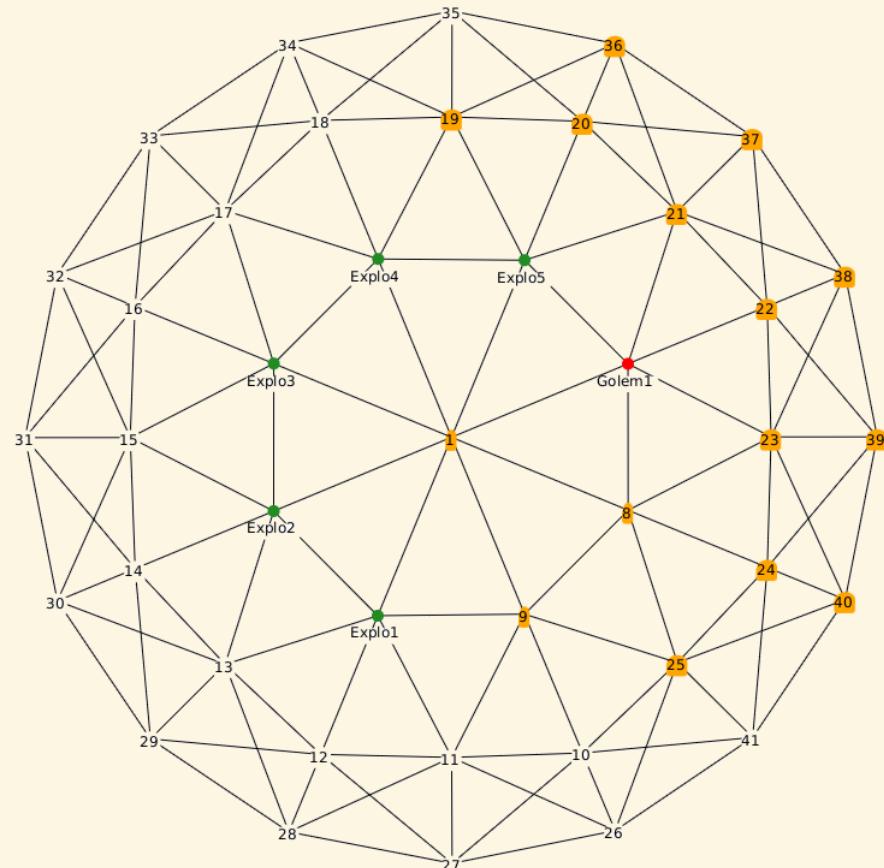
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INTRODUCTION TO MULTI-AGENT SYSTEMS

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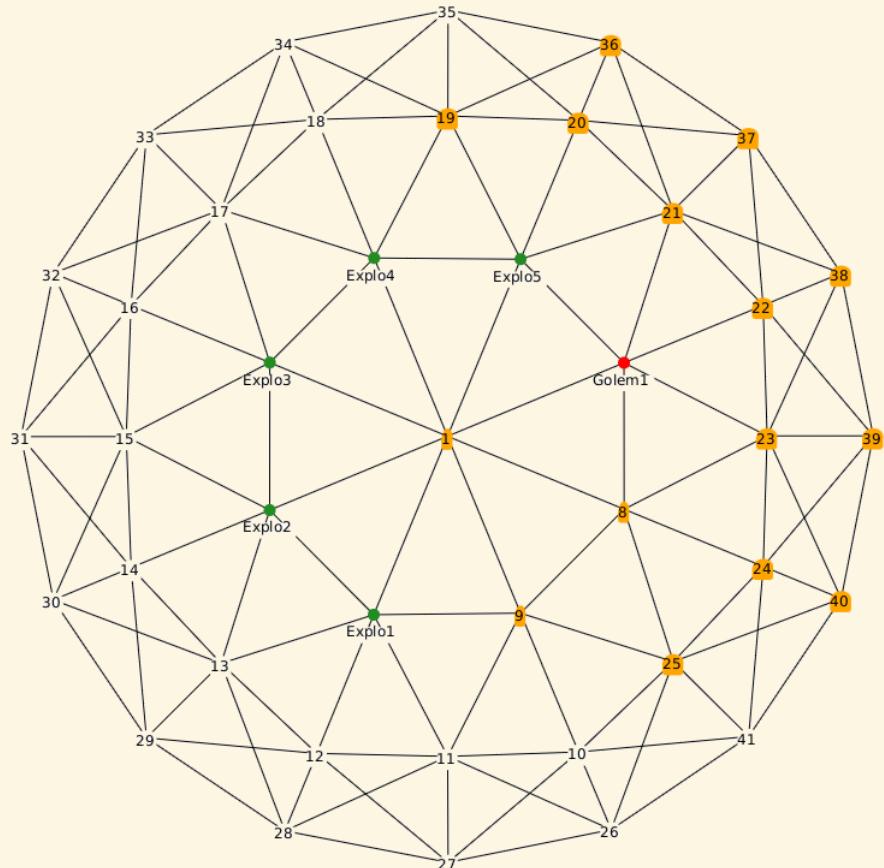
Martín Suárez | Isabel Piedrahita | Mario Rosas | Laura Roldan | Alam López

PROBLEM DESCRIPTION



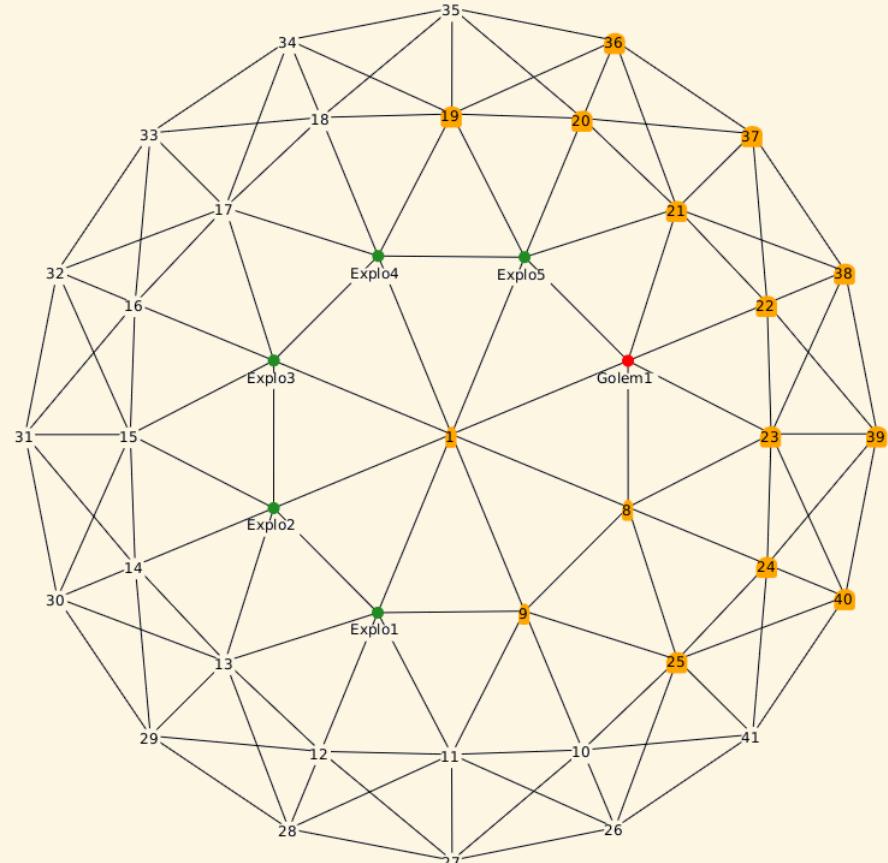
PROBLEM DESCRIPTION

- Implementation of a treasure hunt simulation with the goal of optimizing treasure exploration and collection.



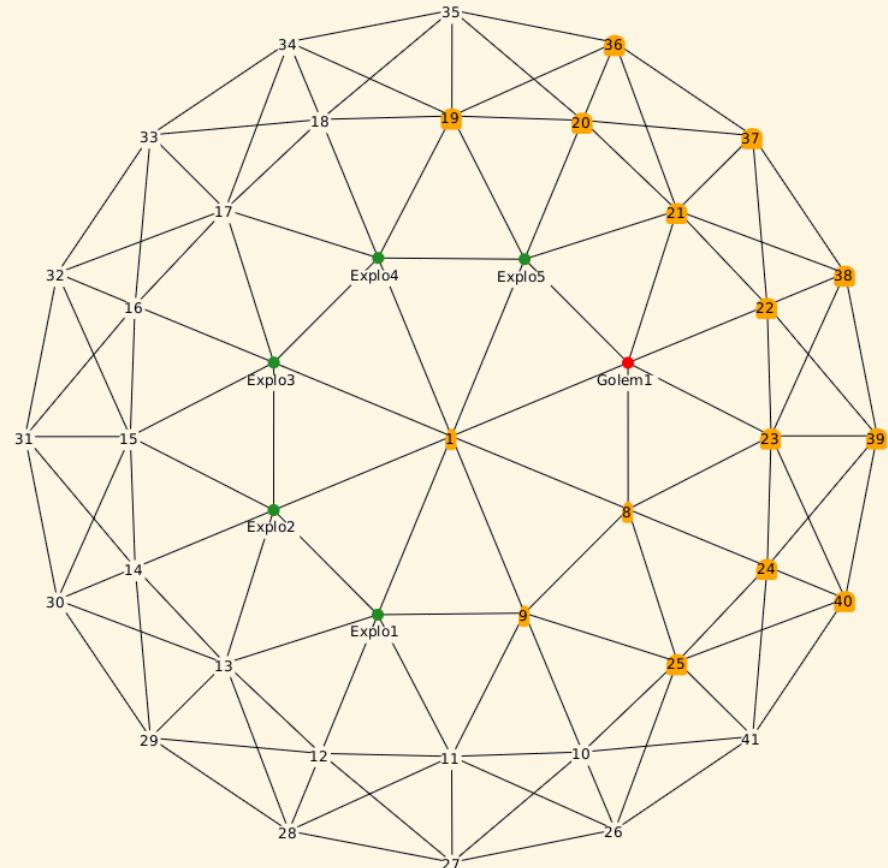
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- Implementation of a treasure hunt simulation with the goal of optimizing treasure exploration and collection.
- Inclusion of various agent types, coordination mechanisms, communication protocols, and cooperation strategies.



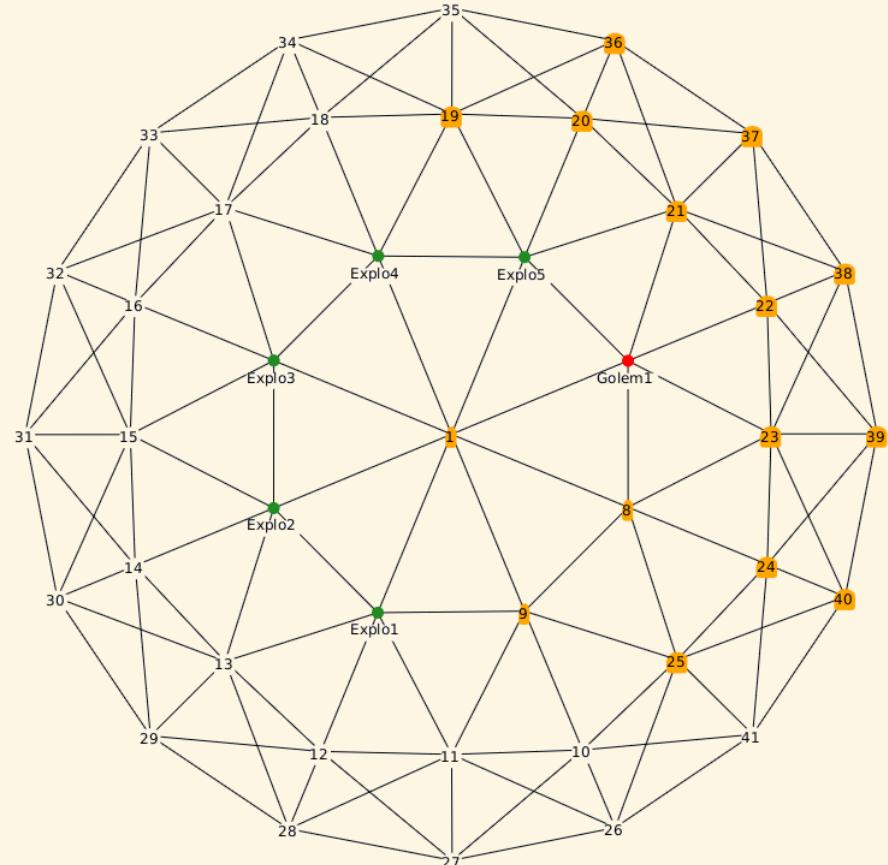
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- Utilization of an undirected graph as the world map.
- Evaluation of time and step requirements for task completion.



RESOURCES & ROADMAP

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MANAGEMENT AND CODING TOOLS



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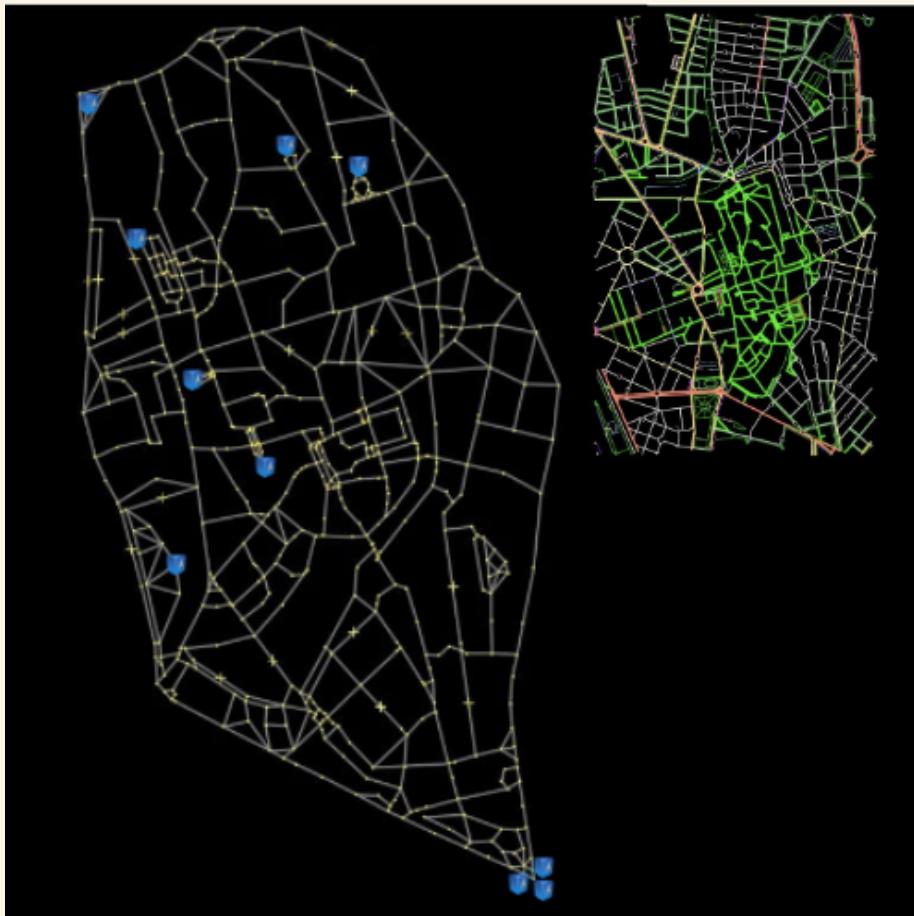


SOLUTION APPROACH ROADMAP



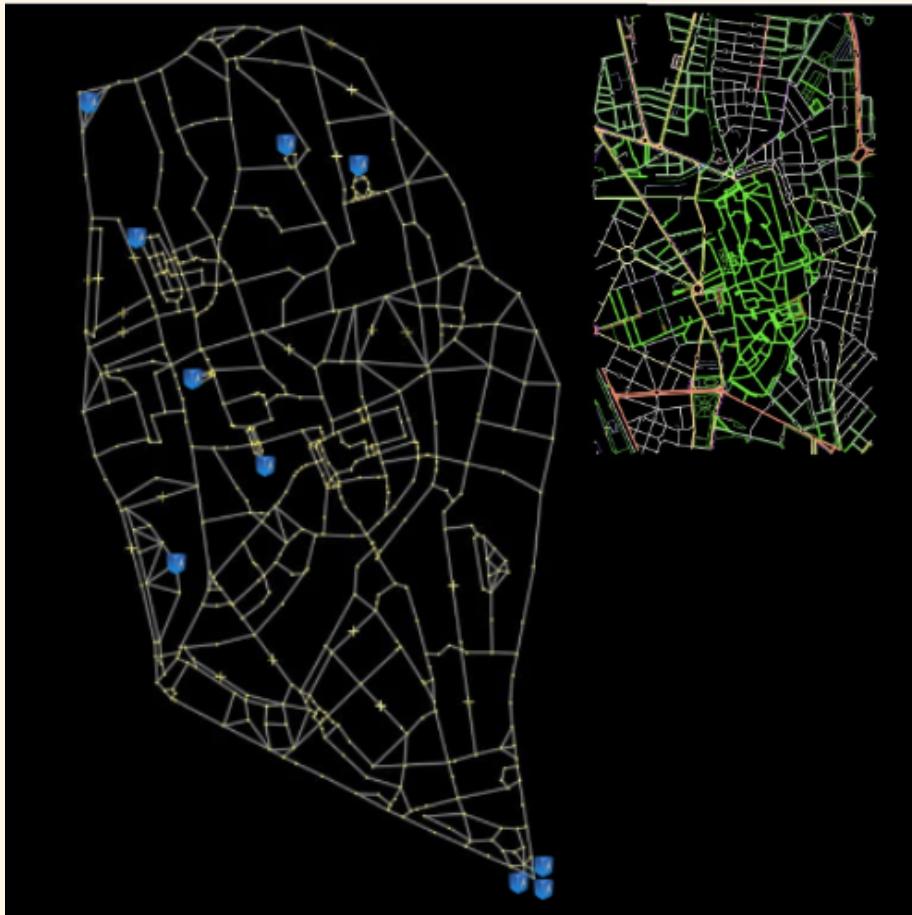
GENERAL ANALYSIS

- Environment Characteristics
- Metrics
- The map



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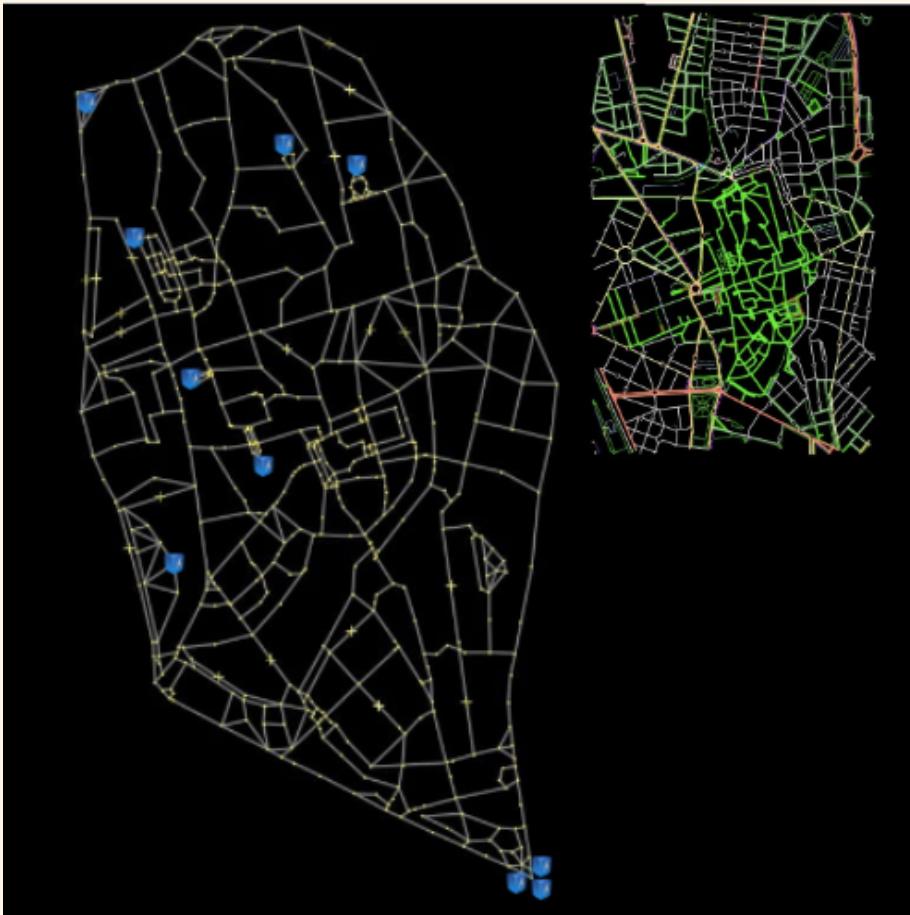


GENERAL ANALYSIS



- Environment Characteristics
 - Partially/Fully observable
 - Deterministic
 - Dynamic
 - Discrete
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GENERAL ANALYSIS



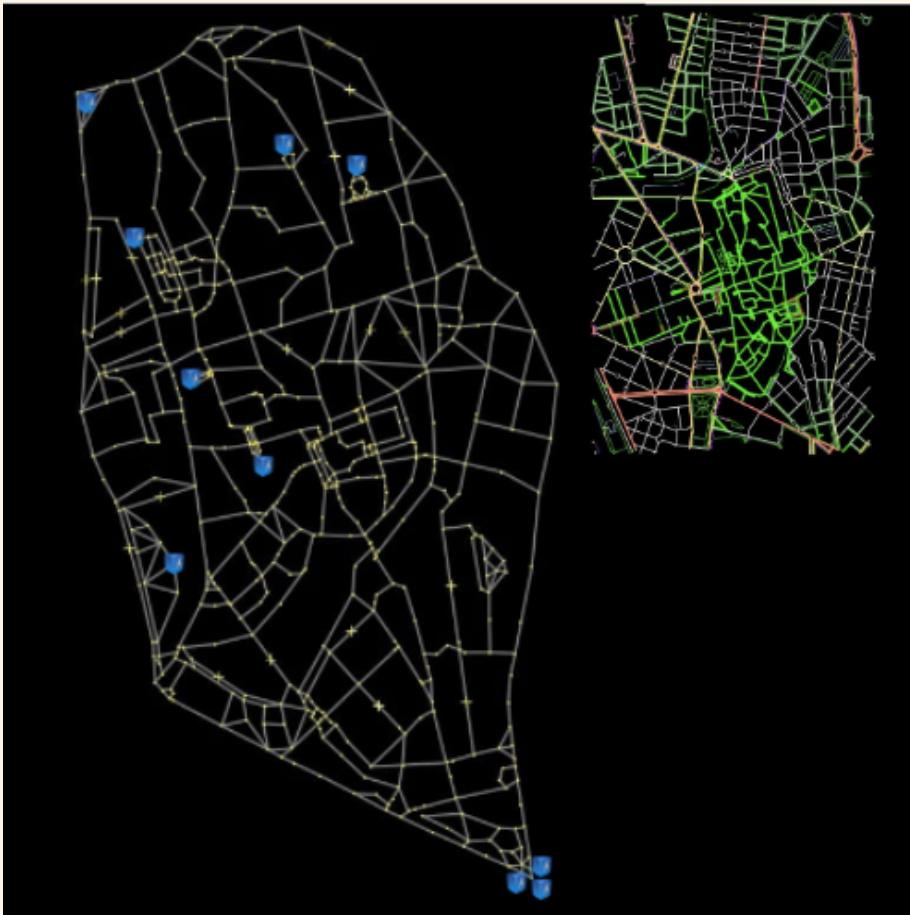
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 - Total collected goal
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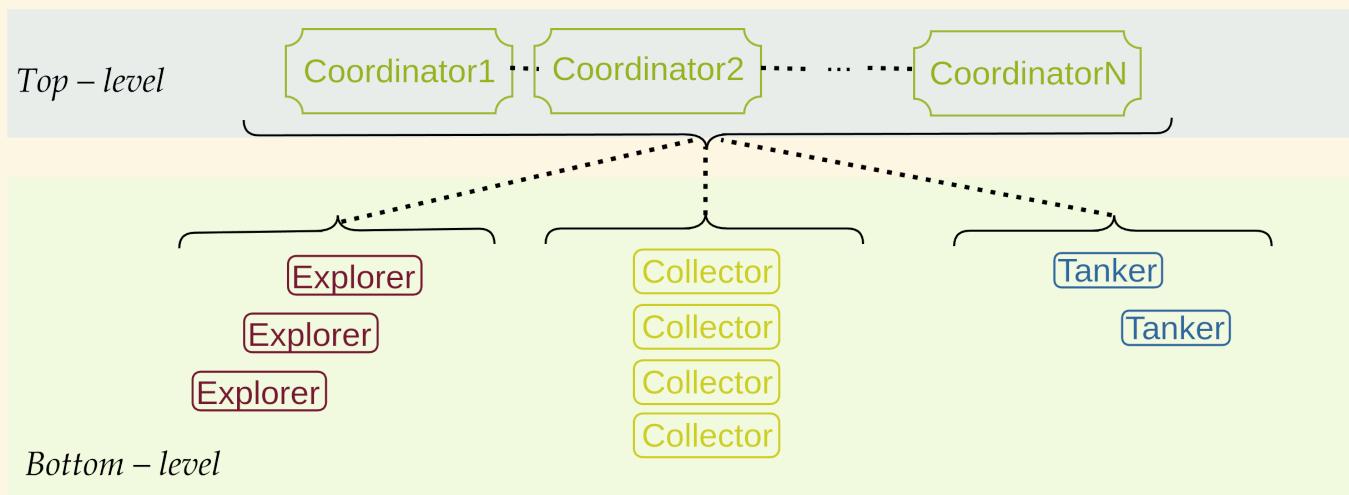
GENERAL ANALYSIS



- **Environment Characteristics**
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- **Metrics**
 - Total collected goal
 - Total collected diamonds
 - Total moves required per agent
- **The map**
 - 547 Nodes
 - Based on León, Spain
 - Undirected, biconnected graph
 - Treasure placement definition

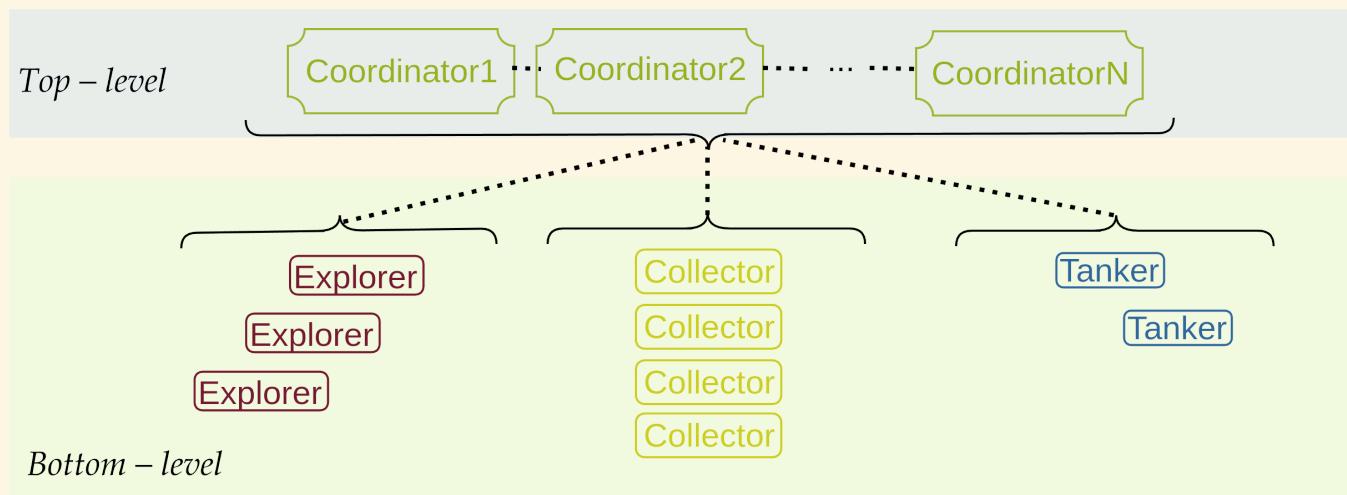
GENERAL SYSTEM ARCHITECTURE

- Architecture Characteristics



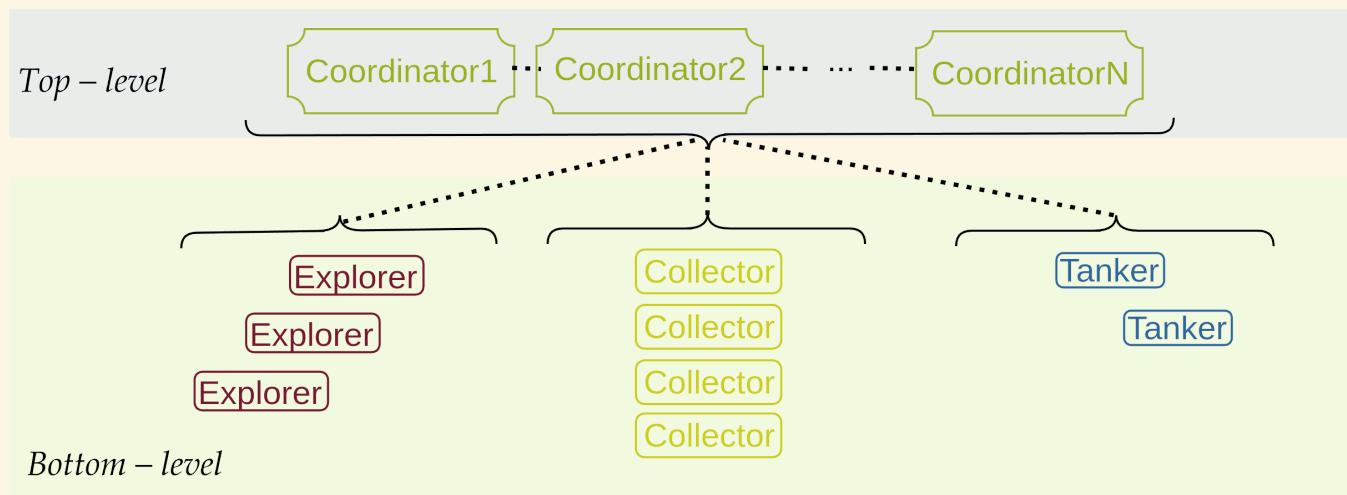
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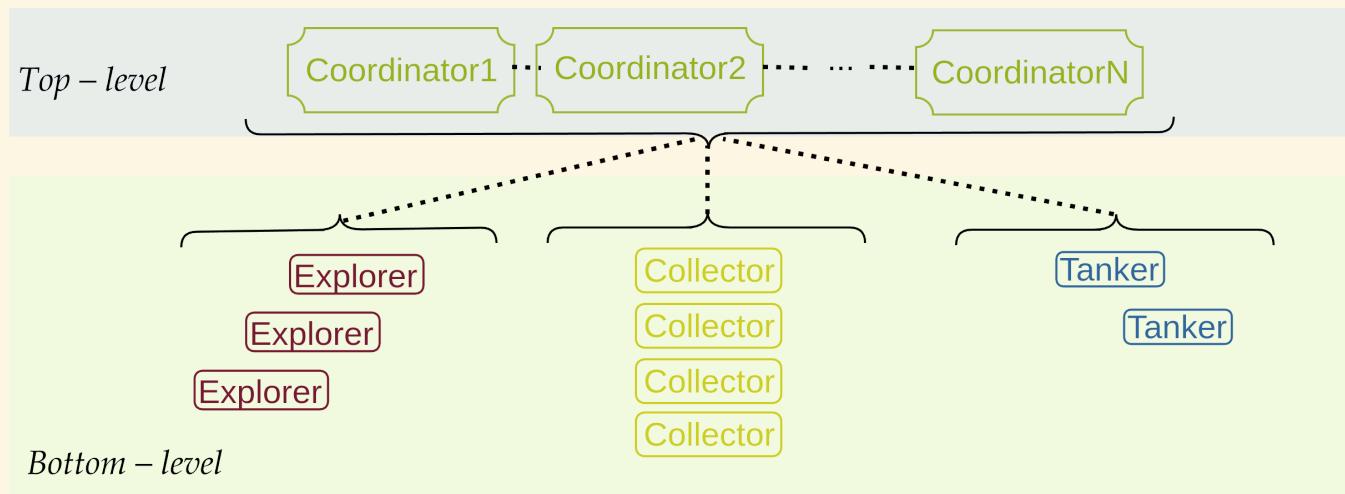
GENERAL SYSTEM ARCHITECTURE

- **Architecture Characteristics**
 - Hierarchical



GENERAL SYSTEM ARCHITECTURE

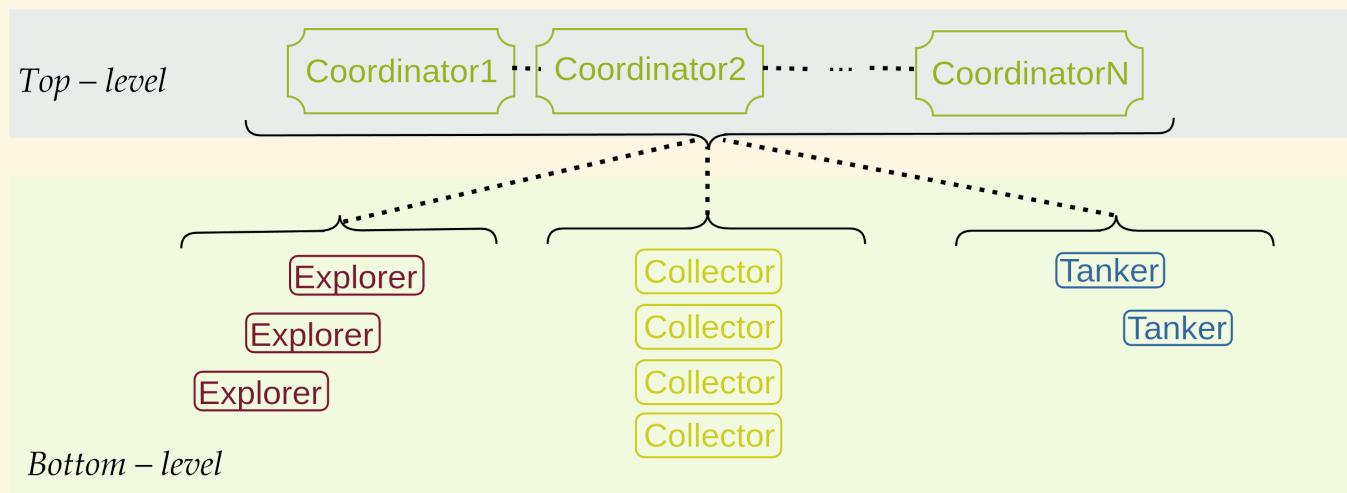
- **Architecture Characteristics**
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 - Efficient task distribution and coordination



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- **Architecture Characteristics**

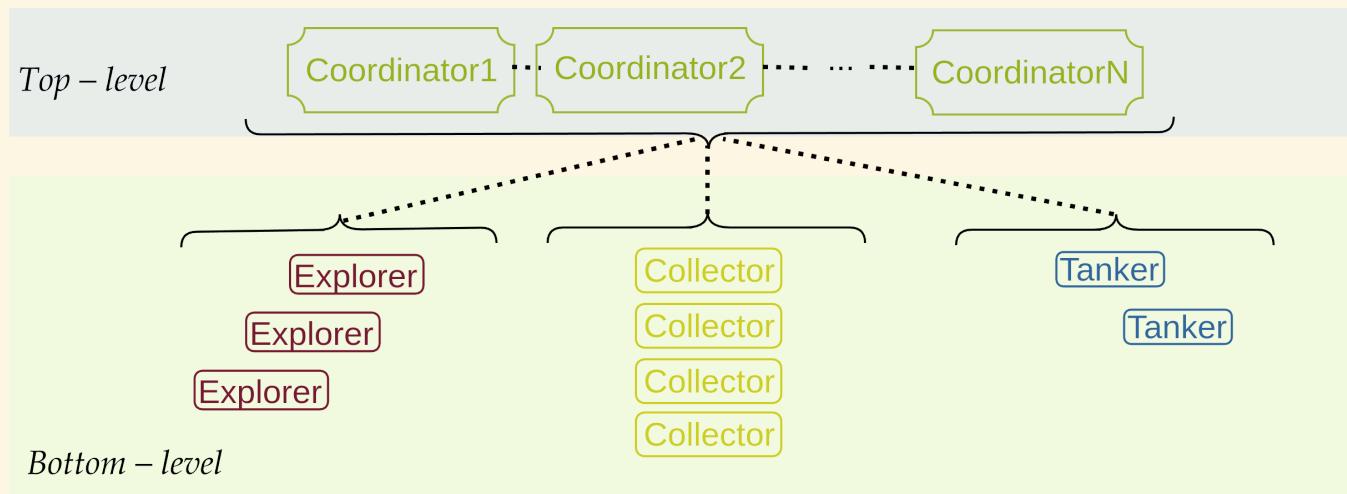
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- Efficient task distribution and coordination
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GENERAL SYSTEM ARCHITECTURE

- **Architecture Characteristics**

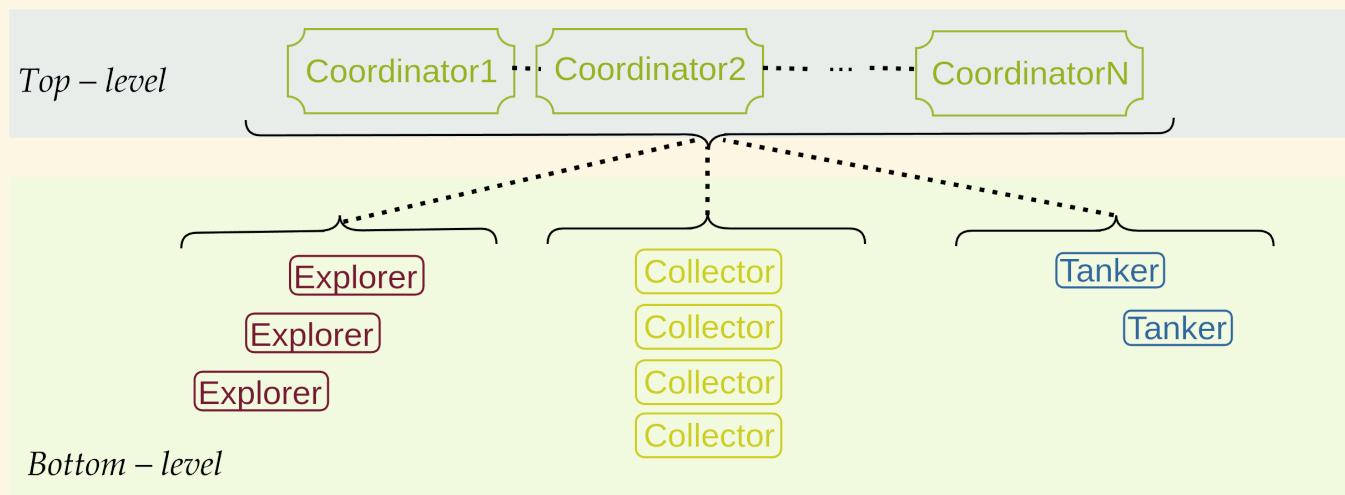
- Hierarchical
- Efficient task distribution and coordination
- Multi-level control
- Overall statistical measures



GENERAL SYSTEM ARCHITECTURE

- **Architecture Characteristics**

- Hierarchical
- Efficient task distribution and coordination
- Multi-level control
- Overall statistical measures
- Focus and Adaptability



AGENTS DEFINITION

COORDINATOR



• Responsibilities

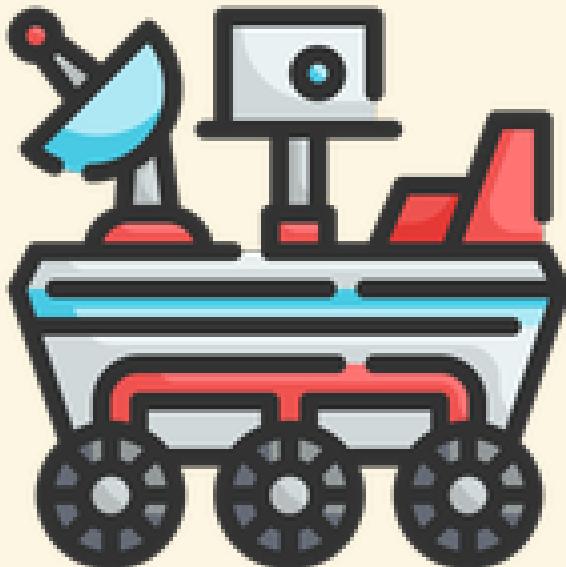
- Focus on long-term global objectives
- Keep track of the environment state
- Maintain statistics
- Facilitate communication between agents
- Mobilizing the agents to treasure spots when necessary

Coordinator agents properties

Agent	Gold Cap.	Diamond Cap.	Detection Radius	Lock picking	St
Coordinator	-1	-1	0	-1	

AGENTS DEFINITION

EXPLORER



- **Characteristics**

- Systematically explore the unknown terrain
- Construct a comprehensive map of the environment
- Communicate environment updates while exploring
- Lockpicking and Strength, no carrying capacity

Coordinator agents properties

Agent	Gold Cap.	Diamond Cap.	Detection Radius	Lock picking	Strength
Explorer1	-1	-1	0	2	3
Explorer2	-1	-1	0	3	2
Explorer3	-1	-1	0	3	2

AGENTS DEFINITION

COLLECTOR



• Responsibilities

- Transport treasure to tankers
- Limited carrying capacity of either gold or diamonds
- Moderate lockpicking & strength
- Help coordinators, travel to treasure spots
- Update about environment status

Coordinator agents properties

Agent	Gold Cap.	Diamond Cap.	Detection Radius	Lock picking	Strength
Collector1	50	-1	0	1	
Colector2	50	-1	0	1	
Collector3	-1	50	0	1	
Collector4	-1	50	0	1	

AGENTS DEFINITION

TANKER



- **Responsibilities**

- Store the collected treasure
- High carrying capacity of gold and diamond
- Move freely around the map
- Attend a storage treasure request

Coordinator agents properties

Agent	Gold Cap.	Diamond Cap.	Detection Radius	Lock picking	Strength
Tanker1	400	400	0	0	0
Tanker2	400	400	0	0	0

PROBLEM DECOMPOSITION

- Map Exploration



- Deadlock Management



- Treasure collection

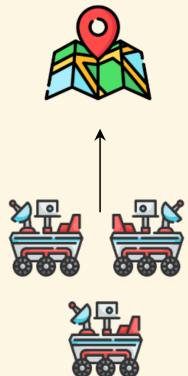


- Communication and Information Sharing
- Basic Behaviours and Dynamic Task Allocation



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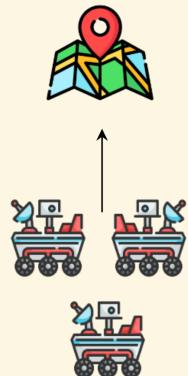


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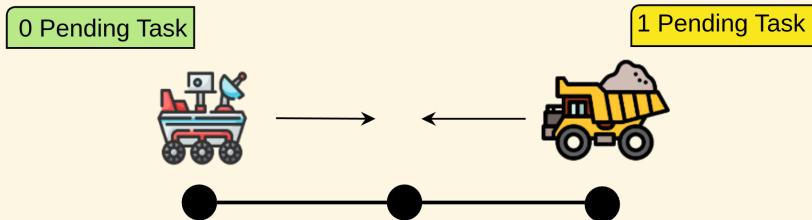


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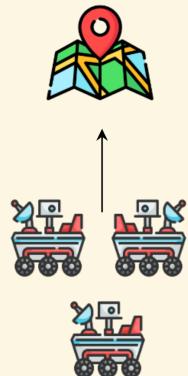


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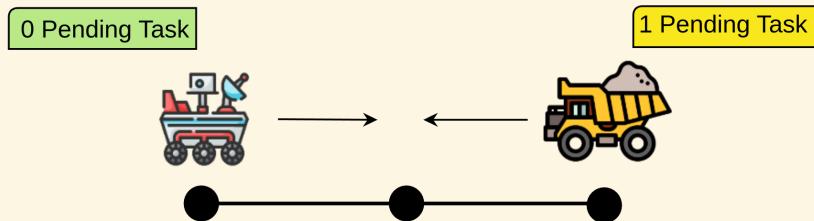


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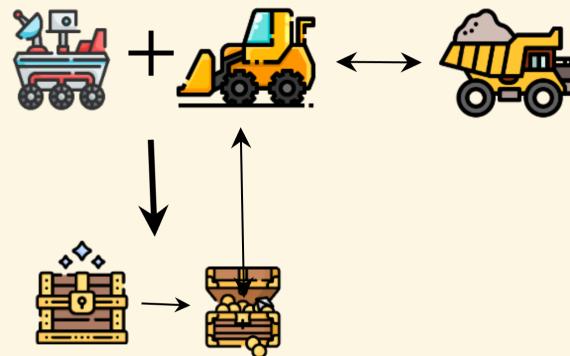
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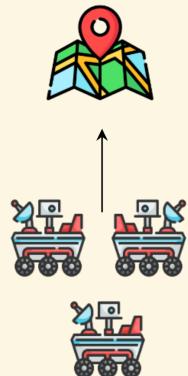


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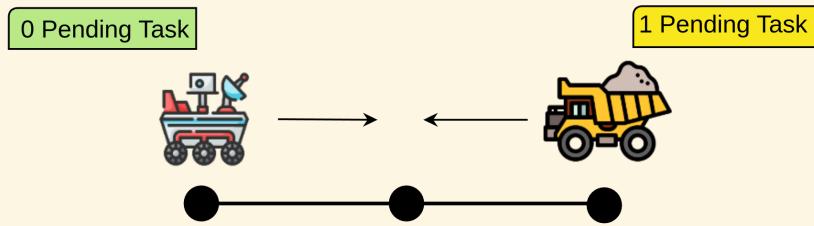


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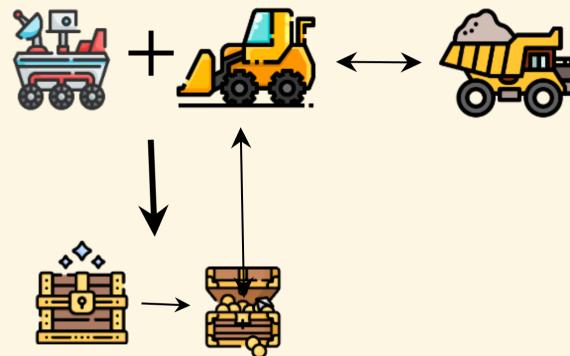
- Map Exploration



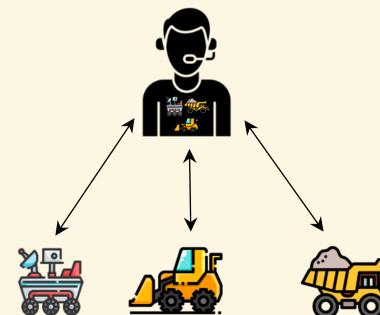
- Deadlock Management



- Treasure collection

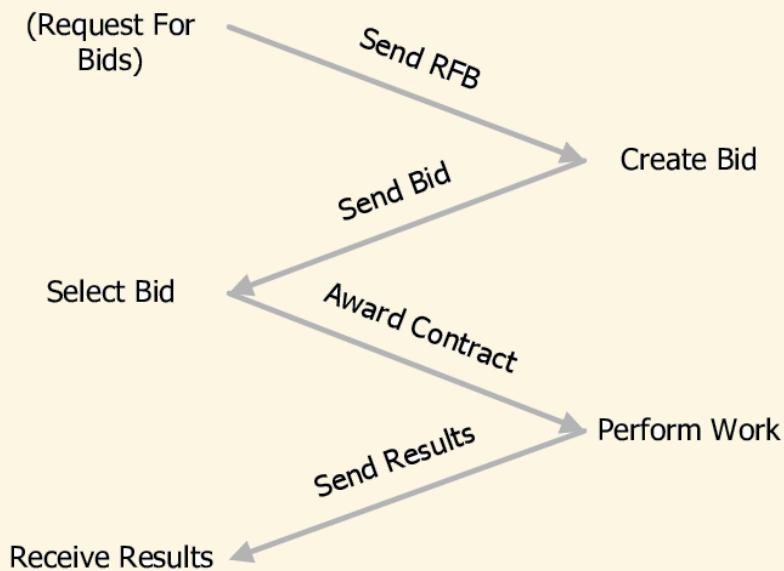


- Communication and Information Sharing
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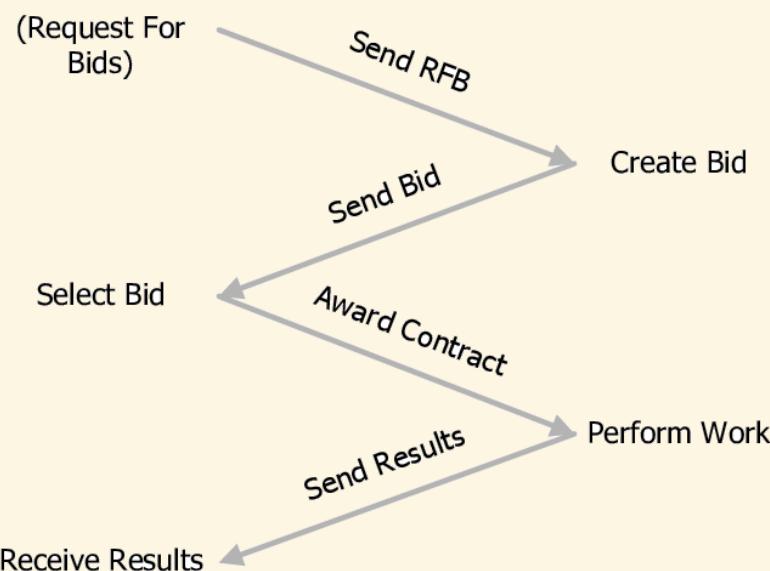


TASK SHARING

TASK SHARING



TASK SHARING



CONTRACT NET

Managers - Coordinators

Contractors - Low-level agents

Contract	Contractors	Cost function
Safe opening	A small icon showing a red truck and a yellow crane.	$C = d + \alpha (lp_a)$
Treasure collection	A small icon showing a yellow excavator.	$C = d$

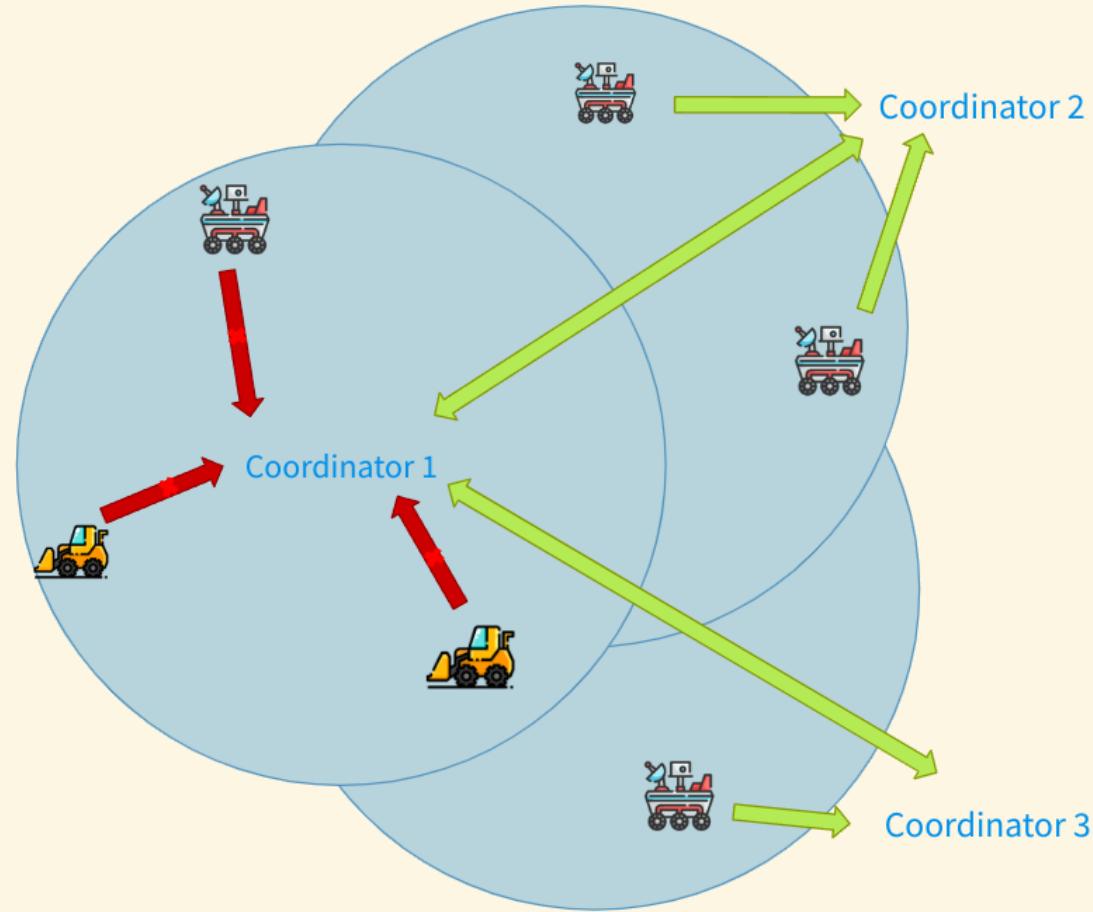
**TASK
SHARING**

**BROADCASTING
CONTRACTS**

**TASK
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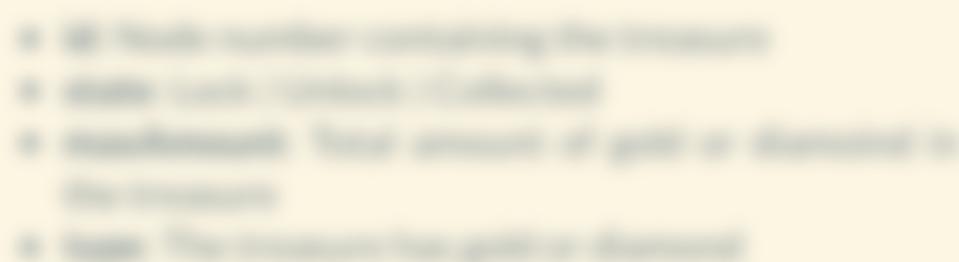
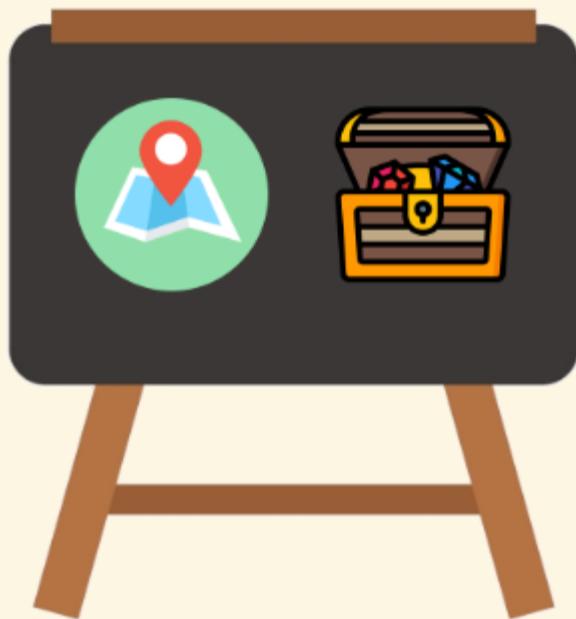
**BROADCASTING
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TASK SHARING BROADCASTING CONTRACTS



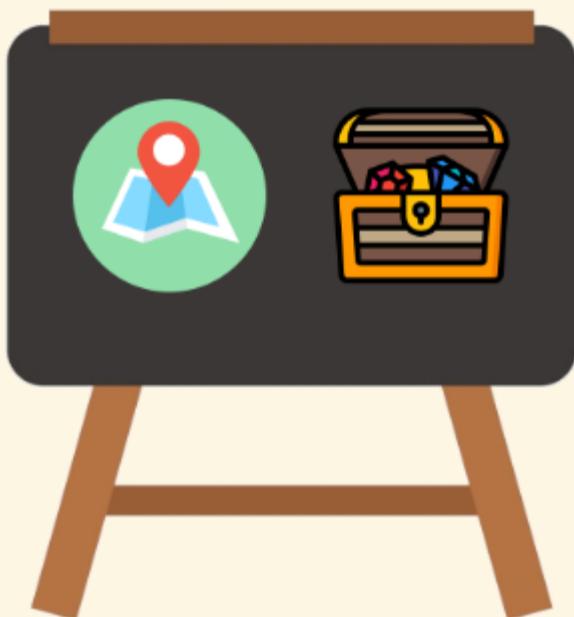
RESULTS SHARING

BLACKBOARD

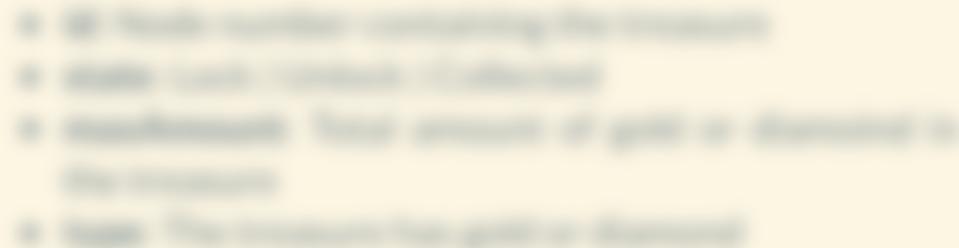


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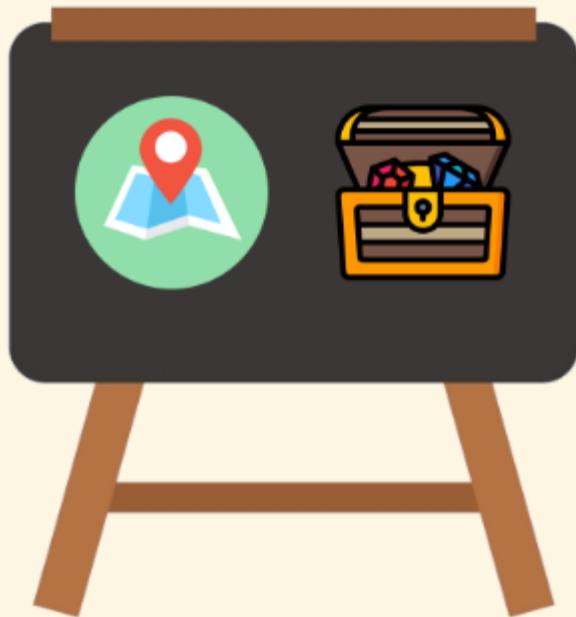


- Current state of progress on the map and treasures



RESULTS SHARING

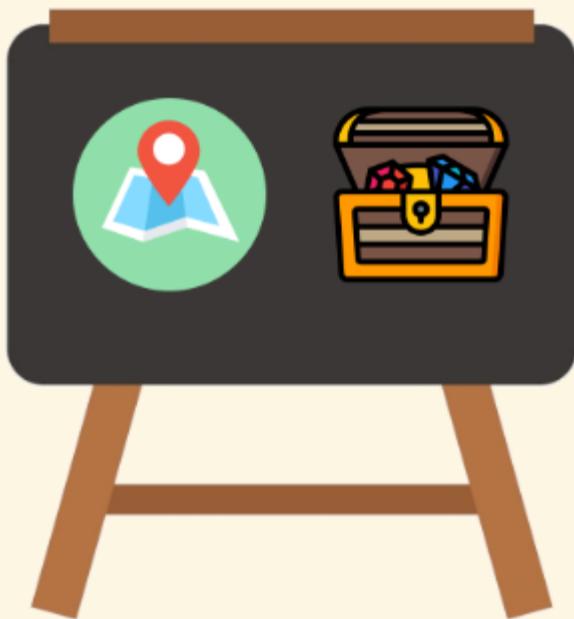
BLACKBOARD



- Current state of progress on the map and treasures
- Global list with different access levels according to the type of agent

RESULTS SHARING

BLACKBOARD

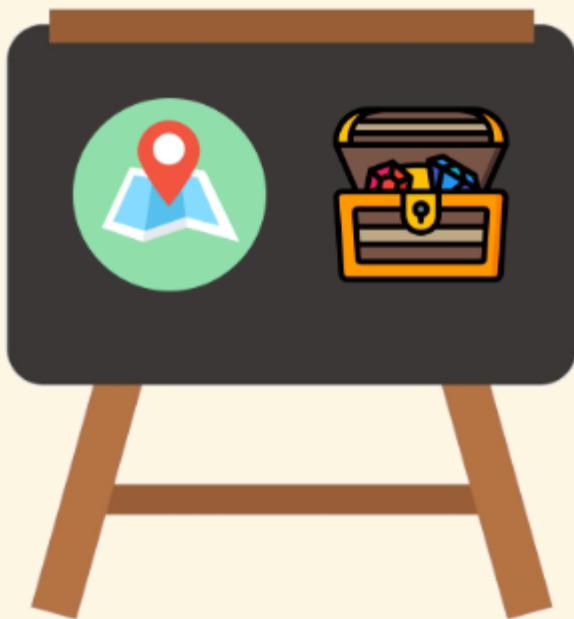


- Current state of progress on the map and treasures
- Global list with different access levels according to the type of agent
- Treasure info in the blackboard:

...
...
...
...

RESULTS SHARING

BLACKBOARD



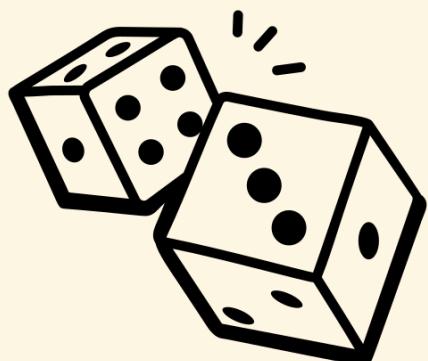
- Current state of progress on the map and treasures
- Global list with different access levels according to the type of agent
- Treasure info in the blackboard:
 - id: Node number containing the treasure
 - state: Lock | Unlock | Collected
 - maxAmount: Total amount of gold or diamoind in the treasure
 - type: The treasure has gold or diamond

SOCIAL NORMS



SOCIAL NORMS

- Deadlock Handling



SOCIAL NORMS



• [View](#)



• [View](#)



• [View](#)



SOCIAL NORMS

- Proactive Lock-Picking



SOCIAL NORMS



• [View](#)



• [View](#)



• [View](#)



SOCIAL NORMS

- Send tanker to collector that needs it



SOCIAL NORMS



• [View](#)



• [View](#)



• [View](#)



SOCIAL NORMS

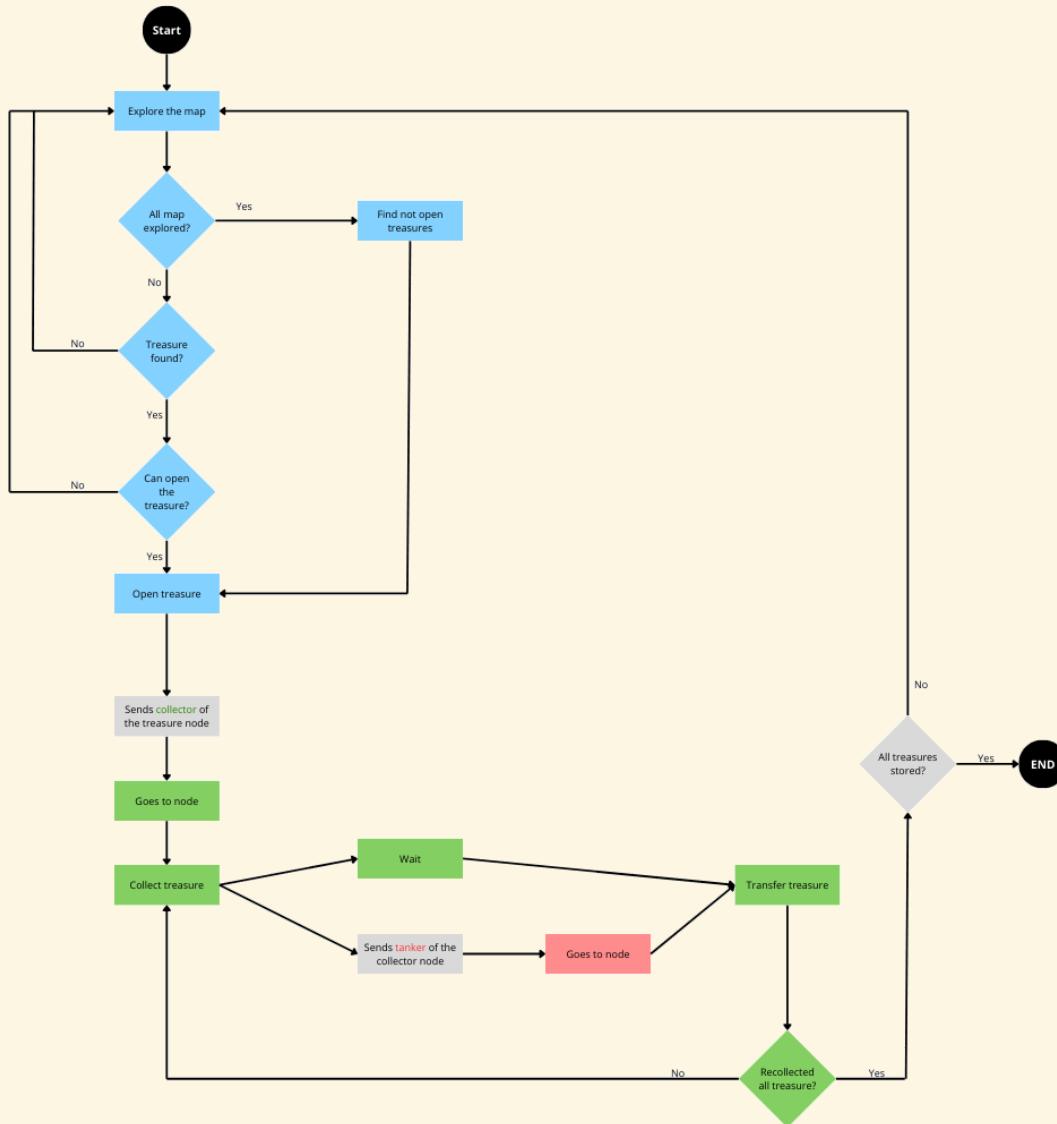
- Explorer lockpicking after mapping



AGENT BEHAVIOURS

While each agent shares a common basic behavior in terms of movement and properties **each agent is assigned different tasks** that introduce significant variations in their roles.





AGENT BEHAVIOURS

MAP REPRESENTATION

```
1 /**
2  * Adds a new treasure with the specified ID, amount, and type to the map.
3  * @param id      The unique identifier for the treasure.
4  * @param amount  The amount of the treasure.
5  * @param type    The type of the treasure (e.g., "GOLD" or "DIAMOND")
6 */
7 public void addTreasure(int id, int amount, String type) {
8     // Implementation goes here
9 }
10
11 /**
12  * Unlocks a treasure with the specified ID.
13  * @param id The unique identifier of the treasure to unlock.
14 */
15 public void unlockTreasure(int id) {
```

MAP REPRESENTATION

```
3     * @param id       The unique identifier for the treasure.
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18
```

MAP REPRESENTATION

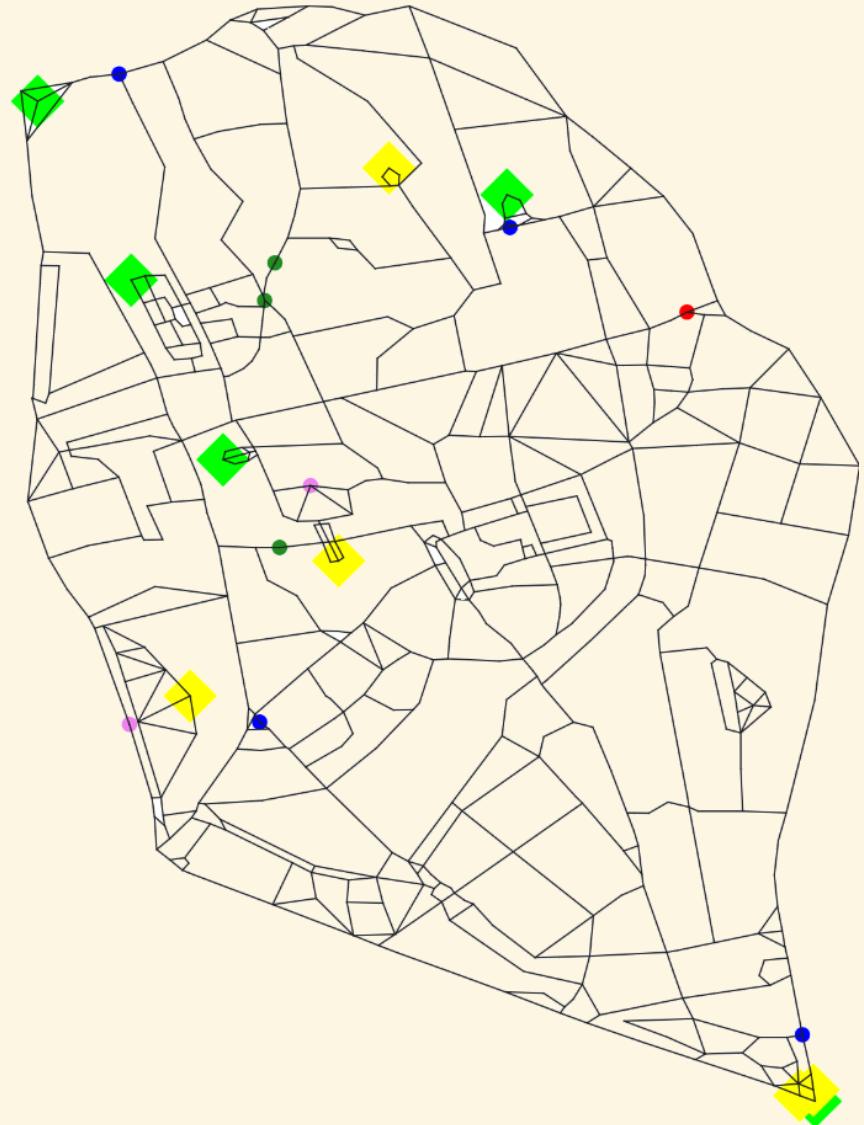
```
21 * @param id The unique identifier of the treasure to check.  
22 * @return True if the treasure is unlocked, false otherwise.  
23 */  
24 public boolean checkUnlocked(int id) {  
25     // Implementation goes here  
26 }  
27  
28 /**  
29 * Updates the state of a treasure with the specified ID to "COLLECTED".  
30 * @param id The unique identifier of the treasure to update.  
31 */  
32 public void updateTreasure(int id) {  
33     // Implementation goes here  
34 }  
35
```

MAP REPRESENTATION

```
35 /**
36  * Returns a list of unlocked treasures.
37  * @return A list of unlocked treasures.
38  */
39
40 public List<Treasure> getUnlockedTreasures() {
41     // Implementation goes here
42 }
43
44 /**
45  * Returns a list of all treasures.
46  * @return A list of all treasures, including locked and unlocked ones.
47 */
48 public List<Treasure> getTreasures() {
49     // Implementation goes here
50 }
```

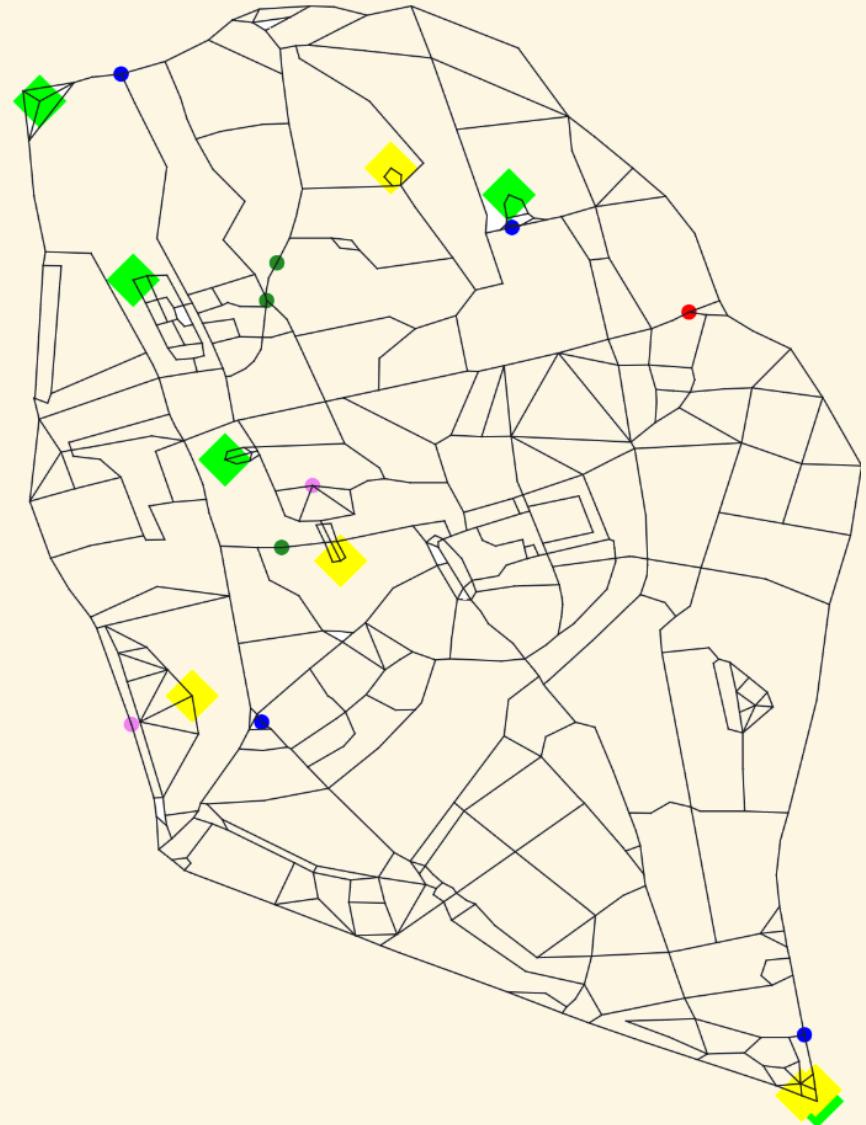
RESULTS

- Metrics
- Our experiments



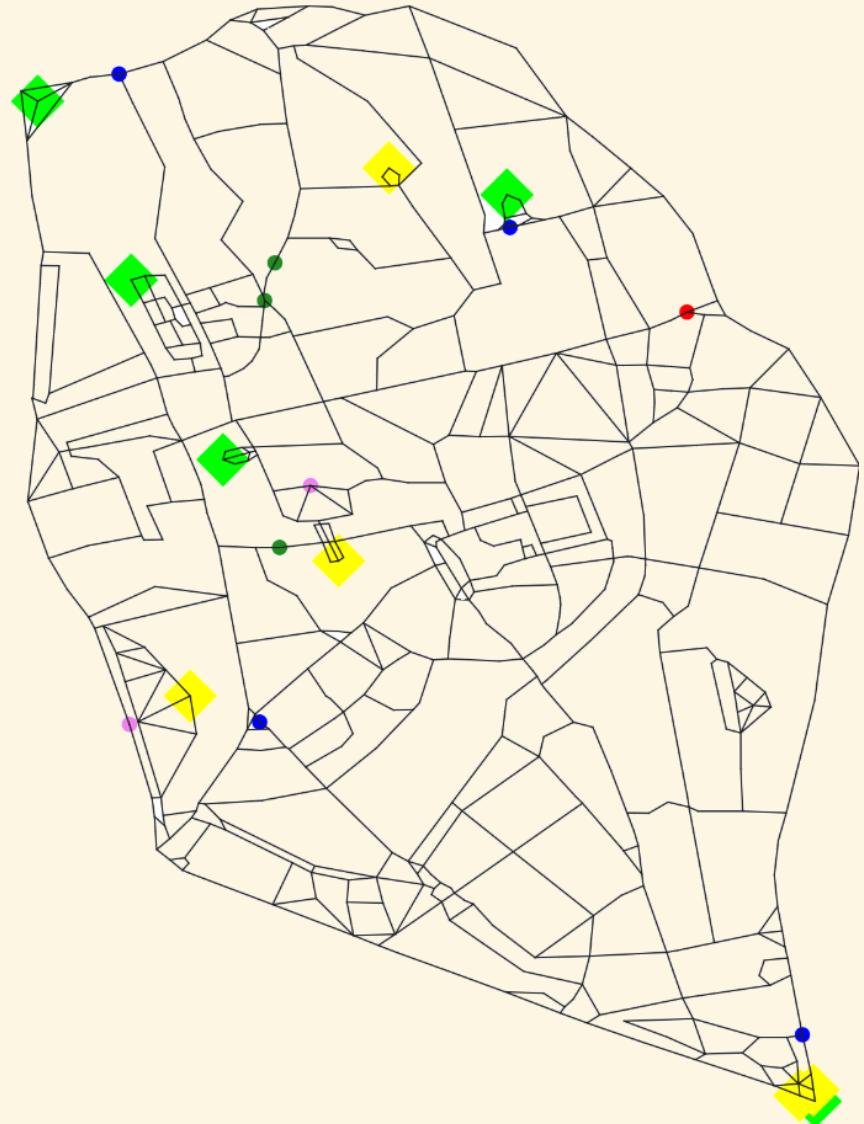
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 - Amount of gold obtained
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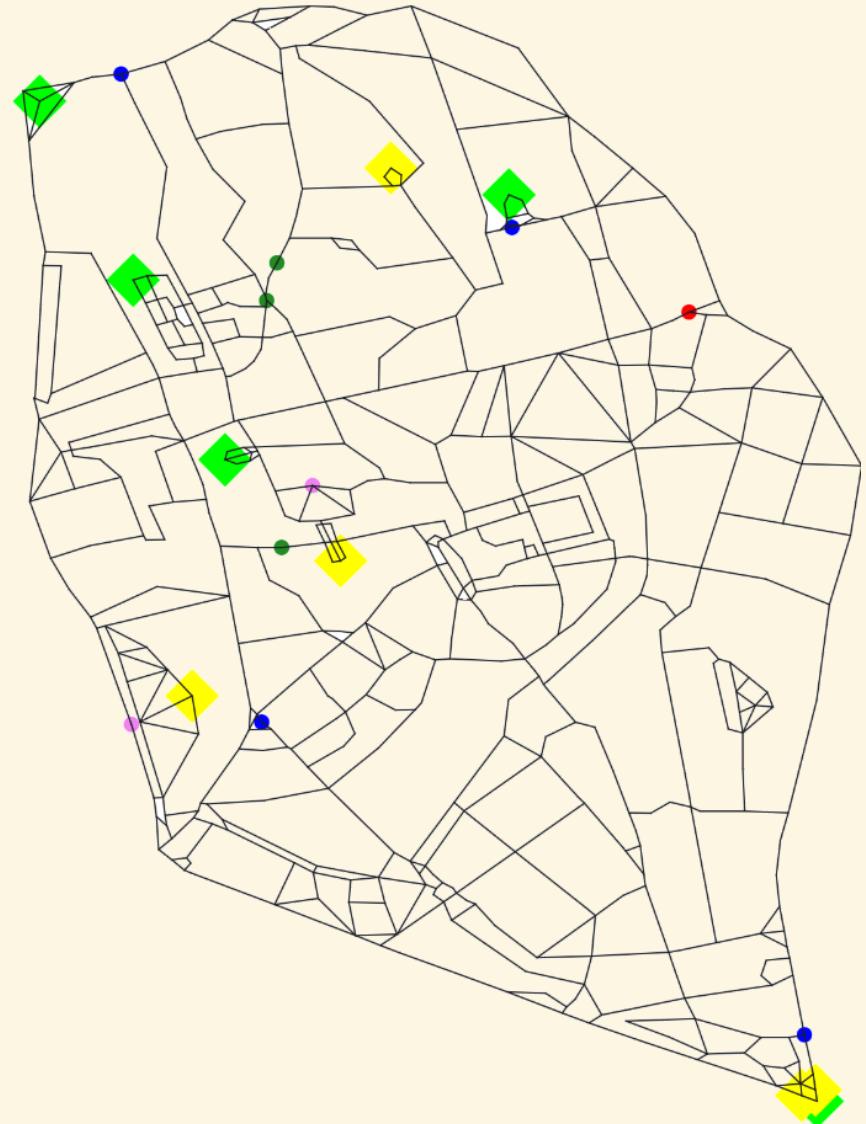
RESULTS

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 - Amount of diamonds obtained
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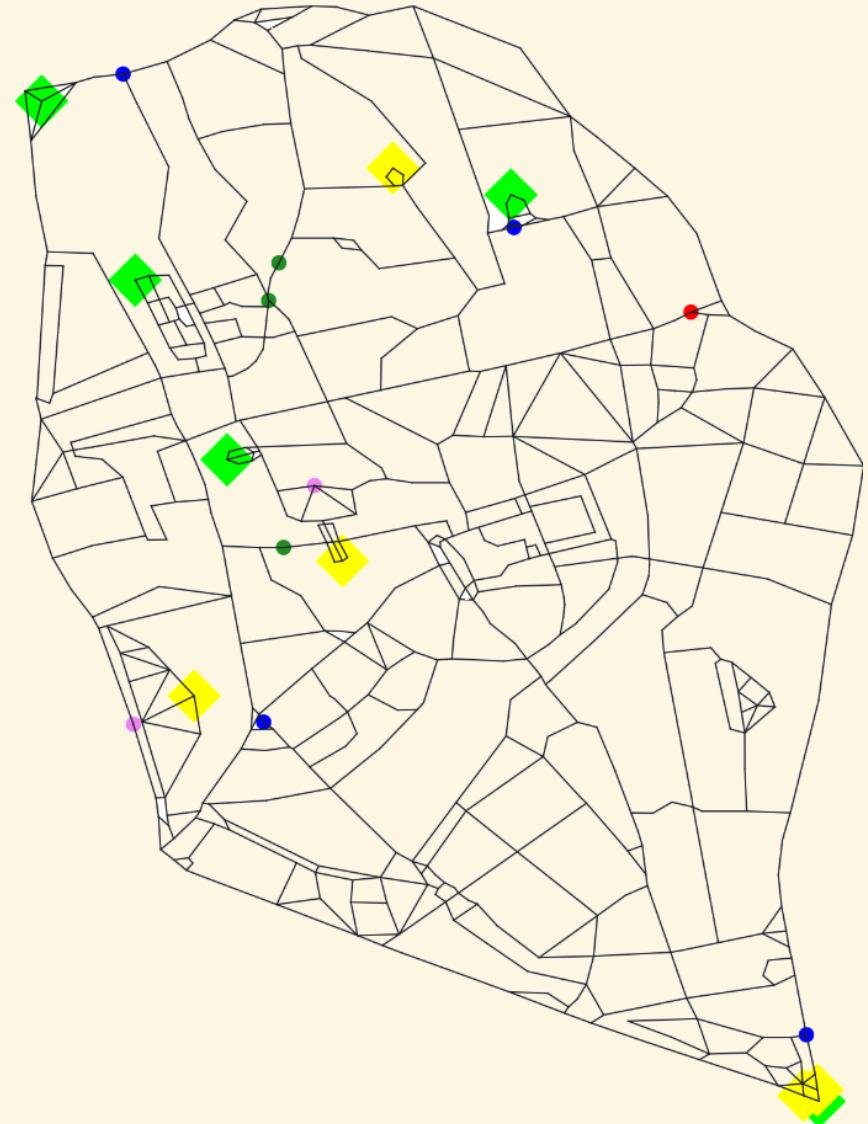
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 - Amount of gold obtained
 - Amount of diamonds obtained
 - Number of movements per agent
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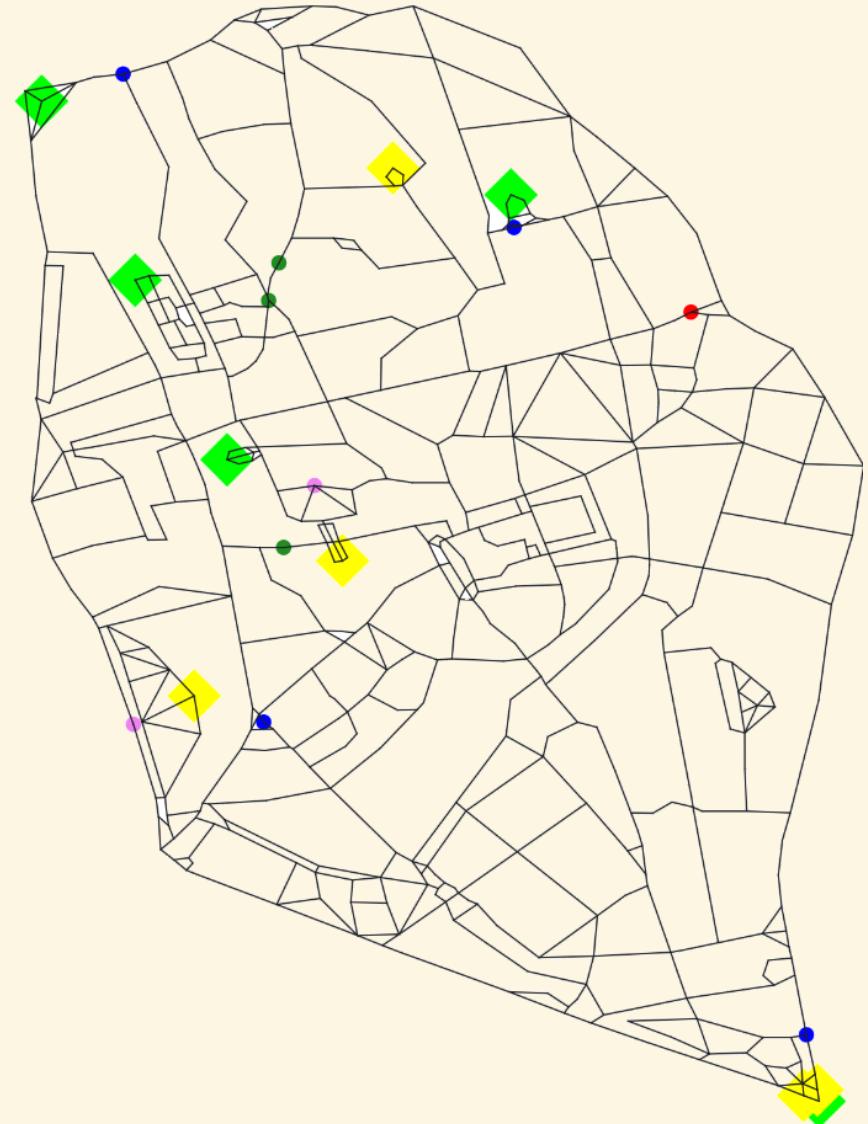
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 - Gathered the 100 gold and 100 diamond treasures



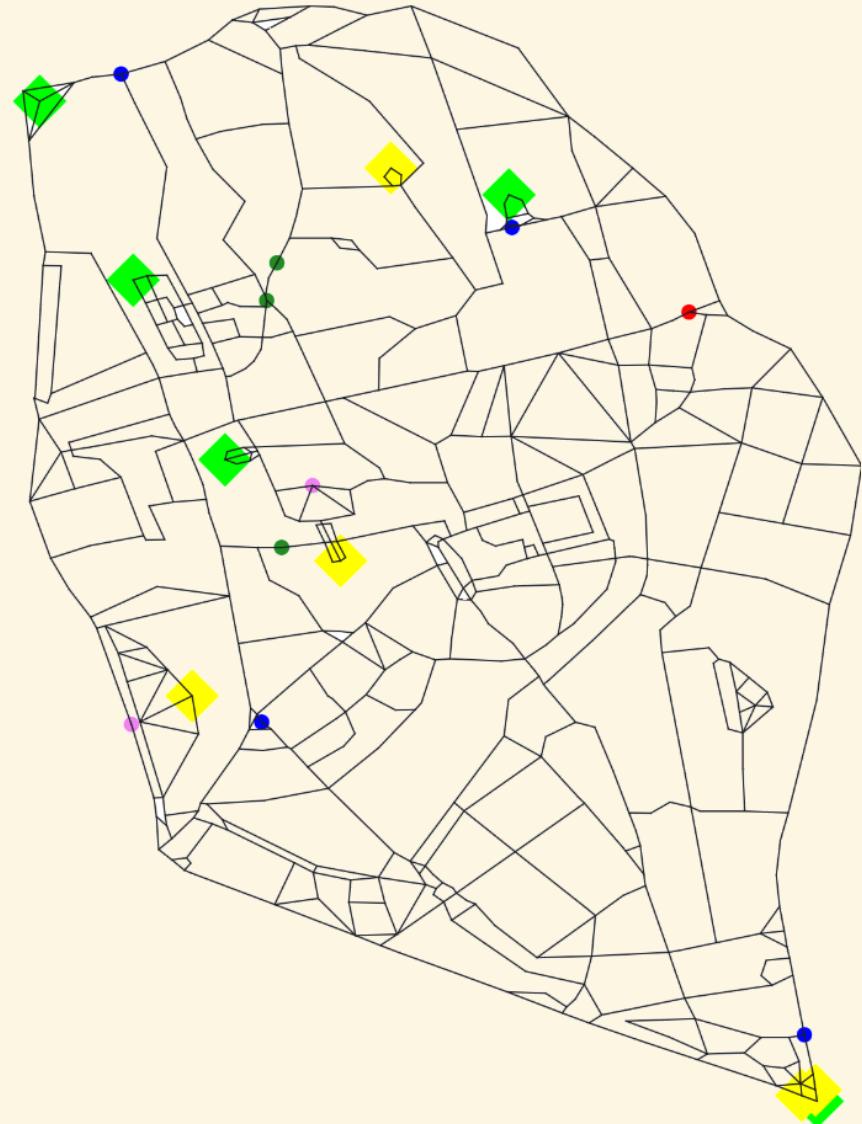
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 - Execution times: $2 \text{ min} \pm 5 \text{ seg}$



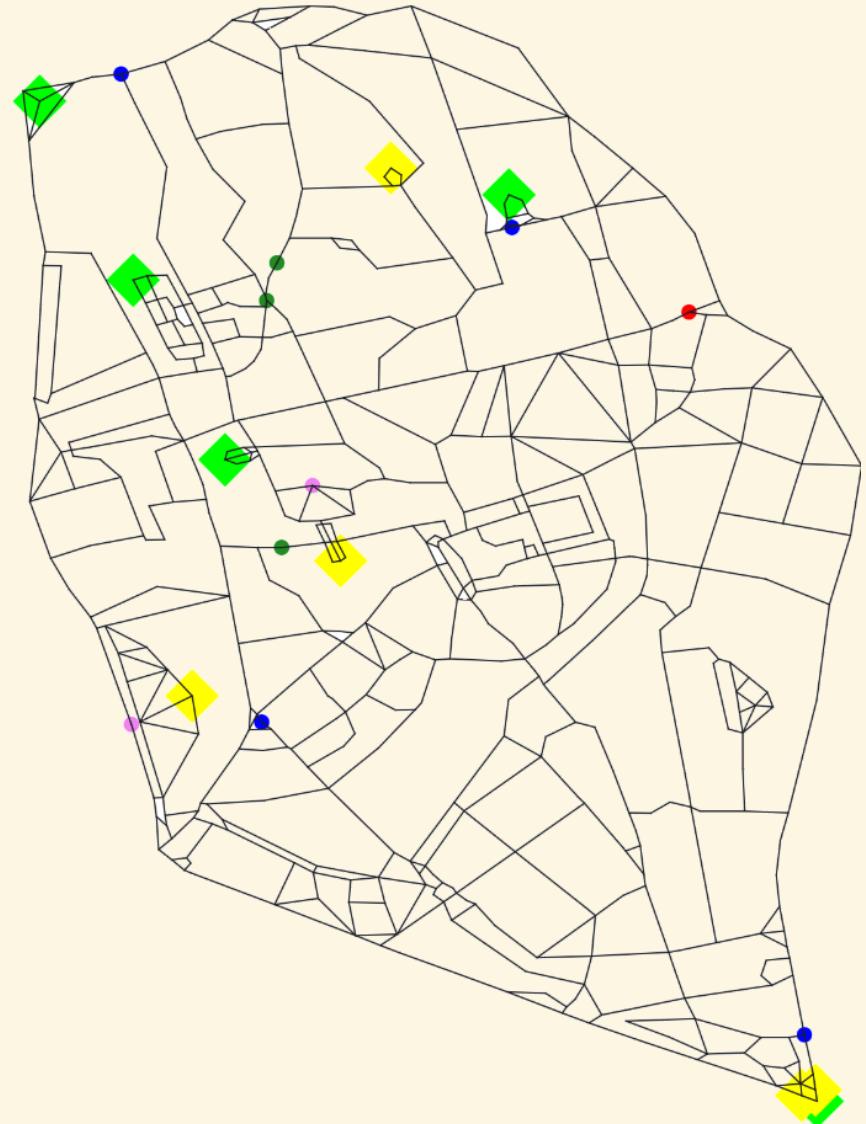
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 - Number of movements per agent: ± 500

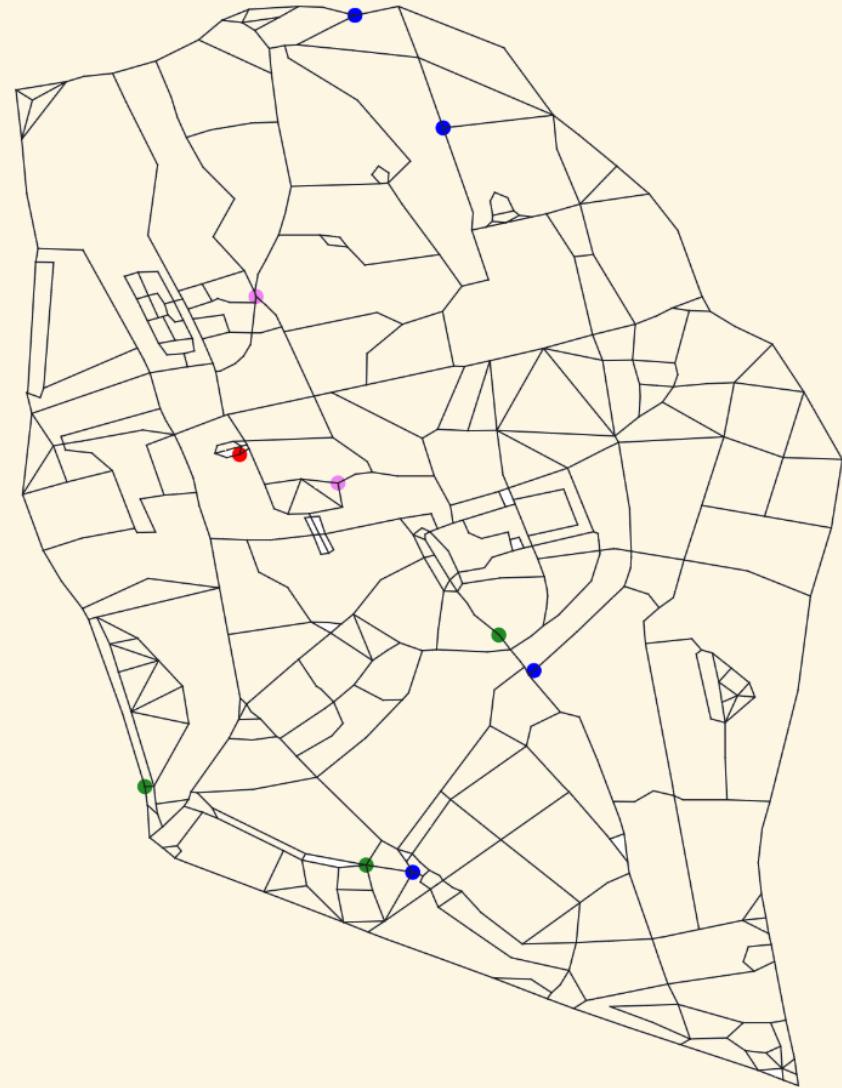


RESULTS

- Metrics
 - Amount of gold obtained
 - Amount of diamonds obtained
 - Number of movements per agent
- Our experiments
 - Gathered the 100 gold and 100 diamond treasures
 - Execution times: $2 \text{ min} \pm 5 \text{ seg}$
 - Number of movements per agent: ± 500
 - Communication Range: 30 nodes

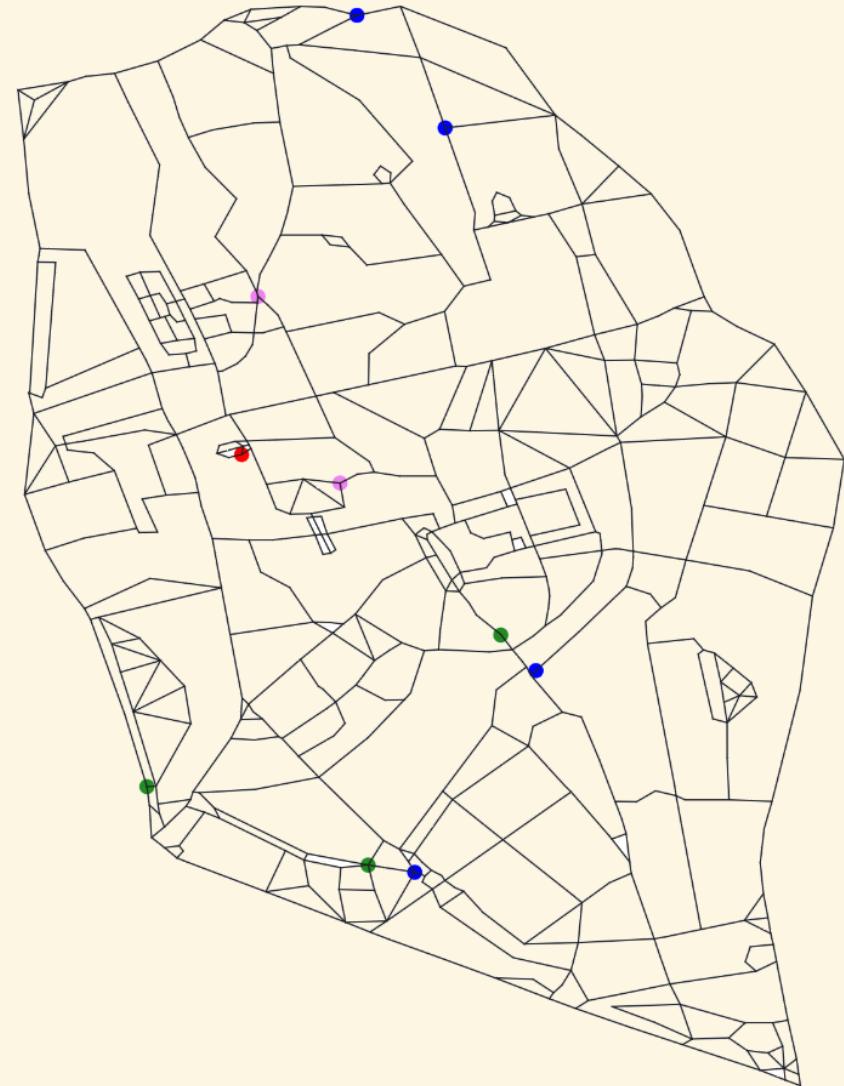


RESULTS & CONCLUSION



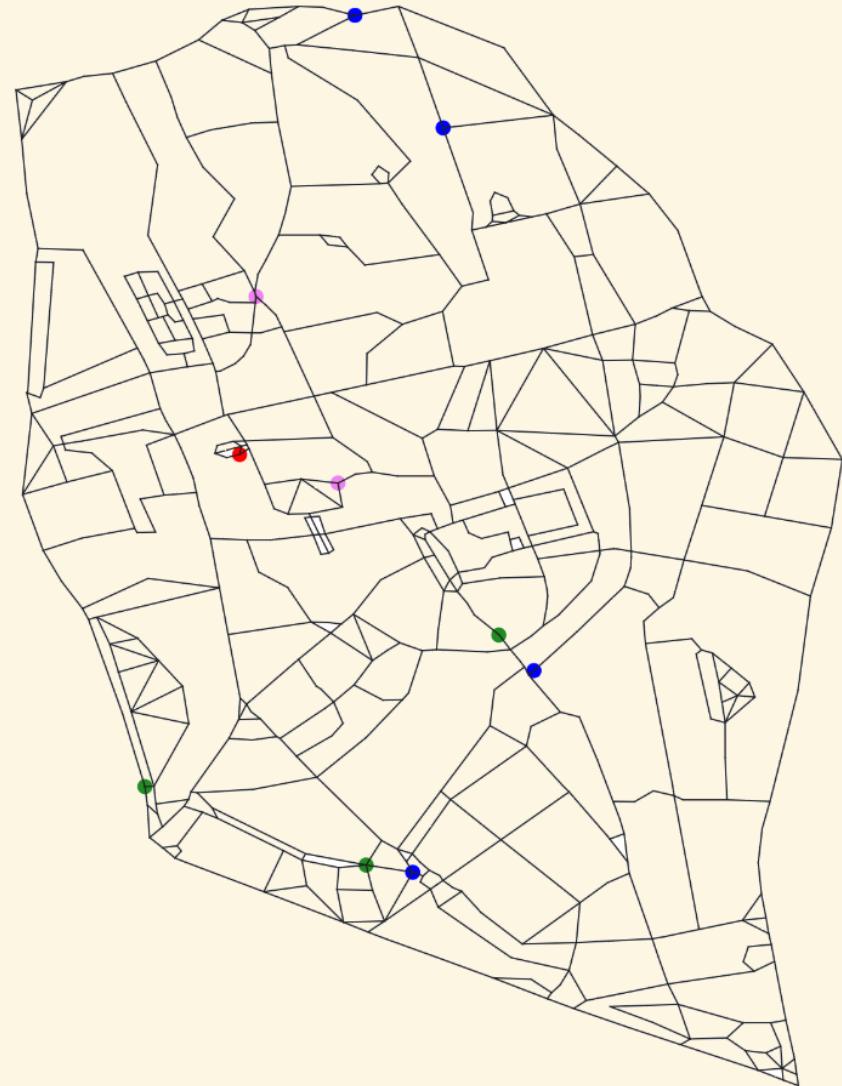
RESULTS & CONCLUSION

- Multiple updates to the implementation idea on the fly



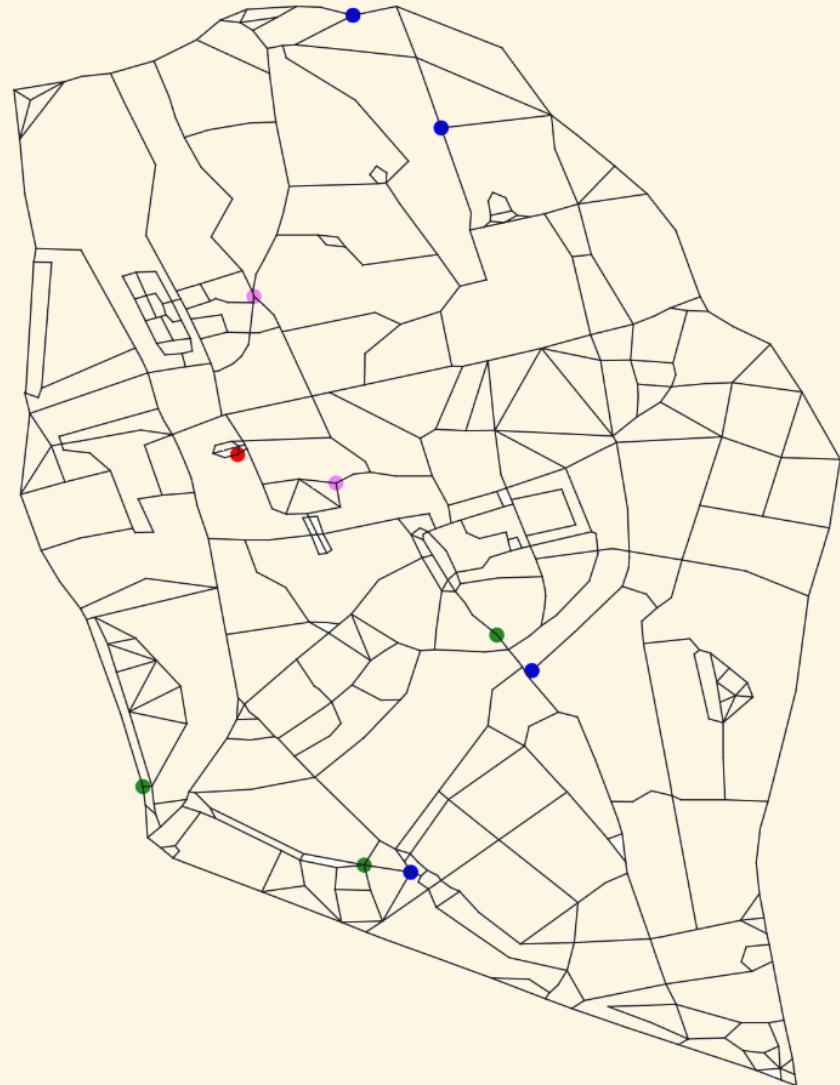
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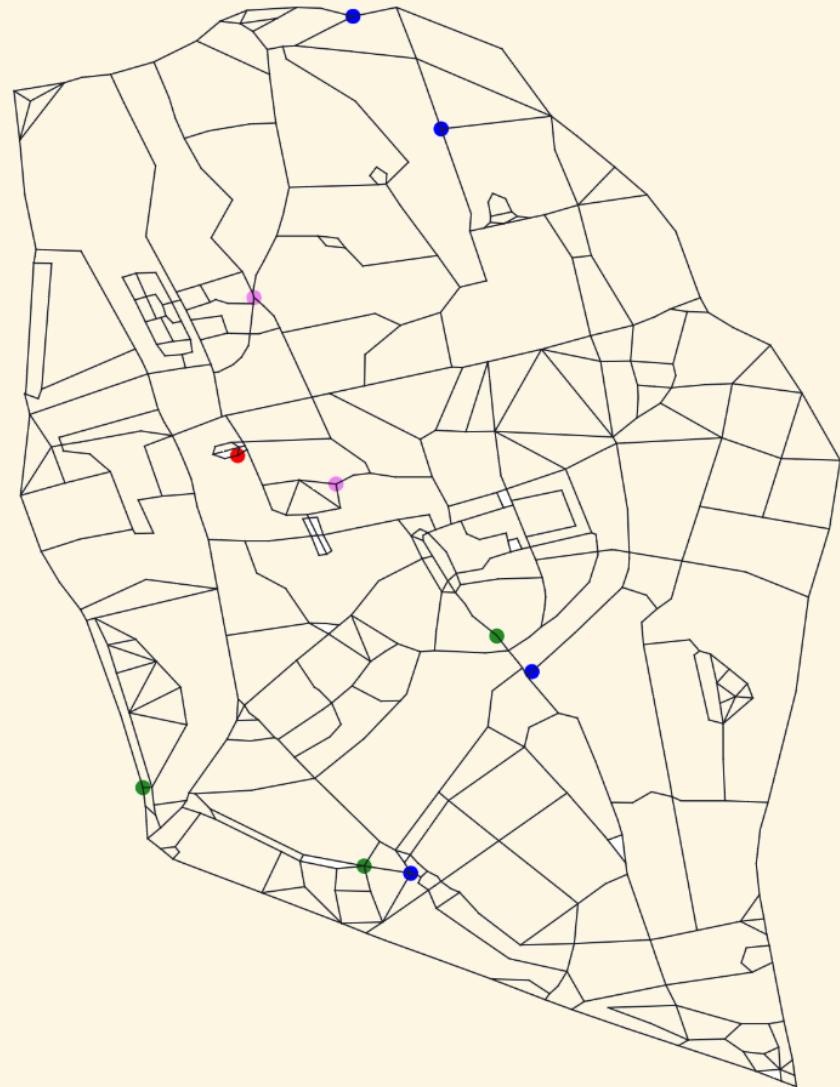
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- Theoretical and practical knowledge about MAS.



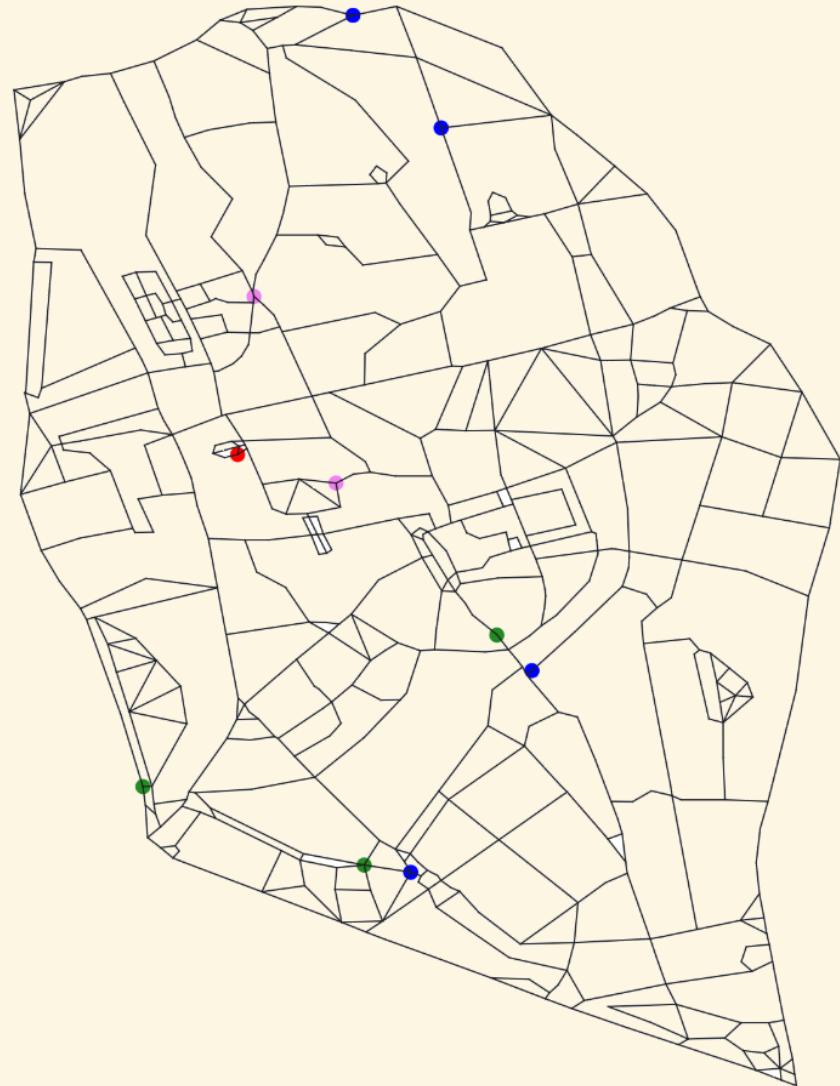
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- Evaluation of time and step requirements for task completed sucessfully.



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- Multiple intermediate versions that guided us to improve the implementation
- Theoretical and practical knowledge about MAS.
- Evaluation of time and step requirements for task completed sucessfully.
- The effectiveness of the coordination and communication mechanisms helped MAS solve the problem at least 15x faster, in the worst case scenario.



TREASURE HUNT PROBLEM

INTRODUCTION TO MULTI-AGENT SYSTEMS

MASTER IN ARTIFICIAL INTELLIGENCE

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