Razonamiento y planificación automática

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Tema 11: Planificación por múltiples agentes (2ª parte)


Planificación por múltiples agentes
Planificadores distribuidos
Formalización Multi Agente
Protocolos de cooperación multi agente
FMAP Planificador multi agente
Definición
Tarea de planificación
Refinamiento de planes

Índice

- Planificación Multi Agente (2ª parte)
  - Planificación por múltiples agentes


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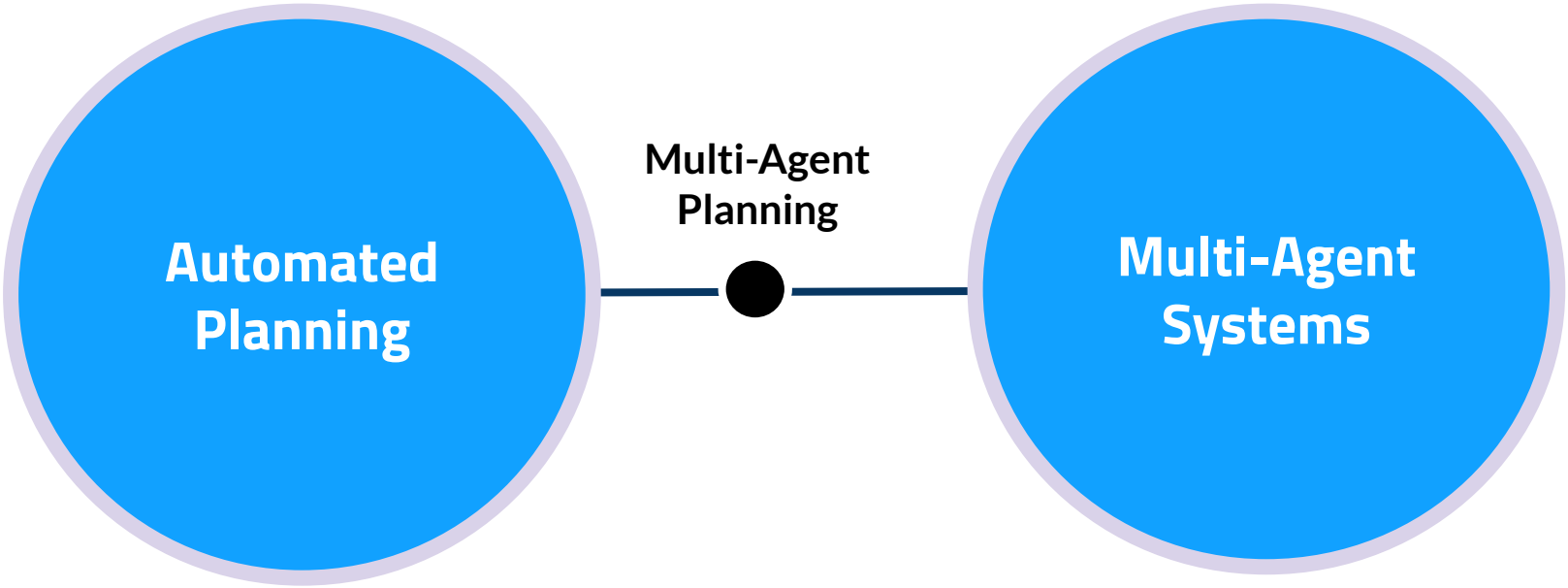
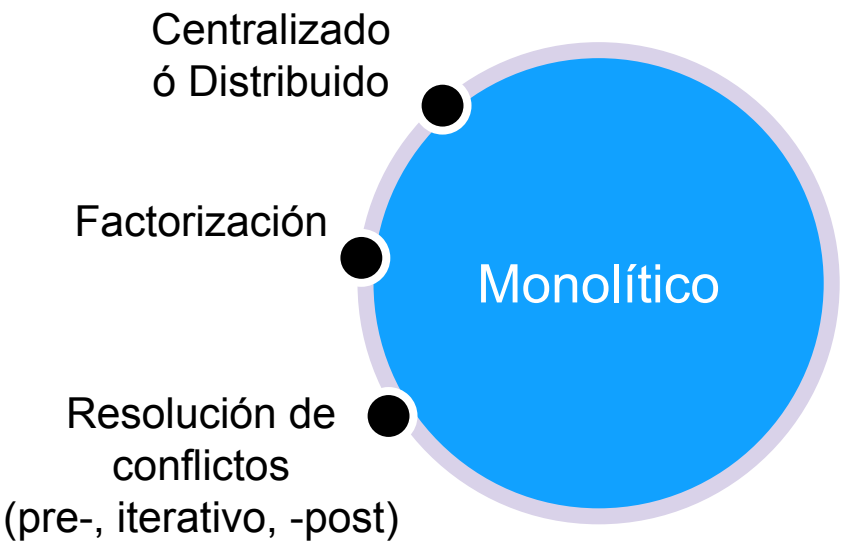
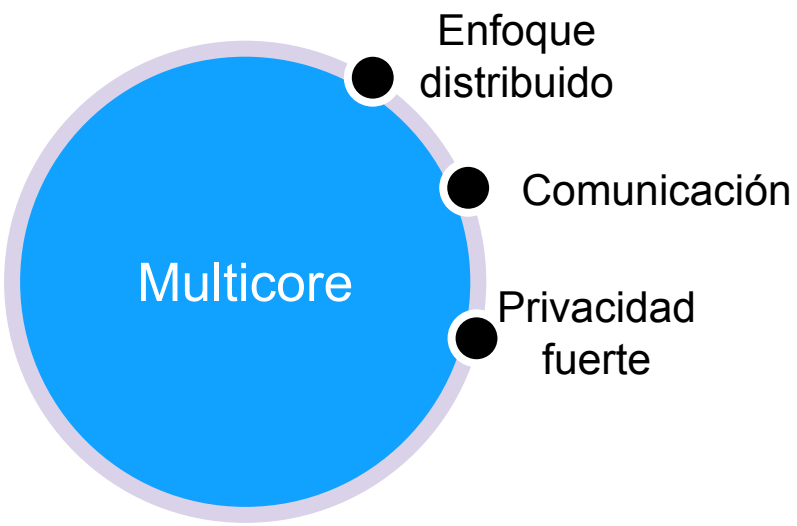
Hoy

Dónde estamos



Tipos de enfoques multi agentes





Planificación **para** múltiples agentes

Planificación **por** múltiples agentes

Características de multi-agent planning

Agents' Distribution

- Centralized
- Distributed

Computational Process

- Monolithic
- Distributed

Plan synthesis schemes

- Solving interactions
- Pre- post- or during planning

Communication

- External
- Internal (optional)

Privacy Preservation

- Sensitive information is hidden

Heuristic Search

- Local heuristics
- Global heuristics

MA-PDDL

```
(define ( domain transport - agency )
    (:requirements :factored-privacy :typing :equality :fluents )
    (:types transport - agency area location package product - object truck
place - location factory - place )

    (:predicates
        ( manufactured ? p - product ) ( at ?p - package ? l - location )
    (:private ( area ? ag - transport - agency ?a - area ) (in - area ?p -
    place ?a - area ) ( owner ?a - transport - agency ?t - truck ) ( pos ?t
    - truck ?l - location ) ( link ? p1 - place ? p2 - place ) ) )
    (:action drive
        :parameters (? ag - transport - agency ?a - area ? t - truck ? p1 -
        place ? p2 - place )
        :precondition ( and ( area ? ag ?a) (in - area ? p1 ?a ) ( in - area
    ? p2 ?a) ( owner ?a ?t) ( pos ? t ? p1 ) ( link ? p1 ? p2 ))
        :effect ( and ( not ( pos ? t ? p1 )) ( pos ? t ? p2 )) )
    [...] )
```

MA-PDDL

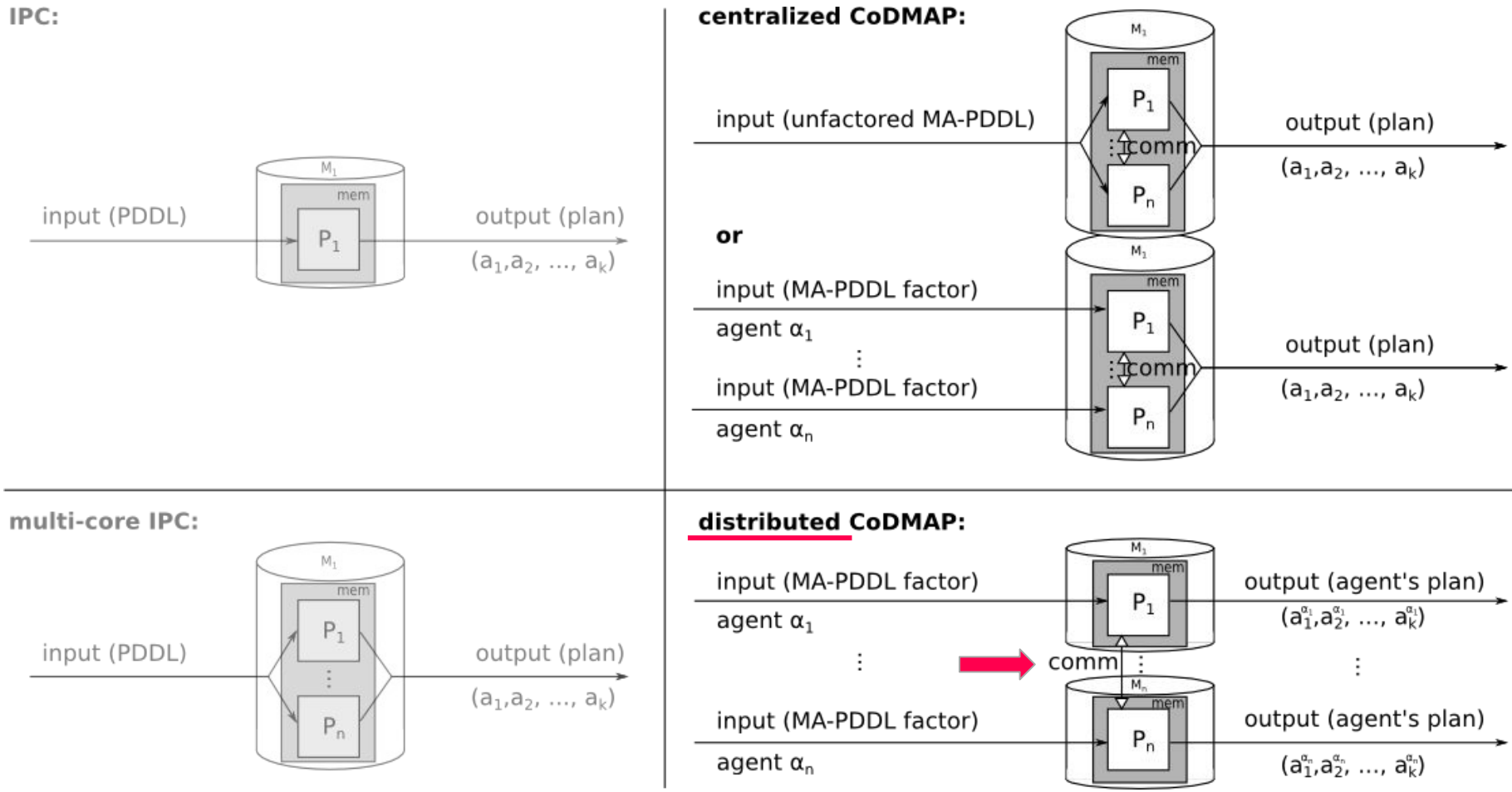
```
( define ( problem ta1 )
    (: domain transport-agency )
    (: objects
        ta1 - transport-agency
        ga1 - area l1 l2
        sf - place
        p - package
        fp - product
    (: private t1 - truck ) )
    (: init ( area ta1 ga1 ) ( pos t1 l1 ) ( owner t1 ta1 ) ( at p l1 )
    ( link l1 l2 ) ( link l2 l1 ) ( link l1 sf ) ( link sf l1 ) ( link
    l2 sf ) ( link sf l2 ) (in - area l1 ga1 ) (in - area l2 ga1 ) (in -
    area sf ga1 ) )
    (: goal (manufactured fp)) )
```

Características de multi-agent planning

Referencias:

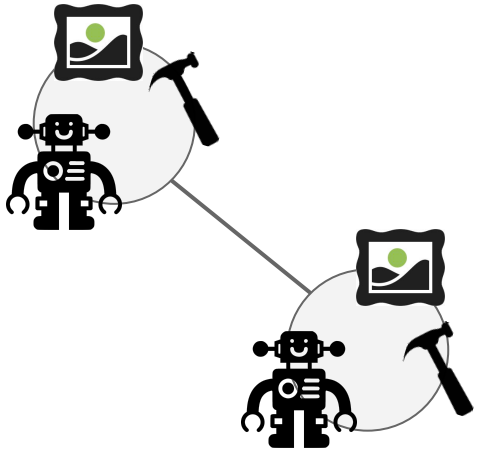
- Torreño et al (2017) Cooperative Multi-Agent Planning: A Survey https://arxiv.org/pdf/1711.09057.pdf
- CoDMAP http://agents.fel.cvut.cz/codmap/

CoDMAP


IPC:
input (PDDL)
output (plan)
(a1,a2, ..., ak)
centralized CoDMAP:
input (unfactored MA-PDDL)
output (plan)
(a1,a2, ..., ak)
or
input (MA-PDDL factor)
agent α1
input (MA-PDDL factor)
agent αn
output (plan)
(a1,a2, ..., ak)
multi-core IPC:
input (PDDL)
output (plan)
(a1,a2, ..., ak)
distributed CoDMAP:
input (MA-PDDL factor)
agent α1
input (MA-PDDL factor)
agent αn
output (agent's plan)
output (agent's plan)

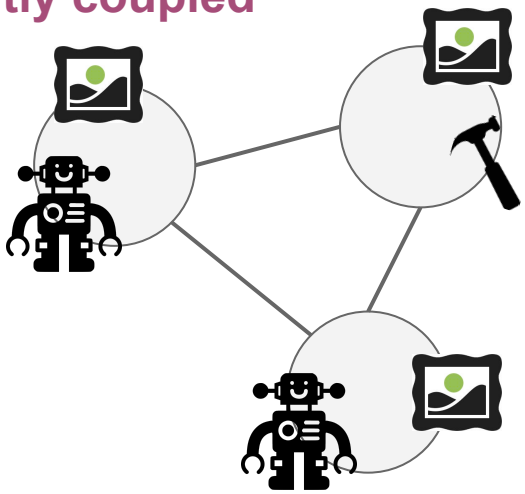
Tipos de interacción

Loosely coupled



Menor interacción, no hay recursos compartidos

Tightly coupled



Interacción entre los agentes y/o con los recursos compartidos

Planning coordination

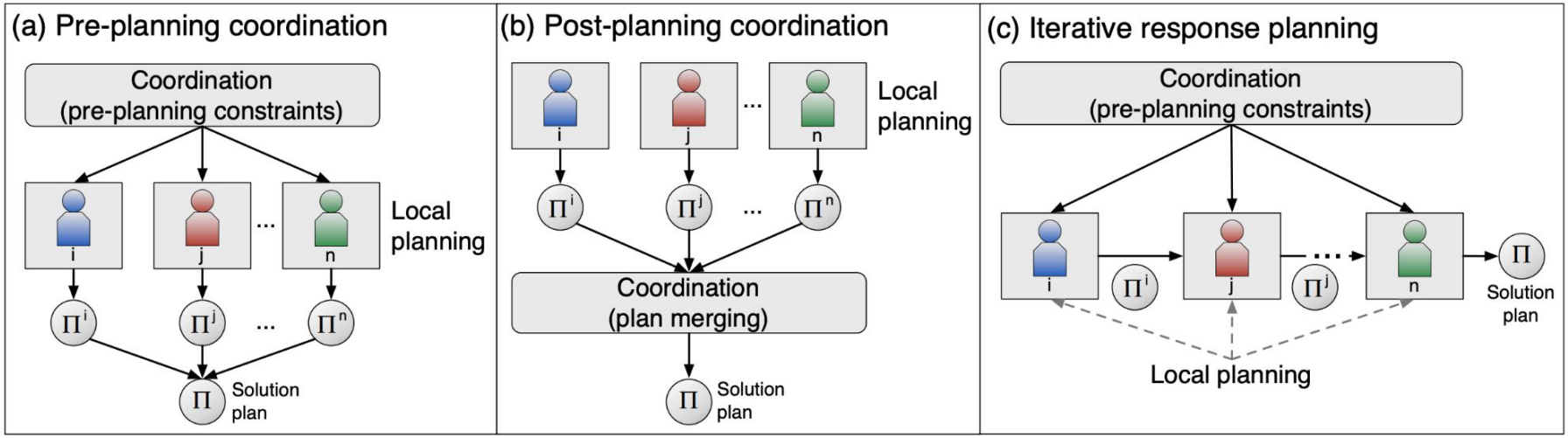


Fig. 3. Plan synthesis schemes in unthreaded planning and coordination

Privacidad

Table III. Categorization of privacy properties in MAP

Privacy criterion	Categories
Modelling of private information	Imposed privacy [Brafman and Domshlak 2008]
	Induced privacy [Torreño et al. 2014b]
Information sharing	MA-STRIPS [Brafman and Domshlak 2008]
	Subset privacy [Bonisoli et al. 2014]
Practical guarantees	No privacy [Decker and Lesser 1992]
	Weak privacy [Borrajo 2013]
	Object cardinality privacy [Shani et al. 2016]
	Strong privacy [Brafman 2015]

Multi-agent planners

Table IV. Summary of the state-of-the-art MAP solvers and their features. For unthreaded solvers, the plan synthesis schemes are listed in form of pairs "agent coordination" & "local planning technique".

MAP Solver	Coordination strategy	Computational process	Plan synthesis scheme	Heuristic	Privacy	CoDMAP	
						Cent. track	Dist. track
ADP [Crosby et al. 2013]	UT	C	Automated task agentization & heuristic forward search (FD)	L	N	1st/5th	-
MAP-LAPKT [Muise et al. 2015]	UT	C	Task mapping into single-agent task & heuristic forward search (LAPKT)	G	W	2nd/3rd/6th	-
MARC [Sreedharan et al. 2015]	UT	C	Task mapping into transformer agent task & planning via FD or IBACOP → solution plan translation into original MAP task	G	W	4th	-
CMAP [Borrajo and Fernández 2015]	UT	C	Pre-planning goal allocation → task mapping into single-agent task → solution plan parallelization & heuristic forward search (LAMA)	G	W	7th/8th	-
MAPlan [Fišer et al. 2015]	IL	D	Multi-agent heuristic forward search	G/L	W	9th/18th/19th	2nd/5th/6th
GPPP [Maliah et al. 2016]	IL	C	Multi-agent heuristic forward search (relaxed, subgoals)	G	W	10th/11th	-
PSM [Tožička et al. 2016]	UT	D	Intersection of Finite Automata & heuristic forward search (LAMA) → Finite Automata	G	W	12th/16th	1st/4th
MADLA [Štolba and Komenda 2014]	IL	C	Multi-agent multi-heuristic state-based search	G/L	W	13th	-
PMR [Luis and Borrajo 2014]	UT	C	Pre-planning goal allocation → Plan merging → plan repair → solution plan parallelization & heuristic forward search (LAMA)	L	W	14th	-
MAPR [Borrajo 2013]	UT	C	Pre-planning goal allocation → iterative response planning → solution plan parallelization & heuristic forward search (LAMA)	L	W	15th	-
MH-FMAP [Torreño et al. 2015]	IL	D	Multi-agent A* multi-heuristic search via forward POP	G	W	17th	3rd
DPP [Shani et al. 2016]	UT	C	Synthesis of high-level plan over DP projection (FD) & heuristic forward search (FF)	L	OC	-	-
FMAP [Torreño et al. 2014b]	IL	D	Multi-agent A* heuristic search via forward POP	G	W	-	-
MAFS [Nissim and Brafman 2012]	IL	D	Multi-agent heuristic forward search	L	W	-	-
MAD-A* [Nissim and Brafman 2012]	IL	D	Multi-agent A* heuristic forward search	L	W	-	-
MAP-POP [Torreño et al. 2014a]	IL	D	Multi-agent A* heuristic search via backward POP	G	W	-	-
Planning First [Brafman and Domshlak 2008]	UT	C	Post-planning coordination via DisCSP & heuristic forward search (FF)	–	N	-	-
μ-SATPLAN [Dimopoulos et al. 2012]	UT	C	Pre-planning goal allocation → iterative response planning & SAT	–	N	-	-
TFPOP [Kvarnström 2011]	UT	C	Forward-chaining partial-order planning & synthesis of agent-specific thread of actions	–	N	-	-
Distoplan [Fabre et al. 2010]	UT	C	Message passing algorithm & Finite Automata	–	N	-	-
DPGM [Pellier 2010]	UT	C	Iterative response planning & GraphPlan + CSP plan extraction	–	N	-	-
A# [Jezequel and Fabre 2012]	UT	C	Asynchronous communication mechanism & A* heuristic forward search	G	N	-	-
Secure-MAFS [Brafman 2015]	IL	C	Multi-agent heuristic forward search	L	S	-	-

Computational process: C - centralized solver, D - distributed solver
Coordination strategy: UT - unthreaded, IL - interleaved
Privacy: N - no privacy, W - weak privacy, OC - object cardinality privacy, S - strong privacy
Heuristic: L - local, G - global
CoDMAP: coverage classification, Cent. track - centralized track, Dist. track - distributed track, a '-' indicates that the solver did not participate in a track.

FMAP

https://arxiv.org/pdf/1501.07250.pdf

FMAP es un planificador multi agente que utiliza un POP (partial-order planner) y un algoritmo de búsqueda A* multi agente. Implementa una planificación hacia adelante (Forward). El algoritmo general de FMAP se divide en tres fases:

1. Intercambio de información entre los agentes
2. Refinamiento individual
3. Proceso de coordinación

Las fases 2 y 3 se repiten hasta que un plan solución es encontrado o el espacio de búsqueda es completamente

Planificación por múltiples agentes (FMAP)

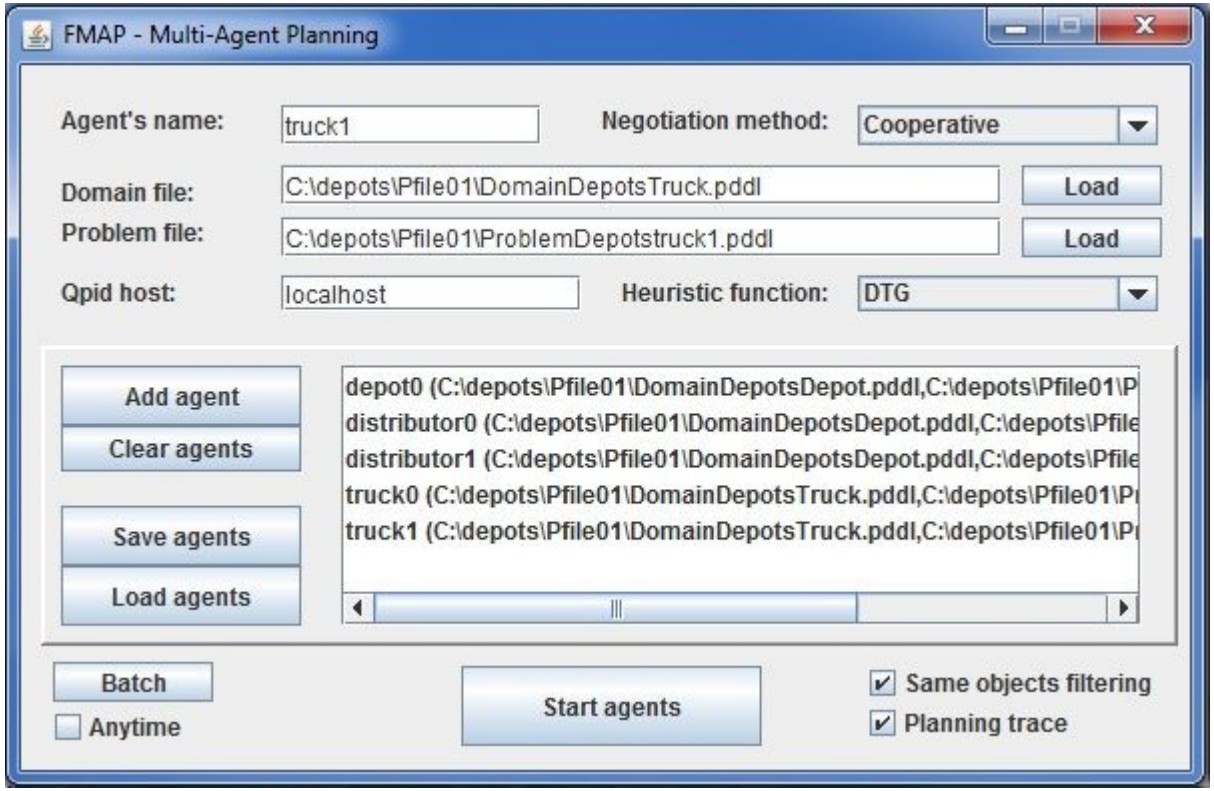
En un PBMA (Torreno Lerma A , 2016), definiremos una tarea como una tupla <AG, V, I, G, A> formada por:

- AG = {1, ..., n}: Un conjunto finito no vacío de agentes de planificación.
- V = $\bigcup_{i \in AG} V^i$: Donde V^i es un conjunto de variables estado que definen un estado en el que se pueda encontrar un agente i en el entorno.
- I = $\bigcup_{i \in AG} I^i$: Es un estado inicial definido por un conjunto de variable instanciadas (fluents). Como en este tipo de problemas pueden existir agentes especializados, ellos pueden solo conocer un subconjunto de I. Como premisa, el estado inicial de dos agentes nunca se contradice.
- G: Conjunto de metas que deben alcanzar entre todos los agentes, teniendo en cuenta que se considerará cumplido el estado meta independientemente del agente que consiga el última fluent buscado. Definen los objetivos de la tarea de planificación multi agente.
- A = $\bigcup_{i \in AG} A^i$: Conjunto de acciones de planificación deterministas de los agentes.

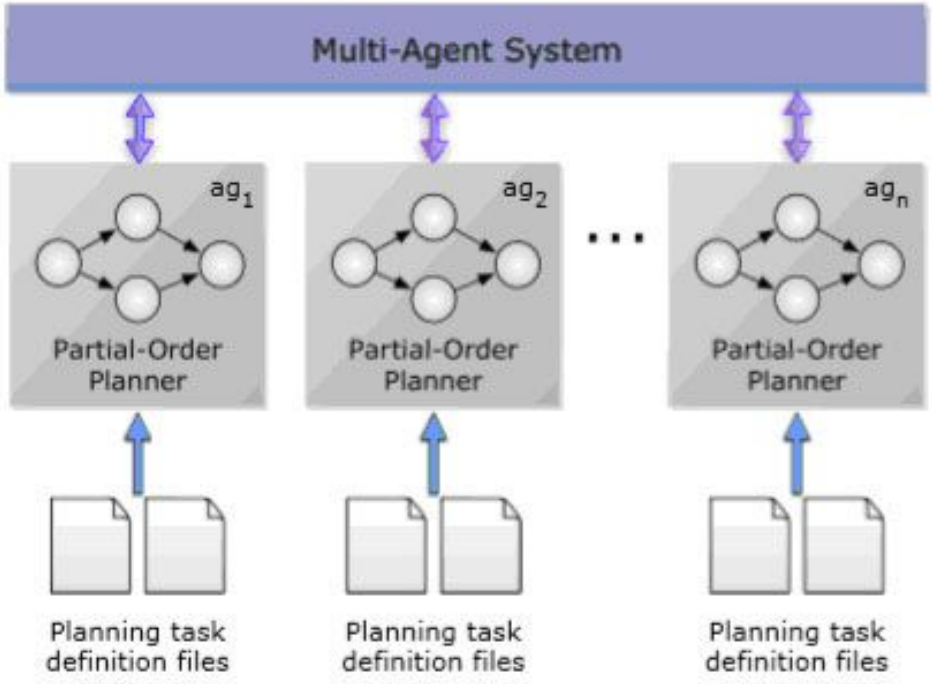
FMAP - Inputs

- **Una descripción formal del dominio y el problema**, especificada por medio de un lenguaje de planificación, aunque es necesario extender los estándares PDDL. En ninguna de sus versiones, cubre todas las necesidades del problema descentralizado.
- **Un sistema multiagente distribuido** para permitir la gestión y comunicación de varios agentes, el intercambio de los planes construidos y la toma de decisiones del plan inicial.
- Un **Partial-Order Planner** (POP) que tendrá embebido cada uno de los agentes y que le permitir refinar el plan global inicial aportando sus subplanes elaborados.

FMAP - Configuración y factorización



FMAP - Arquitectura (alto nivel)



FMAP - Metas del problema

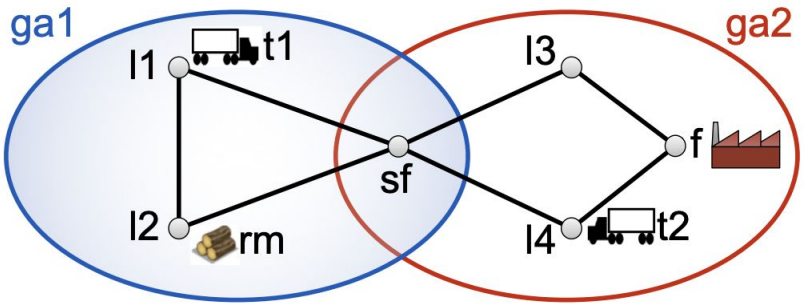


Fig. 1 Example of a transportation task

- **Goal 1:** Recoger la madera (rm) y llevarla al almacén (sf),
- **Goal 2:** Recoger los materiales procesados del almacén (sf) y llevarlos a la fábrica (f:factory)

rm = raw material

sf = storage facility
f = factory

FMAP - Planificación individual

FLEX allows inserting actions at any position of the plan without assuming that any action in the plan has already been executed. T

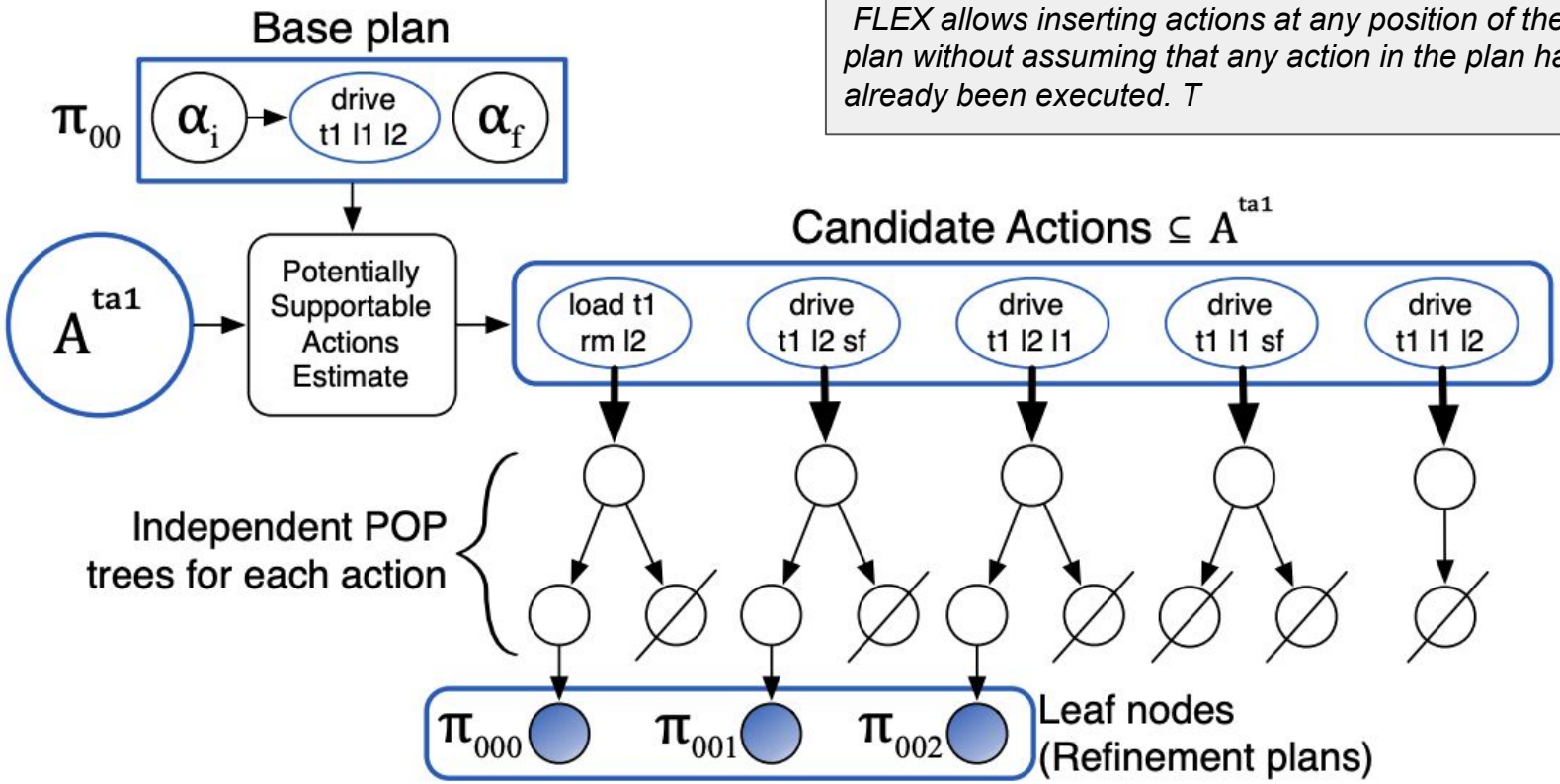


Fig. 5 FLEX algorithm as applied by agent $ta1$ over plan Π_{00}

FMAP - Planificación y Coordinación

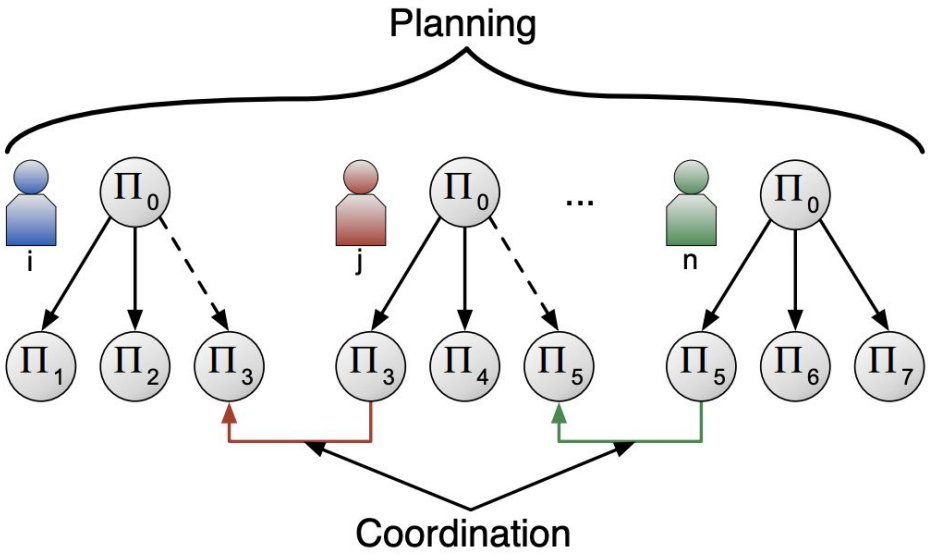
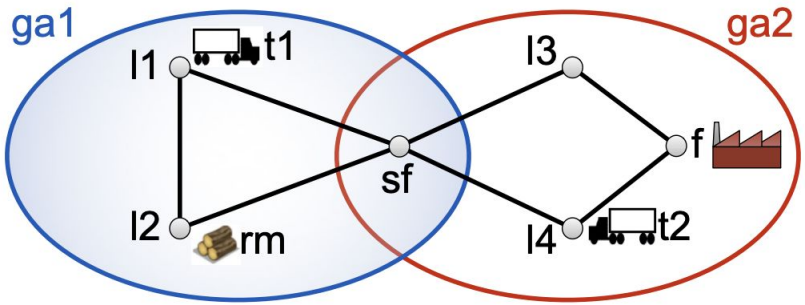


Fig. 4. Multi-agent search in interleaved planning and coordination

FMAP - Abstracción de la información



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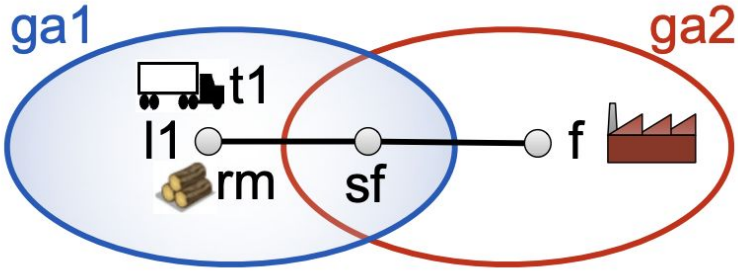

Fig. 6 Reduced transport example task

sf = storage facility

www.unir.net