

# Multi-Agent Planning OntologyMulti-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	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#Agent">https://purl.org/ai4s/ontology/planning/multi-agent#Agent</a>
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	<a href="#">plan:ProblemObject</a>

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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](#)
- [used alert set](#)
- [has agent set](#)
- [has initial states](#)
- [has goal states](#)
- [has conflict constraint](#)
- [involves agents](#)
- [forbidden region](#)
- [derives from](#)
- [generated by](#)
- [resolves conflict](#)
- [triggered by](#)
- [occurs at time](#)
- [involves agents \(event\)](#)
- [conflict location](#)
- [alerts conflict](#)
- [target agent](#)
- [belongs to agent \(segment\)](#)
- [has valid time interval](#)
- [has path sequence](#)
- [observed forbidden cells](#)
- [observed forbidden segment](#)
- [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](#)
- [action space](#)
- [has channel](#)
- [mask dimension](#)
- [conflict ID](#)
- [conflict event type](#)
- [alert ID](#)
- [rewind window](#)
- [select time](#)

<div> <a href="#">sosa:Platform</a> </div> <div> <b><u>In Domain Of</u></b> <div> <a href="#">has agent ID</a><sup>dp</sup>  <a href="#">has capability</a><sup>op</sup>  <a href="#">has initial location</a><sup>op</sup>  <a href="#">has goal location</a><sup>op</sup>  <a href="#">executes action</a><sup>op</sup> </div> </div> <div> <b><u>In Range Of</u></b> <div> <a href="#">belongs to agent</a><sup>op</sup>  <a href="#">has agent set</a><sup>op</sup>  <a href="#">involves agents</a><sup>op</sup>  <a href="#">involves agents (event)</a><sup>op</sup>  <a href="#">target agent</a><sup>op</sup>  <a href="#">belongs to agent (segment)</a><sup>op</sup> </div> </div>	<div> <a href="#">alert type</a>  <a href="#">static forbidden cells</a>  <a href="#">dynamic forbidden path</a>  <a href="#">strategy ID</a>  <a href="#">used static replanning</a>  <a href="#">used dynamic replanning</a>  <a href="#">procedure ID</a>  <a href="#">implements stage</a>  <a href="#">agent selection policy</a>  <a href="#">default rewind window</a>  <a href="#">procedure rationale</a>  <a href="#">planner type</a>  <a href="#">supports conflict detection</a>  <a href="#">communication overhead</a>  <a href="#">performance trade-off</a> </div> <div> <b><u>Namespaces</u></b> <div> <a href="#">cora</a>  <a href="#">dct</a>  <a href="#">ma</a>  <a href="#">owl</a>  <a href="#">plan</a>  <a href="#">prov</a>  <a href="#">rdf</a>  <a href="#">rdfs</a>  <a href="#">sosa</a>  <a href="#">time</a>  <a href="#">vann</a>  <a href="#">xsd</a> </div> </div> <div> <b><u>Legend</u></b> </div>
<div> Agent State<sup>c</sup> </div> <div> <b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#AgentState">https://purl.org/ai4s/ontology/planning/multi-agent#AgentState</a> </div> <div> <b><u>Description</u></b> <div> A snapshot of an agent's state at a particular instant during plan execution, typically capturing its location and other relevant properties. </div> </div> <div> <b><u>Sub Class Of</u></b> <a href="#">plan:State</a> </div> <div> <b><u>In Domain Of</u></b> <div> <a href="#">occurs at time</a><sup>op</sup>  <a href="#">agent at</a><sup>op</sup> </div> </div> <div> <b><u>In Range Of</u></b> <div> <a href="#">has initial states</a><sup>op</sup>  <a href="#">has goal states</a><sup>op</sup> </div> </div>	
<div> Agent Sub-Plan<sup>c</sup> </div> <div> <b>IRI</b> <a href="https://purl.org/ai4s/ontology/planning/multi-agent#AgentSubPlan">https://purl.org/ai4s/ontology/planning/multi-agent#AgentSubPlan</a> </div> <div> <b><u>Description</u></b> <div> A per-agent plan describing the sequence of actions taken by a single agent within a multi-agent plan. </div> </div> <div> <b><u>Sub Class Of</u></b> <a href="#">plan:Plan</a> </div> <div> <b><u>In Domain Of</u></b> <div> <a href="#">belongs to agent</a><sup>op</sup>  <a href="#">has plan cost</a><sup>dp</sup>  <a href="#">has path data</a><sup>op</sup> </div> </div> <div> <b><u>In Range Of</u></b> <a href="#">composed of sub-plans</a><sup>op</sup> </div> <div> <b><u>Super Class Of</u></b> <a href="#">Original Agent Sub-Plan</a><sup>c</sup> </div>	

## [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<sup>c</sup>

<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<sup>c</sup>

<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<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#AgentPolicy">https://purl.org/ai4s/ontology/planning/multi-agent#AgentPolicy</a>
<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.
<b>In Domain Of</b>	<a href="#">policy name</a> <sup>dp</sup> <a href="#">trained on environment</a> <sup>dp</sup> <a href="#">observation channels</a> <sup>dp</sup> <a href="#">action space</a> <sup>dp</sup>

## Observation Mask Specification<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#ObservationMaskSpec">https://purl.org/ai4s/ontology/planning/multi-agent#ObservationMaskSpec</a>
<b>Description</b>	A specification of observation channels and masks used by an agent policy to encode partial observability of the environment.
<b>In Domain Of</b>	<a href="#">has channel</a> <sup>dp</sup> <a href="#">mask dimension</a> <sup>dp</sup>

## Collision Event<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#CollisionEvent">https://purl.org/ai4s/ontology/planning/multi-agent#CollisionEvent</a>
<b>Description</b>	An event representing a detected collision or conflict between agents at a specific time and location.
<b>In Domain Of</b>	<a href="#">conflict ID</a> <sup>dp</sup> <a href="#">occurs at time</a> <sup>op</sup> <a href="#">conflict event type</a> <sup>dp</sup> <a href="#">involves agents (event)</a> <sup>op</sup> <a href="#">conflict location</a> <sup>op</sup>
<b>In Range Of</b>	<a href="#">resolves conflict</a> <sup>op</sup> <a href="#">alerts conflict</a> <sup>op</sup>

## Conflict Alert<sup>c</sup>

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

<b><u>In Domain Of</u></b>	<a href="#">selection rationale</a> <sup>dp</sup> <a href="#">alert ID</a> <sup>dp</sup> <a href="#">alerts conflict</a> <sup>op</sup> <a href="#">target agent</a> <sup>op</sup> <a href="#">rewind window</a> <sup>dp</sup> <a href="#">alert type</a> <sup>dp</sup> <a href="#">static forbidden cells</a> <sup>dp</sup> <a href="#">dynamic forbidden path</a> <sup>dp</sup>
<b><u>In Range Of</u></b>	<a href="#">used alert set</a> <sup>op</sup> <a href="#">triggered by</a> <sup>op</sup>

## Replanning Strategy<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#ReplanningStrategy">https://purl.org/ai4s/ontology/planning/multi-agent#ReplanningStrategy</a>
<b><u>Description</u></b>	A strategy or procedure that describes how conflicts are handled and new sub-plans are generated (e.g., static vs dynamic replanning).
<b><u>In Domain Of</u></b>	<a href="#">triggered by</a> <sup>op</sup> <a href="#">strategy ID</a> <sup>dp</sup> <a href="#">used static replanning</a> <sup>dp</sup> <a href="#">used dynamic replanning</a> <sup>dp</sup> <a href="#">observed forbidden cells</a> <sup>op</sup> <a href="#">observed forbidden segment</a> <sup>op</sup>

## Planner Procedure<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#PlannerProcedure">https://purl.org/ai4s/ontology/planning/multi-agent#PlannerProcedure</a>
<b><u>Description</u></b>	A higher-level description of the stages or procedures implemented by a multi-agent planner, including agent selection and conflict-handling policies.
<b><u>In Domain Of</u></b>	<a href="#">procedure ID</a> <sup>dp</sup> <a href="#">implements stage</a> <sup>dp</sup> <a href="#">agent selection policy</a> <sup>dp</sup> <a href="#">default rewind window</a> <sup>dp</sup> <a href="#">procedure rationale</a> <sup>dp</sup>
<b><u>In Range Of</u></b>	<a href="#">implements procedure</a> <sup>op</sup>

## Multi-Agent Planner<sup>c</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#MultiAgentPlanner">https://purl.org/ai4s/ontology/planning/multi-agent#MultiAgentPlanner</a>
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<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>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasCapability">https://purl.org/ai4s/ontology/planning/multi-agent#hasCapability</a>
<b>Description</b>	Links an agent to its capabilities, as described in the CORA ontology, such as motion or sensing capabilities.
<b>Domain</b>	<a href="#">Agent</a> <sup>c</sup>
<b>Range</b>	<a href="#">cora:Capability</a>

has initial location <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasInitialLocation">https://purl.org/ai4s/ontology/planning/multi-agent#hasInitialLocation</a>
<b>Description</b>	Links an agent to its initial grid location at the start of the MAPF problem.
<b>Domain</b>	<a href="#">Agent</a> <sup>c</sup>
<b>Range</b>	<a href="#">Grid Location</a> <sup>c</sup>

has goal location <sup>op</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasGoalLocation">https://purl.org/ai4s/ontology/planning/multi-agent#hasGoalLocation</a>
<b>Description</b>	Links an agent to its goal grid location in the MAPF problem.
<b>Domain</b>	<a href="#">Agent</a> <sup>c</sup>
<b>Range</b>	<a href="#">Grid Location</a> <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> <sup>c</sup>
<b>Range</b>	<a href="#">Agent Sub-Plan</a> <sup>c</sup>

#### 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> <sup>c</sup>
<b>Range</b>	<a href="#">Conflict Alert</a> <sup>c</sup>

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

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

#### 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](#)<sup>c</sup>

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](#)<sup>c</sup>

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](#)<sup>c</sup>

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

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](#)<sup>c</sup>

**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](#)<sup>op</sup>

<b><u>Domain</u></b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b><u>Range</u></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><u>Description</u></b>	Relates a resolved sub-plan to the replanning activity that generated it.
<b><u>Sub Property Of</u></b>	<a href="#">was generated by</a> <sup>op</sup>
<b><u>Domain</u></b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b><u>Range</u></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><u>Description</u></b>	Connects a revised sub-plan to the collision event it is intended to resolve.
<b><u>Domain</u></b>	<a href="#">Resolved Agent Sub-Plan</a> <sup>c</sup>
<b><u>Range</u></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><u>Description</u></b>	Links a replanning strategy to the conflict alert that triggered it.
<b><u>Domain</u></b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b><u>Range</u></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><u>Description</u></b>	Links a collision event or agent state to the time instant at which it occurs.
<b><u>Domain</u></b>	

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

**Range**      [time:Instant](#)

## involves agents (event)<sup>op</sup>

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

**Description**      Links a collision event to the agents involved in that event.

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

**Range**      [Agent](#)<sup>c</sup>

## conflict location<sup>op</sup>

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

**Description**      Specifies the grid location at which a collision event occurs.

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

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

## alerts conflict<sup>op</sup>

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

**Description**      Associates a conflict alert with the collision event it refers to.

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

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

## target agent<sup>op</sup>

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

**Description**      Indicates the agent selected as the target for replanning in response to a conflict alert.

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

**Range**      [Agent](#)<sup>c</sup>

## belongs to agent (segment) <sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#belongsToAgentSegment">https://purl.org/ai4s/ontology/planning/multi-agent#belongsToAgentSegment</a>
<b>Description</b>	Links an agent path segment to the agent whose movement it represents.
<b>Domain</b>	<a href="#">Agent Path Segment</a> <sup>c</sup>
<b>Range</b>	<a href="#">Agent</a> <sup>c</sup>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasValidTime">https://purl.org/ai4s/ontology/planning/multi-agent#hasValidTime</a>
<b>Description</b>	Associates a path segment with the time interval during which it is executed.
<b>Domain</b>	<a href="#">Agent Path Segment</a> <sup>c</sup>
<b>Range</b>	<a href="#">time:Interval</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasPathSequence">https://purl.org/ai4s/ontology/planning/multi-agent#hasPathSequence</a>
<b>Description</b>	Represents the ordered sequence of grid locations for a path segment as an RDF list.
<b>Domain</b>	<a href="#">Agent Path Segment</a> <sup>c</sup>
<b>Range</b>	<a href="#">List</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenCells">https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenCells</a>
<b>Description</b>	Links a replanning strategy to the specific cells observed as forbidden during execution.
<b>Domain</b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b>Range</b>	<a href="#">plan:Cell</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenSegment">https://purl.org/ai4s/ontology/planning/multi-agent#observedForbiddenSegment</a>
<b>Description</b>	Links a replanning strategy to a path segment that is treated as forbidden during replanning.
<b>Domain</b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b>Range</b>	<a href="#">Agent Path Segment</a> <sup>c</sup>

#### implements procedure<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#implementsProcedure">https://purl.org/ai4s/ontology/planning/multi-agent#implementsProcedure</a>
<b>Description</b>	Links a multi-agent planner to the procedures it implements as part of its pipeline.
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">Planner Procedure</a> <sup>c</sup>

#### generates plan<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#generatesPlan">https://purl.org/ai4s/ontology/planning/multi-agent#generatesPlan</a>
<b>Description</b>	Relates a multi-agent planner to the plans it generates.
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">plan:Plan</a>

#### agent at<sup>op</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#agentAt">https://purl.org/ai4s/ontology/planning/multi-agent#agentAt</a>
<b>Description</b>	Links an agent state to the grid location where the agent is at that state.
<b>Domain</b>	<a href="#">Agent State</a> <sup>c</sup>
<b>Range</b>	<a href="#">Grid Location</a> <sup>c</sup>

## Datatype Properties

#### has agent ID<sup>dp</sup>

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-">https://purl.org/ai4s/ontology/planning/multi-</a>
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	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><u>Range</u></b>	<a href="#">xsd:decimal</a>
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conflict resolution protocol <sup>dp</sup>	
<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><u>Description</u></b>	Describes the high-level conflict resolution protocol or strategy used for a joint plan.
<b><u>Domain</u></b>	<a href="#">Joint Plan</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>

  

conflict type <sup>dp</sup>	
<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><u>Description</u></b>	Describes the type of conflict constrained (e.g., vertex conflict, edge conflict).
<b><u>Domain</u></b>	<a href="#">Conflict Constraint</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>

  

selection rationale <sup>dp</sup>	
<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><u>Description</u></b>	Provides a textual explanation of why a specific agent was chosen as the target of a conflict alert.
<b><u>Domain</u></b>	<a href="#">Conflict Alert</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>

  

policy name <sup>dp</sup>	
<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><u>Description</u></b>	The human-readable name of an agent policy (e.g., the RL architecture or configuration name).
<b><u>Domain</u></b>	<a href="#">Agent Policy</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>



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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#trainedOnEnvironment">https://purl.org/ai4s/ontology/planning/multi-agent#trainedOnEnvironment</a>
<b>Description</b>	Describes the environment or scenario distribution on which the agent policy was trained.
<b>Domain</b>	<a href="#">Agent Policy</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#observationChannels">https://purl.org/ai4s/ontology/planning/multi-agent#observationChannels</a>
<b>Description</b>	Lists the observation channels exposed to the policy (e.g., grid layers, agent positions, obstacles).
<b>Domain</b>	<a href="#">Agent Policy</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#actionSpace">https://purl.org/ai4s/ontology/planning/multi-agent#actionSpace</a>
<b>Description</b>	Describes the available actions for the policy (e.g., up/down/left/right/stay).
<b>Domain</b>	<a href="#">Agent Policy</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasChannel">https://purl.org/ai4s/ontology/planning/multi-agent#hasChannel</a>
<b>Description</b>	Names an observation channel included in an observation mask specification.
<b>Domain</b>	<a href="#">Observation Mask Specification</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

## 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.

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

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

### alert type<sup>dp</sup>

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

**Description** Describes the type of conflict alert (e.g., static, dynamic, local, global).

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

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

### static forbidden cells<sup>dp</sup>

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

**Description** Encodes static forbidden cells communicated in the alert, e.g., as a serialized list or mask.

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

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

### dynamic forbidden path<sup>dp</sup>

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

**Description** Encodes a dynamic forbidden path (e.g., moving obstacle trajectory) communicated in the alert.

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

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

### strategy ID<sup>dp</sup>

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

**Description** Identifier for a replanning strategy instance.

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

<b><u>Range</u></b>	<a href="#">xsd:string</a>
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used static replanning <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#usedStaticReplanning">https://purl.org/ai4s/ontology/planning/multi-agent#usedStaticReplanning</a>
<b><u>Description</u></b>	Indicates whether the strategy used static replanning constraints (e.g., fixed forbidden cells).
<b><u>Domain</u></b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:boolean</a>

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used dynamic replanning <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#usedDynamicReplanning">https://purl.org/ai4s/ontology/planning/multi-agent#usedDynamicReplanning</a>
<b><u>Description</u></b>	Indicates whether the strategy used dynamic replanning constraints (e.g., moving forbidden paths).
<b><u>Domain</u></b>	<a href="#">Replanning Strategy</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:boolean</a>

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procedure ID <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#procedureID">https://purl.org/ai4s/ontology/planning/multi-agent#procedureID</a>
<b><u>Description</u></b>	Identifier for a planner procedure or stage.
<b><u>Domain</u></b>	<a href="#">Planner Procedure</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>

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implements stage <sup>dp</sup>	
<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#implementsStage">https://purl.org/ai4s/ontology/planning/multi-agent#implementsStage</a>
<b><u>Description</u></b>	Describes which pipeline stage (e.g., conflict detection, agent selection) a procedure implements.
<b><u>Domain</u></b>	<a href="#">Planner Procedure</a> <sup>c</sup>
<b><u>Range</u></b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#agentSelectionPolicy">https://purl.org/ai4s/ontology/planning/multi-agent#agentSelectionPolicy</a>
<b>Description</b>	Describes the policy used to select agents for replanning or conflict resolution (e.g., earliest arrival, random).
<b>Domain</b>	<a href="#">Planner Procedure</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#rewindWindowDefault">https://purl.org/ai4s/ontology/planning/multi-agent#rewindWindowDefault</a>
<b>Description</b>	Default temporal rewind window used by the procedure when triggering replanning.
<b>Domain</b>	<a href="#">Planner Procedure</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:integer</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#hasRationale">https://purl.org/ai4s/ontology/planning/multi-agent#hasRationale</a>
<b>Description</b>	Provides a textual rationale or description of a planner procedure's design and trade-offs.
<b>Domain</b>	<a href="#">Planner Procedure</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

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

<b>IRI</b>	<a href="https://purl.org/ai4s/ontology/planning/multi-agent#ofPlannerType">https://purl.org/ai4s/ontology/planning/multi-agent#ofPlannerType</a>
<b>Description</b>	Indicates the type or family of a multi-agent planner (e.g., RL-based, search-based, hybrid).
<b>Domain</b>	<a href="#">Multi-Agent Planner</a> <sup>c</sup>
<b>Range</b>	<a href="#">xsd:string</a>

## 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

### cora

<http://www.IEEE1872-2015/cora#>

### dct

<http://purl.org/dc/terms/>

### ma

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

### owl

<http://www.w3.org/2002/07/owl#>

### plan

<https://ai4society.github.io/planning-ontology#>

### prov

<http://www.w3.org/ns/prov#>

### rdf

<http://www.w3.org/1999/02/22-rdf-syntax-ns#>

### rdfs

<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 Propertie s
dp	Datatype Propertie s