

# Multi-Agent Planning Ontology

## Multi-Agent Planning Ontology (maPO)

### Metadata

#### IRI

<https://purl.org/ai4s/ontology/planning/multi-agent>

#### Title

Multi-Agent Planning Ontology

Multi-Agent Planning Ontology (maPO)

#### Creator

Anonymous AI Researcher

#### Contributor

This ontology extends the base Planning Ontology available at <https://ai4society.github.io/planning-ontology#>.

#### Date Issued

2024-07-22

#### License

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#### Version Iri

<https://purl.org/ai4s/ontology/planning/multi-agent/v1.0.0>

#### Preferred Namespace Prefix

ma

#### Preferred Namespace Uri

[ma:](#)

#### Description

An ontology for representing knowledge in Multi-Agent Path Finding (MAPF) problems. This ontology defines concepts such as agents, plans, conflicts, and replanning strategies to support explainable AI in MAPF.

maPO extends a generic planning ontology with multi-agent path finding (MAPF) concepts such as agents, paths, conflicts, alerts, and replanning strategies, enabling semantic querying and explanation of MAPF executions.

### Classes

#### Agent<sup>c</sup>

##### IRI

<https://purl.org/ai4s/ontology/planning/multi-agent#Agent>

##### Description

An individual MAPF agent acting in a shared environment, modeled both as a planning problem object and as a platform in the SOSA sense (for integration with sensing/actuation descriptions).

##### Sub Class Of

[plan:ProblemObject](#)

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#### Object Properties

[has capability](#)  
[has initial location](#)  
[has goal location](#)  
[executes action](#)  
[at location](#)  
[belongs to agent](#)  
[has path data](#)  
[composed of sub-plans](#)  
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[has agent set](#)  
[has initial states](#)  
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[\(segment\)](#)  
[has valid time interval](#)  
[has path sequence](#)  
[observed forbidden cells](#)  
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[implements procedure](#)  
[generates plan](#)  
[agent at](#)

#### Datatype Properties

[has agent ID](#)  
[x coordinate](#)  
[y coordinate](#)  
[has plan cost](#)  
[has global makespan](#)  
[conflict resolution](#)  
[protocol](#)  
[conflict type](#)  
[selection rationale](#)  
[policy name](#)  
[trained on environment](#)  
[observation channels](#)  
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[has channel](#)  
[mask dimension](#)  
[conflict ID](#)  
[conflict event type](#)  
[alert ID](#)  
[rewind window](#)

[sosa:Platform](#)

**In Domain Of**

[has agent ID](#) dp  
[has capability](#) op  
[has initial location](#) op  
[has goal location](#) op  
[executes action](#) op

**In Range Of**

[belongs to agent](#) op  
[has agent set](#) op  
[involves agents](#) op  
[involves agents \(event\)](#) op  
[target agent](#) op  
[belongs to agent \(segment\)](#) op

[aier: type](#)  
[static forbidden cells](#)  
[dynamic forbidden path](#)  
[strategy ID](#)  
[used static replanning](#)  
[used dynamic replanning](#)  
[procedure ID](#)  
[implements stage](#)  
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[supports conflict detection](#)  
[communication overhead](#)  
[performance trade-off](#)

**Namespaces**

[cora](#)  
[dct](#)  
[ma](#)  
[owl](#)  
[plan](#)  
[prov](#)  
[rdf](#)  
[rdfs](#)  
[sosa](#)  
[time](#)  
[vann](#)  
[xsd](#)

**Agent State** C

**IRI**

<https://purl.org/ai4s/ontology/planning/multi-agent#AgentState>

**Description**

A snapshot of an agent's state at a particular instant during plan execution, typically capturing its location and other relevant properties.

**Sub Class Of**

[plan:State](#)

**In Domain Of**

[occurs at time](#) op  
[agent at](#) op

**In Range Of**

[has initial states](#) op  
[has goal states](#) op

**Legend**

**Agent Sub-Plan** C

**IRI**

<https://purl.org/ai4s/ontology/planning/multi-agent#AgentSubPlan>

**Description**

A per-agent plan describing the sequence of actions taken by a single agent within a multi-agent plan.

**Sub Class Of**

[plan:Plan](#)

**In Domain Of**

[belongs to agent](#) op  
[has plan cost](#) dp  
[has path data](#) op

**In Range Of**

[composed of sub-plans](#) op

**Super Class Of**

[Original Agent Sub-Plan](#) C

## [Resolved Agent Sub-Plan](#)<sup>c</sup>

### Original Agent Sub-Plan<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#OriginalSubPlan">https://purl.org/ai4s/ontology/planning/multi-agent#OriginalSubPlan</a>
<b>Description</b>	The initial sub-plan for an agent before any replanning is triggered by conflict resolution.
<b>Sub Class Of</b>	<a href="#">Agent Sub-Plan</a> <sup>c</sup>
<b>In Range Of</b>	<a href="#">derives from</a> <sup>op</sup>

### Resolved Agent Sub-Plan<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#ResolvedSubPlan">https://purl.org/ai4s/ontology/planning/multi-agent#ResolvedSubPlan</a>
<b>Description</b>	A revised sub-plan for an agent produced by a replanning step in response to a detected conflict.
<b>Sub Class Of</b>	<a href="#">Agent Sub-Plan</a> <sup>c</sup>
<b>In Domain Of</b>	<a href="#">derives from</a> <sup>op</sup> <a href="#">generated by</a> <sup>op</sup> <a href="#">resolves conflict</a> <sup>op</sup>

### Joint Plan<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#JointPlan">https://purl.org/ai4s/ontology/planning/multi-agent#JointPlan</a>
<b>Description</b>	A global MAPF plan obtained by composing individual agent sub-plans into a coordinated, collision-free joint execution.
<b>Sub Class Of</b>	<a href="#">plan:Plan</a>
<b>In Domain Of</b>	<a href="#">has path data</a> <sup>op</sup> <a href="#">composed of sub-plans</a> <sup>op</sup> <a href="#">has global makespan</a> <sup>dp</sup> <a href="#">used alert set</a> <sup>op</sup> <a href="#">conflict resolution protocol</a> <sup>dp</sup>

### Conflict Constraint<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#ConflictConstraint">https://purl.org/ai4s/ontology/planning/multi-agent#ConflictConstraint</a>
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<b>Description</b>	A domain constraint capturing forbidden regions or interaction patterns between agents that may lead to conflicts in the MAPF problem.
<b>Sub Class Of</b>	<a href="#">plan:DomainRequirement</a>
<b>In Domain Of</b>	<a href="#">involves agents</a> <sup>op</sup> <a href="#">conflict type</a> <sup>dp</sup> <a href="#">forbidden region</a> <sup>op</sup>
<b>In Range Of</b>	<a href="#">has conflict constraint</a> <sup>op</sup>

## Agent Path Segment C

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#AgentPathSegment">https://purl.org/ai4s/ontology/planning/multi-agent#AgentPathSegment</a>
<b>Description</b>	A contiguous segment of an agent's path over a time interval, used for plan segmentation and visualization of movement patterns.
<b>In Domain Of</b>	<a href="#">belongs to agent (segment)</a> <sup>op</sup> <a href="#">has valid time interval</a> <sup>op</sup> <a href="#">has path sequence</a> <sup>op</sup>
<b>In Range Of</b>	<a href="#">has path data</a> <sup>op</sup> <a href="#">observed forbidden segment</a> <sup>op</sup>

## Grid Location C

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#GridLocation">https://purl.org/ai4s/ontology/planning/multi-agent#GridLocation</a>
<b>Description</b>	A structured representation of a grid cell with x and y coordinates within the MAPF environment.
<b>In Domain Of</b>	<a href="#">x coordinate</a> <sup>dp</sup> <a href="#">y coordinate</a> <sup>dp</sup>
<b>In Range Of</b>	<a href="#">has initial location</a> <sup>op</sup> <a href="#">has goal location</a> <sup>op</sup> <a href="#">at location</a> <sup>op</sup> <a href="#">conflict location</a> <sup>op</sup> <a href="#">agent at</a> <sup>op</sup>

## Agent Policy C

<p><b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#AgentPolicy">https://purl.org/ai4s/ontology/planning/multi-agent#AgentPolicy</a></p> <p><b>Description</b> A description of the decision-making policy used by an agent (e.g., a learned RL policy) including configuration and training information.</p> <p><b>In Domain Of</b></p> <ul style="list-style-type: none"> <li><a href="#">policy name</a> <small>dp</small></li> <li><a href="#">trained on environment</a> <small>dp</small></li> <li><a href="#">observation channels</a> <small>dp</small></li> <li><a href="#">action space</a> <small>dp</small></li> </ul>
<p><b>Observation Mask Specification</b> <small>c</small></p> <p><b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#ObservationMaskSpec">https://purl.org/ai4s/ontology/planning/multi-agent#ObservationMaskSpec</a></p> <p><b>Description</b> A specification of observation channels and masks used by an agent policy to encode partial observability of the environment.</p> <p><b>In Domain Of</b></p> <ul style="list-style-type: none"> <li><a href="#">has channel</a> <small>dp</small></li> <li><a href="#">mask dimension</a> <small>dp</small></li> </ul>
<p><b>Collision Event</b> <small>c</small></p> <p><b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#CollisionEvent">https://purl.org/ai4s/ontology/planning/multi-agent#CollisionEvent</a></p> <p><b>Description</b> An event representing a detected collision or conflict between agents at a specific time and location.</p> <p><b>In Domain Of</b></p> <ul style="list-style-type: none"> <li><a href="#">conflict ID</a> <small>dp</small></li> <li><a href="#">occurs at time</a> <small>op</small></li> <li><a href="#">conflict event type</a> <small>dp</small></li> <li><a href="#">involves agents (event)</a> <small>op</small></li> <li><a href="#">conflict location</a> <small>op</small></li> </ul> <p><b>In Range Of</b></p> <ul style="list-style-type: none"> <li><a href="#">resolves conflict</a> <small>op</small></li> <li><a href="#">alerts conflict</a> <small>op</small></li> </ul>
<p><b>Conflict Alert</b> <small>c</small></p> <p><b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#ConflictAlert">https://purl.org/ai4s/ontology/planning/multi-agent#ConflictAlert</a></p> <p><b>Description</b> An alert raised by the planner or coordinator that selects an agent and context to trigger a local replanning step to resolve a conflict.</p>

**In Domain Of**

[selection rationale](#)<sup>dp</sup>  
[alert ID](#)<sup>dp</sup>  
[alerts conflict](#)<sup>op</sup>  
[target agent](#)<sup>op</sup>  
[rewind window](#)<sup>dp</sup>  
[alert type](#)<sup>dp</sup>  
[static forbidden cells](#)<sup>dp</sup>  
[dynamic forbidden path](#)<sup>dp</sup>

**In Range Of**

[used alert set](#)<sup>op</sup>  
[triggered by](#)<sup>op</sup>

## Replanning Strategy C

**IRI**

<https://purl.org/ai4s/ontology/planning/multi-agent#ReplanningStrategy>

**Description**

A strategy or procedure that describes how conflicts are handled and new sub-plans are generated (e.g., static vs dynamic replanning).

**In Domain Of**

[triggered by](#)<sup>op</sup>  
[strategy ID](#)<sup>dp</sup>  
[used static replanning](#)<sup>dp</sup>  
[used dynamic replanning](#)<sup>dp</sup>  
[observed forbidden cells](#)<sup>op</sup>  
[observed forbidden segment](#)<sup>op</sup>

## Planner Procedure C

**IRI**

<https://purl.org/ai4s/ontology/planning/multi-agent#PlannerProcedure>

**Description**

A higher-level description of the stages or procedures implemented by a multi-agent planner, including agent selection and conflict-handling policies.

**In Domain Of**

[procedure ID](#)<sup>dp</sup>  
[implements stage](#)<sup>dp</sup>  
[agent selection policy](#)<sup>dp</sup>  
[default rewind window](#)<sup>dp</sup>  
[procedure rationale](#)<sup>dp</sup>

**In Range Of**

[implements procedure](#)<sup>op</sup>

## Multi-Agent Planner C

**IRI**

<https://purl.org/ai4s/ontology/planning/multi-agent#MultiAgentPlanner>

<b>Description</b>	A planner capable of generating joint plans for multiple agents, potentially with integrated conflict detection and resolution mechanisms.
<b>Sub Class Of</b>	<a href="#">plan:Planner</a>
<b>In Domain Of</b>	<a href="#">planner type</a> <sup>dp</sup> <a href="#">implements procedure</a> <sup>op</sup> <a href="#">generates plan</a> <sup>op</sup> <a href="#">supports conflict detection</a> <sup>dp</sup> <a href="#">communication overhead</a> <sup>dp</sup> <a href="#">performance trade-off</a> <sup>dp</sup>

## Object Properties

[has capability](#)<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasCapability>

**Description** Links an agent to its capabilities, as described in the CORA ontology, such as motion or sensing capabilities.

**Domain** [Agent](#)<sup>c</sup>

**Range** [cora:Capability](#)

[has initial location](#)<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasInitialLocation>

**Description** Links an agent to its initial grid location at the start of the MAPF problem.

**Domain** [Agent](#)<sup>c</sup>

**Range** [Grid Location](#)<sup>c</sup>

[has goal location](#)<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasGoalLocation>

**Description** Links an agent to its goal grid location in the MAPF problem.

**Domain** [Agent](#)<sup>c</sup>

**Range** [Grid Location](#)<sup>c</sup>

## executes action<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#executesAction>

**Description** Relates an agent to actions it executes as part of its plan.

**Domain** [Agent](#)<sup>c</sup>

**Range** [plan:Action](#)

## at location<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#atLocation>

**Description** Associates any entity (e.g., an agent or obstacle) with a grid location.

**Domain** [Thing](#)<sup>c</sup>

**Range** [Grid Location](#)<sup>c</sup>

## belongs to agent<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#belongsToAgent>

**Description** Links an agent sub-plan to the agent whose behavior it describes.

**Domain** [Agent Sub-Plan](#)<sup>c</sup>

**Range** [Agent](#)<sup>c</sup>

## has path data<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#planData>

**Description** Associates a plan (agent-level or joint) with one or more path segments representing its execution.

**Domain**

- [Agent Sub-Plan](#)<sup>c</sup>
- [Joint Plan](#)<sup>c</sup>

**Range** [Agent Path Segment](#)<sup>c</sup>

## composed of sub-plans<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#composedOfSubPlans">https://purl.org/ai4s/ontology/planning/multi-agent#composedOfSubPlans</a>
<b>Description</b>	Indicates that a joint plan is composed of the sub-plans of individual agents.
<b>Domain</b>	<a href="#">Joint Plan</a>
<b>Range</b>	<a href="#">Agent Sub-Plan</a>

## used alert set<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#usedAlertSet">https://purl.org/ai4s/ontology/planning/multi-agent#usedAlertSet</a>
<b>Description</b>	Links a joint plan to the set of conflict alerts that were used during its construction and refinement.
<b>Domain</b>	<a href="#">Joint Plan</a>
<b>Range</b>	<a href="#">Conflict Alert</a>

## has agent set<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasAgentSet">https://purl.org/ai4s/ontology/planning/multi-agent#hasAgentSet</a>
<b>Description</b>	Links a planning problem to the agents that participate in it.
<b>Domain</b>	<a href="#">plan:PlanningProblem</a>
<b>Range</b>	<a href="#">Agent</a>

## has initial states<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasInitialStates">https://purl.org/ai4s/ontology/planning/multi-agent#hasInitialStates</a>
<b>Description</b>	Associates a planning problem with initial states for its agents.
<b>Domain</b>	<a href="#">plan:PlanningProblem</a>
<b>Range</b>	<a href="#">Agent State</a>

## has goal states<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasGoalStates">https://purl.org/ai4s/ontology/planning/multi-agent#hasGoalStates</a>
<b>Description</b>	

Associates a planning problem with goal states for its agents.

**Domain** [plan:PlanningProblem](#)

**Range** [Agent State](#)

has conflict constraint<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasConflictConstraint>

**Description** Links a planning problem to conflict constraints that restrict agent interactions or regions.

**Domain** [plan:PlanningProblem](#)

**Range** [Conflict Constraint](#)

involves agents<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#involvesAgents>

**Description** Specifies the agents that are involved in a given conflict constraint.

**Domain** [Conflict Constraint](#)

**Range** [Agent](#)

forbidden region<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#forbiddenRegion>

**Description** Links a conflict constraint to a region that is forbidden or restricted for certain agents.

**Domain** [Conflict Constraint](#)

**Range** [plan:Region](#)

derives from<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#derivesFrom>

**Description** Indicates that a resolved sub-plan is derived from a specific original sub-plan.

**Sub Property Of** [was derived from](#)

<b>Domain</b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b>Range</b>	<a href="#">Original Agent Sub-Plan</a> <sup>c</sup>
generated by <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#generatedBy">https://purl.org/ai4s/ontology/planning/multi-agent#generatedBy</a>
<b>Description</b>	Relates a resolved sub-plan to the replanning activity that generated it.
<b>Sub Property Of</b>	<a href="#">was generated by</a> <sup>op</sup>
<b>Domain</b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b>Range</b>	<a href="#">Activity</a> <sup>c</sup>
resolves conflict <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#resolvesConflict">https://purl.org/ai4s/ontology/planning/multi-agent#resolvesConflict</a>
<b>Description</b>	Connects a revised sub-plan to the collision event it is intended to resolve.
<b>Domain</b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b>Range</b>	<a href="#">Collision Event</a> <sup>c</sup>
triggered by <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#triggeredBy">https://purl.org/ai4s/ontology/planning/multi-agent#triggeredBy</a>
<b>Description</b>	Links a replanning strategy to the conflict alert that triggered it.
<b>Domain</b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b>Range</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
occurs at time <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#occursAtTime">https://purl.org/ai4s/ontology/planning/multi-agent#occursAtTime</a>
<b>Description</b>	Links a collision event or agent state to the time instant at which it occurs.
<b>Domain</b>	

- [Collision Event](#)<sup>c</sup>
- [Agent State](#)<sup>c</sup>

<b>Range</b>	<a href="#">time:Instant</a>
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## involves agents (event)<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#involvesAgentsEvent">https://purl.org/ai4s/ontology/planning/multi-agent#involvesAgentsEvent</a>
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<b>Description</b>	Links a collision event to the agents involved in that event.
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<b>Domain</b>	<a href="#">Collision Event</a> <sup>c</sup>
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<b>Range</b>	<a href="#">Agent</a> <sup>c</sup>
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## conflict location<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#conflictLocation">https://purl.org/ai4s/ontology/planning/multi-agent#conflictLocation</a>
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<b>Description</b>	Specifies the grid location at which a collision event occurs.
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<b>Domain</b>	<a href="#">Collision Event</a> <sup>c</sup>
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<b>Range</b>	<a href="#">Grid Location</a> <sup>c</sup>
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## alerts conflict<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#alertsConflict">https://purl.org/ai4s/ontology/planning/multi-agent#alertsConflict</a>
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<b>Description</b>	Associates a conflict alert with the collision event it refers to.
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<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
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<b>Range</b>	<a href="#">Collision Event</a> <sup>c</sup>
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## target agent<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#targetAgent">https://purl.org/ai4s/ontology/planning/multi-agent#targetAgent</a>
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<b>Description</b>	Indicates the agent selected as the target for replanning in response to a conflict alert.
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<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
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<b>Range</b>	<a href="#">Agent</a> <sup>c</sup>
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## belongs to agent (segment)<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#belongsToAgentSegment>

**Description** Links an agent path segment to the agent whose movement it represents.

**Domain** [Agent Path Segment](#)<sup>c</sup>

**Range** [Agent](#)<sup>c</sup>

## has valid time interval<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasValidTime>

**Description** Associates a path segment with the time interval during which it is executed.

**Domain** [Agent Path Segment](#)<sup>c</sup>

**Range** [time:Interval](#)

## has path sequence<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasPathSequence>

**Description** Represents the ordered sequence of grid locations for a path segment as an RDF list.

**Domain** [Agent Path Segment](#)<sup>c</sup>

**Range** [List](#)

## observed forbidden cells<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenCells>

**Description** Links a replanning strategy to the specific cells observed as forbidden during execution.

**Domain** [Replanning Strategy](#)<sup>c</sup>

**Range** [plan:Cell](#)

## observed forbidden segment<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenSegment>

**Description** Links a replanning strategy to a path segment that is treated as forbidden during replanning.

**Domain** [Replanning Strategy](#)<sup>c</sup>

**Range** [Agent Path Segment](#)<sup>c</sup>

implements procedure<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#implementsProcedure>

**Description** Links a multi-agent planner to the procedures it implements as part of its pipeline.

**Domain** [Multi-Agent Planner](#)<sup>c</sup>

**Range** [Planner Procedure](#)<sup>c</sup>

generates plan<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#generatesPlan>

**Description** Relates a multi-agent planner to the plans it generates.

**Domain** [Multi-Agent Planner](#)<sup>c</sup>

**Range** [plan:Plan](#)

agent at<sup>op</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#agentAt>

**Description** Links an agent state to the grid location where the agent is at that state.

**Domain** [Agent State](#)<sup>c</sup>

**Range** [Grid Location](#)<sup>c</sup>

## Datatype Properties

has agent ID<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi->

agent#hasAgentID

<b>Description</b>	Associates an agent with its identifier from the underlying MAPF planner or environment.
<b>Domain</b>	<a href="#">Agent</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

x coordinate<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#xCoordinate">https://purl.org/ai4s/ontology/planning/multi-agent#xCoordinate</a>
<b>Description</b>	The x-coordinate of a grid location.
<b>Domain</b>	<a href="#">Grid Location</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:integer</a>

y coordinate<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#yCoordinate">https://purl.org/ai4s/ontology/planning/multi-agent#yCoordinate</a>
<b>Description</b>	The y-coordinate of a grid location.
<b>Domain</b>	<a href="#">Grid Location</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:integer</a>

has plan cost<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasPlanCost">https://purl.org/ai4s/ontology/planning/multi-agent#hasPlanCost</a>
<b>Description</b>	Stores the cost of an agent sub-plan (e.g., path length or time).
<b>Domain</b>	<a href="#">Agent Sub-Plan</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:decimal</a>

has global makespan<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasGlobalMakespan">https://purl.org/ai4s/ontology/planning/multi-agent#hasGlobalMakespan</a>
<b>Description</b>	Stores the makespan (total execution time) of a joint plan.
<b>Domain</b>	<a href="#">Joint Plan</a> <sup>c</sup>

<b>Range</b>	<a href="#">xsd:decimal</a>
<b>conflict resolution protocol</b> <small>dp</small>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#conflictResolutionProtocol">https://purl.org/ai4s/ontology/planning/multi-agent#conflictResolutionProtocol</a>
<b>Description</b>	Describes the high-level conflict resolution protocol or strategy used for a joint plan.
<b>Domain</b>	<a href="#">Joint Plan</a> <small>c</small>
<b>Range</b>	<a href="#">xsd:string</a>
<b>conflict type</b> <small>dp</small>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#conflictType">https://purl.org/ai4s/ontology/planning/multi-agent#conflictType</a>
<b>Description</b>	Describes the type of conflict constrained (e.g., vertex conflict, edge conflict).
<b>Domain</b>	<a href="#">Conflict Constraint</a> <small>c</small>
<b>Range</b>	<a href="#">xsd:string</a>
<b>selection rationale</b> <small>dp</small>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#selectionRationale">https://purl.org/ai4s/ontology/planning/multi-agent#selectionRationale</a>
<b>Description</b>	Provides a textual explanation of why a specific agent was chosen as the target of a conflict alert.
<b>Domain</b>	<a href="#">Conflict Alert</a> <small>c</small>
<b>Range</b>	<a href="#">xsd:string</a>
<b>policy name</b> <small>dp</small>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#policyName">https://purl.org/ai4s/ontology/planning/multi-agent#policyName</a>
<b>Description</b>	The human-readable name of an agent policy (e.g., the RL architecture or configuration name).
<b>Domain</b>	<a href="#">Agent Policy</a> <small>c</small>
<b>Range</b>	<a href="#">xsd:string</a>

## trained on environment<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#trainedOnEnvironment>

**Description** Describes the environment or scenario distribution on which the agent policy was trained.

**Domain** [Agent Policy](#)<sup>c</sup>

**Range** [xsd:string](#)

## observation channels<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#observationChannels>

**Description** Lists the observation channels exposed to the policy (e.g., grid layers, agent positions, obstacles).

**Domain** [Agent Policy](#)<sup>c</sup>

**Range** [xsd:string](#)

## action space<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#actionSpace>

**Description** Describes the available actions for the policy (e.g., up/down/left/right/stay).

**Domain** [Agent Policy](#)<sup>c</sup>

**Range** [xsd:string](#)

## has channel<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasChannel>

**Description** Names an observation channel included in an observation mask specification.

**Domain** [Observation Mask Specification](#)<sup>c</sup>

**Range** [xsd:string](#)

## mask dimension<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#maskDimension">https://purl.org/ai4s/ontology/planning/multi-agent#maskDimension</a>
<b>Description</b>	Describes the dimensionality or shape of the observation mask (e.g., 11x11 window).
<b>Domain</b>	<a href="#">Observation Mask Specification</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

conflict ID <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#conflictID">https://purl.org/ai4s/ontology/planning/multi-agent#conflictID</a>
<b>Description</b>	Identifier for a collision event in the planner's logs or the knowledge graph.
<b>Domain</b>	<a href="#">Collision Event</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

conflict event type <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#conflictTypeEvent">https://purl.org/ai4s/ontology/planning/multi-agent#conflictTypeEvent</a>
<b>Description</b>	Specifies the type of collision event (e.g., vertex conflict, edge conflict) detected in execution.
<b>Domain</b>	<a href="#">Collision Event</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

alert ID <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#alertID">https://purl.org/ai4s/ontology/planning/multi-agent#alertID</a>
<b>Description</b>	Identifier for a conflict alert in the planner logs or knowledge graph.
<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

rewind window <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#rewindWindow">https://purl.org/ai4s/ontology/planning/multi-agent#rewindWindow</a>
<b>Description</b>	

	The temporal window (in timesteps) over which an agent may rewind during replanning triggered by this alert.
<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:integer</a>
<hr/>	
alert type	<a href="#">dp</a>
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#alertType">https://purl.org/ai4s/ontology/planning/multi-agent#alertType</a>
<b>Description</b>	Describes the type of conflict alert (e.g., static, dynamic, local, global).
<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>
<hr/>	
static forbidden cells	<a href="#">dp</a>
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#staticForbiddenCells">https://purl.org/ai4s/ontology/planning/multi-agent#staticForbiddenCells</a>
<b>Description</b>	Encodes static forbidden cells communicated in the alert, e.g., as a serialized list or mask.
<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>
<hr/>	
dynamic forbidden path	<a href="#">dp</a>
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#dynamicForbiddenPath">https://purl.org/ai4s/ontology/planning/multi-agent#dynamicForbiddenPath</a>
<b>Description</b>	Encodes a dynamic forbidden path (e.g., moving obstacle trajectory) communicated in the alert.
<b>Domain</b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>
<hr/>	
strategy ID	<a href="#">dp</a>
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#strategyID">https://purl.org/ai4s/ontology/planning/multi-agent#strategyID</a>
<b>Description</b>	Identifier for a replanning strategy instance.
<b>Domain</b>	<a href="#">Replanning Strategy</a> <sup>c</sup>

**Range**[xsd:string](#)used static replanning <sup>dp</sup>**IRI**<https://purl.org/ai4s/ontology/planning/multi-agent#usedStaticReplanning>**Description**

Indicates whether the strategy used static replanning constraints (e.g., fixed forbidden cells).

**Domain**[Replanning Strategy](#)<sup>c</sup>**Range**[xsd:boolean](#)used dynamic replanning <sup>dp</sup>**IRI**<https://purl.org/ai4s/ontology/planning/multi-agent#usedDynamicReplanning>**Description**

Indicates whether the strategy used dynamic replanning constraints (e.g., moving forbidden paths).

**Domain**[Replanning Strategy](#)<sup>c</sup>**Range**[xsd:boolean](#)procedure ID <sup>dp</sup>**IRI**<https://purl.org/ai4s/ontology/planning/multi-agent#procedureID>**Description**

Identifier for a planner procedure or stage.

**Domain**[Planner Procedure](#)<sup>c</sup>**Range**[xsd:string](#)implements stage <sup>dp</sup>**IRI**<https://purl.org/ai4s/ontology/planning/multi-agent#implementsStage>**Description**

Describes which pipeline stage (e.g., conflict detection, agent selection) a procedure implements.

**Domain**[Planner Procedure](#)<sup>c</sup>**Range**[xsd:string](#)

## agent selection policy<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#agentSelectionPolicy>

**Description** Describes the policy used to select agents for replanning or conflict resolution (e.g., earliest arrival, random).

**Domain** [Planner Procedure](#)<sup>c</sup>

**Range** [xsd:string](#)

## default rewind window<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#rewindWindowDefault>

**Description** Default temporal rewind window used by the procedure when triggering replanning.

**Domain** [Planner Procedure](#)<sup>c</sup>

**Range** [xsd:integer](#)

## procedure rationale<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#hasRationale>

**Description** Provides a textual rationale or description of a planner procedure's design and trade-offs.

**Domain** [Planner Procedure](#)<sup>c</sup>

**Range** [xsd:string](#)

## planner type<sup>dp</sup>

**IRI** <https://purl.org/ai4s/ontology/planning/multi-agent#ofPlannerType>

**Description** Indicates the type or family of a multi-agent planner (e.g., RL-based, search-based, hybrid).

**Domain** [Multi-Agent Planner](#)<sup>c</sup>

**Range** [xsd:string](#)

## supports conflict detection<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#supportsConflictDetection">https://purl.org/ai4s/ontology/planning/multi-agent#supportsConflictDetection</a>
<b>Description</b>	Indicates whether the planner has built-in conflict detection capabilities.
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:boolean</a>

communication overhead <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#communicationOverhead">https://purl.org/ai4s/ontology/planning/multi-agent#communicationOverhead</a>
<b>Description</b>	Describes communication overhead characteristics of the planner (e.g., centralized, distributed low-bandwidth).
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>
performance trade-off <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasPerformanceTradeoff">https://purl.org/ai4s/ontology/planning/multi-agent#hasPerformanceTradeoff</a>
<b>Description</b>	Captures performance trade-offs of the planner (e.g., speed vs. solution quality, communication vs. optimality).
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

## Namespaces

<b>cora</b>	<a href="http://wwwIEEE1872-2015/cora#">http://wwwIEEE1872-2015/cora#</a>
<b>dct</b>	<a href="http://purl.org/dc/terms/">http://purl.org/dc/terms/</a>
<b>ma</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#">https://purl.org/ai4s/ontology/planning/multi-agent#</a>
<b>owl</b>	<a href="http://www.w3.org/2002/07/owl#">http://www.w3.org/2002/07/owl#</a>
<b>plan</b>	<a href="https://ai4society.github.io/planning-ontology#">https://ai4society.github.io/planning-ontology#</a>
<b>prov</b>	<a href="http://www.w3.org/ns/prov#">http://www.w3.org/ns/prov#</a>
<b>rdf</b>	<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#">http://www.w3.org/1999/02/22-rdf-syntax-ns#</a>
<b>rdfs</b>	

<http://www.w3.org/2000/01/rdf-schema#>

**sosa**

<http://www.w3.org/ns/sosa/>

**time**

<http://www.w3.org/2006/time#>

**vann**

<http://purl.org/vocab/vann/>

**xsd**

<http://www.w3.org/2001/XMLSchema#>

## Legend

 c	Classes
 op	Object Properties
 dp	Datatype Properties