

DS-ISE Project

ParkingMAS

Simulation

Agents' initial **beliefs**:

d1 -> required_availability(2)

d2 -> required_availability(1)

d3 -> required_availability(3)

d4 -> required_availability(1)

d5 -> required_availability(2)

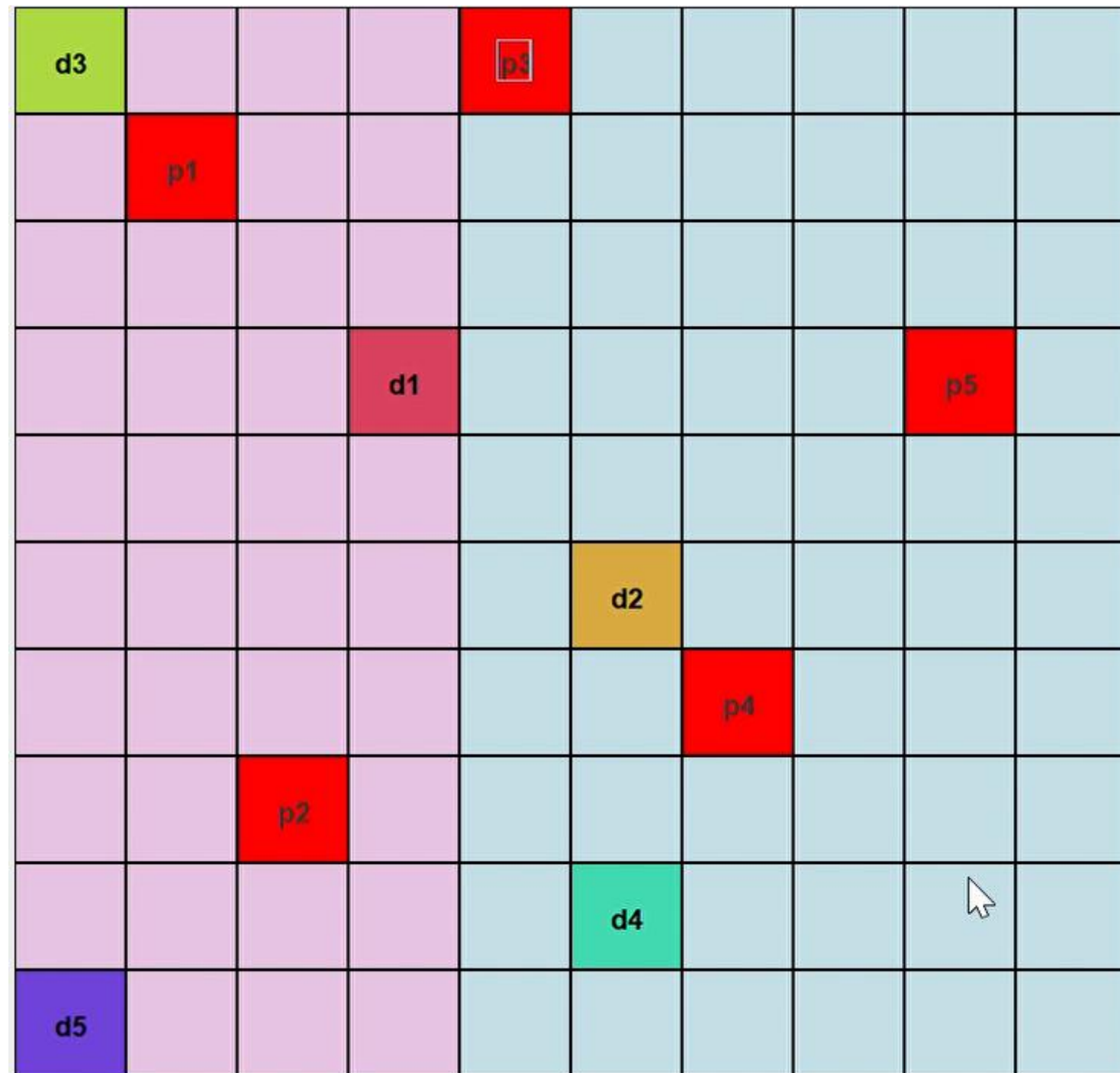
p1 -> available(1)

p2 -> available(2)

p3 -> available(2)

p4 -> available(1)

p5 -> available(3)



Simulation Logs – d4

...

[d2] Successfully entered parking lot p4

[d2] Staying in parking lot p4 for 19.711 seconds

[d4] Entry denied for parking lot p4

[d4] Requesting parking to area agent a2

[d4] Going to parking lot p5 at position(3,8)

...

Simulation Logs – d3

[d3] Requesting parking to area agent a1

[d3] No available parking found; contacting nearest area agent

[d3] Requesting parking to nearest area agent a2

[d3] Going to parking lot p5 at position(3,8)

...

[d3] Driver at (0, 5)

[d3] Trying to go west

[d3] Direction west blocked; trying another direction

[d3] Avoiding obstacle: trying north

[d3] Avoiding obstacle: direction north blocked; trying another direction

[d3] Avoiding obstacle: trying south

[d3] Driver at (1, 5)

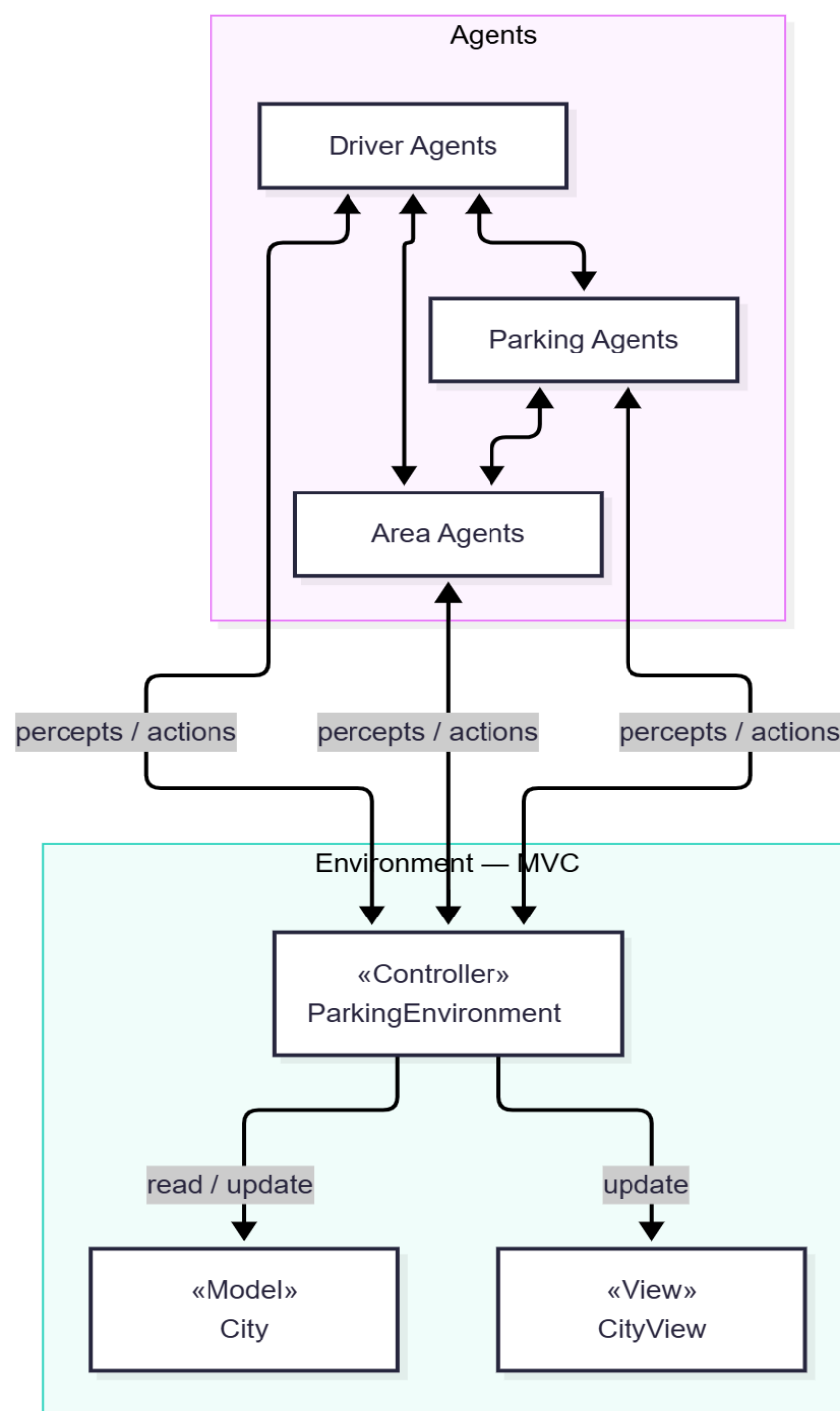
[d3] Trying to continue in previous direction: west

[d3] Driver at (1, 4)

...

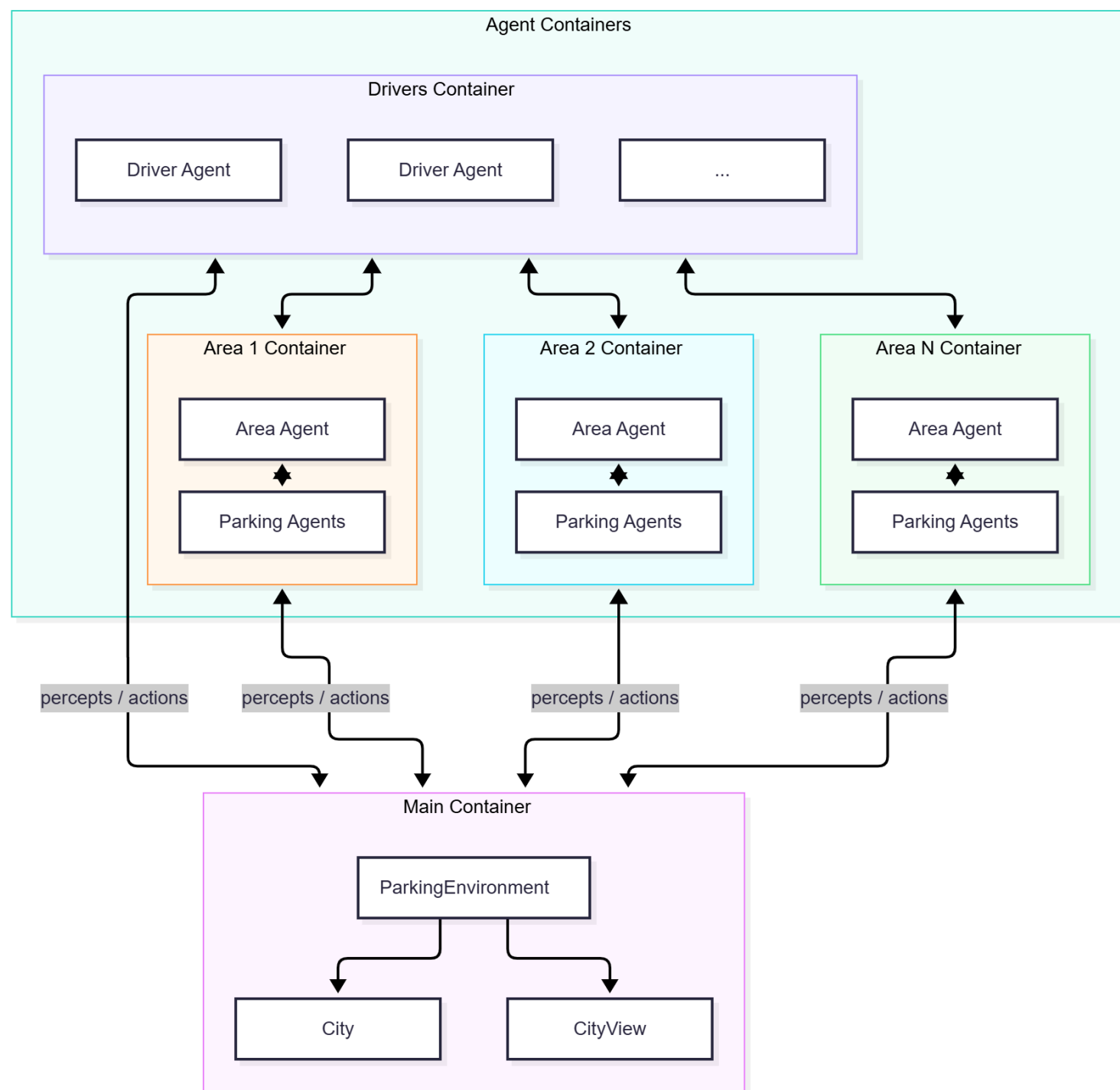
Architecture

- **Agents** as the *autonomous* components of the MAS;
- **Environment** follows the *Model-View-Controller (MVC)* pattern.



Distributed Infrastructure

- **Agent containers** designed accordingly to the agents' *physical distribution*;
- **Main container** as the *centralized* part of the infrastructure.



Inter-Agent Communication

- **Interactions:**
 - **Request-Response:**
 - These interactions are subject to a **bounded waiting period**;
 - In case of a communication error, the requesting agent decides whether to **retry** the communication after a short delay or to proceed in a different way;
 - The **retry mechanisms** are generally **bounded** in the number of failures;
 - When the maximum number of retries is reached, the agent can apply an appropriate **fallback strategy**;
 - **Notifications.**

Consistency, Availability, and Fault Tolerance

- Potential **consistency delay** in the area agents' local representations of the parking information, favoring **locality and reduced communication overhead** over strong global consistency;
- Resilience to **temporary communication failures**;
- Main Container as a **single point of failure**;
- Overall, in the presence of partial communication failures, the system generally prioritizes **availability** when operations can tolerate temporarily stale information, while prioritizing **consistency** for critic operations.

Scalability

- **Horizontal scalability** is supported at the agent level by allowing the agents to be distributed across multiple containers;
- Centralized environment as a potential **bottleneck**:
 - **Mitigation** by limiting interactions between the environment and the agents to operations that strictly concern the **physical aspects** of the world.

Agent Modelling

- **Driver Agent:**
 - *Beliefs*: current position and area, nearest area, home location, parking availability requirements, and retry information;
 - *Main goal*: to find a parking lot satisfying its requirements, stay parked for some amount of time, and eventually return home;
 - **Autonomously adapts** its behavior to the current situation via alternative plans;
 - It uses *rules* to support its operations, particularly navigation, for which the driver agent implements a **local decision-making mechanism**.

Agent Modelling

- **Area Agent:**
 - *Beliefs*: information about parking lots in its area, including their positions and availability;
 - *Main goal*: collect and maintain parking information, and respond to parking queries from driver agents;
 - It contains the logic to find a suitable parking lot for a driver agent;
- **Parking Agent:**
 - *Beliefs*: position and available spots;
 - *Reactive behavior*: it responds to requests concerning parking information, entry, and exit;
 - Entry and exit operations are handled **atomically** to ensure that concurrent requests do not lead to an inconsistent availability state.

Environment Modelling

- *City*: it is the environment's model and it maintains the **physical state** of the city, represented as a grid;
- The *ParkingEnvironment* **separates** the state of the world (the City) from the knowledge maintained by the agents;
- It provides each agent with different **percepts** depending on its type;
- It exposes three **actions**:
 - *Movement*: moves a driver one step in a specified direction;
 - *Parking entry*: makes a driver enter a parking lot;
 - *Parking exit*: makes a driver exit a parking lot in a specified direction.

Testing

- **Automated unit tests** to verify the functionality of the environment model;
- **Automated integration tests** to test the *ParkingEnvironment* in conjunction with the model;
- **Manual end-to-end tests** to evaluate the MAS behavior during realistic execution scenarios;
 - Verifying both agent behavior and interactions;
 - Assessing different failure scenarios involving the activation of fallback strategies.

Future Works

- **DS**: aimed at addressing the main limitation of the current architecture, namely the **centralization of the environment**;
- **ISE**: aimed at improving agent behavior and interactions, mainly by enhancing **failure-handling and fallback mechanisms**, improving the **knowledge maintained by area agents**, or extending the system with a more **complex environment model**.

Thank you for your attention!