Planning Representation: Time & preferences

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Objectives

Specific Objectives

- Model in PDDL 2.1 & PDDL 3.1
- Run SoA planners

Source

- Fox & Long. PDDL2.1: An Extension to PDDL for Expressing Temporal Problems. Journal of AI Research 20 (2003) 61-124
- Gerevini & Long. Plan Constraints and Preferences in PDDL3 (2005) Tech. Report, Dpt. of Electronics Automation, University of Brescia
- Eva Onaindia De La Rivaherrera. Planificación Automática. Videos. UPV. https://media.upv.es/

Outline

- **Introduction**
- Temporal Planning
- PDDL 2.X syntax
- Airport problem
- Preferences in Planning
- PDDL 3.X syntax
- PDDL3.X examples
- Conclusions

Introduction (I)

- Classical planning is restrictive
  - Implicit time assumption
  - Actions no duration
- Need new features for real problems
  - Time
  - Resources
  - Multi-objective
- PDDL is extended: PDDL 2.1

Introduction (II)

- PDDL 2.1 Levels:
  - Level 1: STRIPS version
  - Level 2: the numeric extensions
  - Level 3: the addition of discretised durative actions
  - Level 4: continuous durative actions
  - Level 5: comprised all of the extensions of pddl2.1 and additional components to support the modelling of spontaneous events and physical processes

Introduction (III)

- New
  - Numeric expressions
  - Durative actions
  - Metrics: evaluate the quality of a plan
  - Continuous changes

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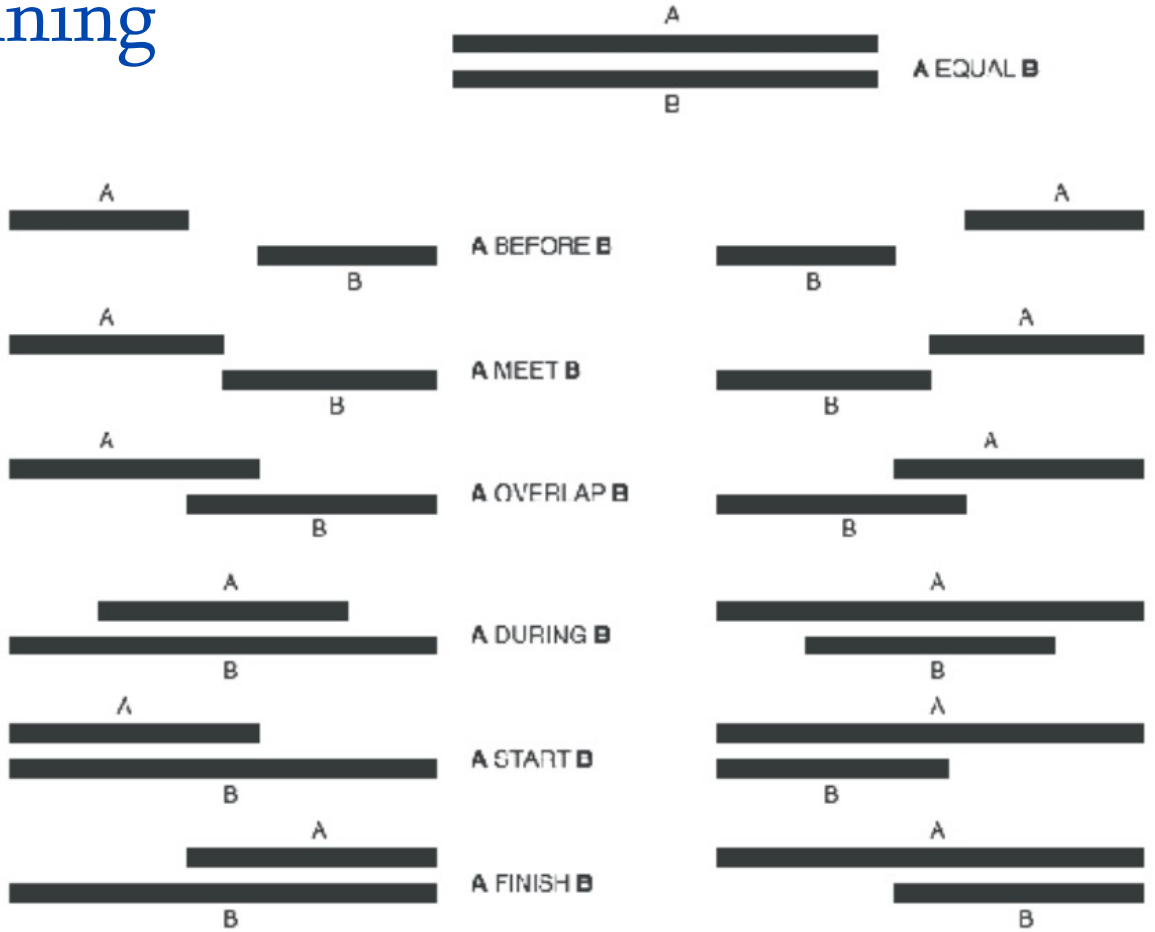
Temporal planning

- Sequential planning is not adequate
- What (actions) + When (execution time)
  - Actions synchronization
  - Actions overlapping
  - New optimization criteria
    - Planning steps vs. plan duration (*makespan*)

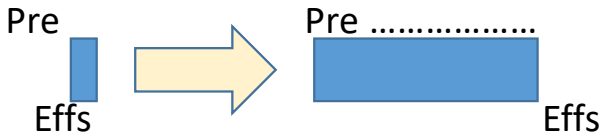
Temporal planning



Source: Flavio S. Corrêa da Silva

Temporal planning: conservative model (I)

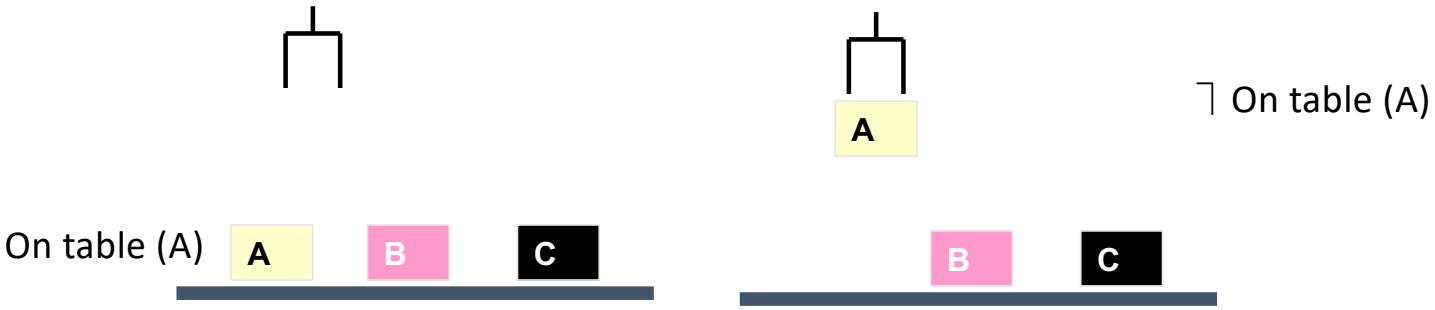
- Easiest way: convert the existing model in a duration model (conservative time model)
- How
  - Preconditions are true at the beginning
  - Effects are true at the end



- Actions are not atomic, allow concurrency (iff no conflicts)
- We cannot know the state of variables in the problem

Temporal planning: conservative model (II)

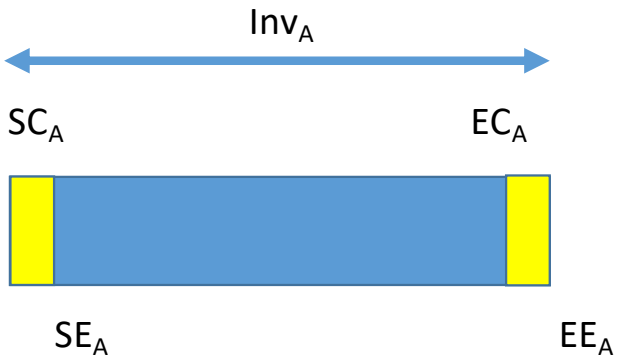
- What happen with pick-up action? Where is A during the process?



- The planner can assume that is all the time on the table (is NOT correct!!!)

Temporal planning: non-conservative model

- Consider when each predicate holds
  - StartCond: (SC_A)
  - $EndCond_A$: (SC_A)
  - $StartEff_A$: (SE_A)
  - $EndEff_A$: (EE_A)
  - $Invariant_A$: (Inv_A)



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PDDL syntax: Domain

```
(define (domain name)
  (:requirements <require-key> :durative-actions :fluents)
  (:types <typed_list (name)>)
<PDDL list of predicates in the domain>
<PDDL list of functions in the domain>

<PDDL code for first action>
...
<PDDL code for last action>
)
```

PDDL syntax: Actions (I)

(:durative-action <action name>
 :parameters (<list>)
 :duration (= ?duration <number> or (<predicate list>))
 :condition (and (at start/at end/overall (<predicate list>))
 :effect (and (at start/at end/overall (<predicate list>))
)

PDDL syntax: Actions (II)

- To assign
  - assign (not =)
- To add
  - increase
- To subtract
  - decrease

PDDL syntax: Problem

```
(define (problem <problem name>)
  (:domain <domain name>)
  <PDDL code for objects>
  <PDDL code for initial state>
  (= (predicate <parameter list>) number)
  <PDDL code for goal specification>
(:metric minimize (predicate))
)
```

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Airport domain

- The domain consists of planes and passengers that travel from one city to another
- Model the duration of the actions and the fuel consumption
- Model 3 actions:
  - Board: a person on a plane that is in a city. As a result the person is not in the city and is on the plane
  - Debark: a person from an airplane. As a result the person is in the city, and is not on the plane
  - Fly: from one city to another. The fuel of the plane depends on the distance between the cities and the fuel ratio consumption of the plane. As a precondition, it should be verified

    Fuel >= (distance-between-cities) x (burn-fuel-ratio of the plane)
  - Metrics: Time

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Introduction

- PDDL2.X is still restrictive
  - Plan quality measured by plan size
  - Hard constraints on actions
  - Hard constraints on goals
- If not satisfied, NO plan!!
- Plan with soft constraints & goals
  - Best quality plan satisfy “as much as possible” the soft constraints & goals
- PDDL2.X is extended: PDDL3

Preferences in planning (I)

- With soft constraints and goals, can be useful to give priorities
  - Numerical weight representing the cost of its violation in a plan (metric)
- Transportation example
  - We would like that every airplane is used (instead of using only a few airplanes, because it is better to distribute the workload among the available resources and limit heavy usage)
  - Whenever a ship is ready at a port to load the containers it has to transport, all such containers should be ready at that port
  - We would like that at the end of the plan all trucks are clean and at their source location
  - We would like no truck to visit any destination more than once

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PDDL syntax: Domain

```
(define (domain name)
  (:requirements <require-key> :constraints :preferences)
  (:types <typed_list (name)>)
<PDDL list of predicates in the domain>
<PDDL list of functions in the domain>
<PDDL code for first action>
...
<PDDL code for last action>
)
```

PDDL syntax: Problem

(define (problem <problem name>)

...

(:goal (and ...

(preference [name] <GD>)

(:constraints

(at end <GD>) | (always <GD>) | (sometime <GD>) | (within <num> <GD>) | (at- most-once <GD>) | (sometime-after <GD> <GD>) | (sometime-before <GD> <GD>) | (always-within <num> <GD> <GD>) | (hold-during <num> <num> <GD> | (hold-after <num> <GD> | ...

(:metric

(is-violated <preference-name>)

))

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PDDL3.X examples: Preferences

- (preference VisitParis (forall (?x - tourist) (sometime (at ?x Paris))))
  - yields a violation count of 1 for (is-violated VisitParis), if at least one tourist fails to visit Paris
- (forall (?x - tourist) (preference VisitParis (sometime (at ?x Paris))))
  - yields a violation count equal to the number of people who failed to visit Paris
- (:goal (and (at package1 London) (preference p1 (clean truck1))))

PDDL3.X examples: Constraints

- Constraints can be used to weighted expressions in metrics

  (:metric minimize (+ (* 10 (fuel-used)) (is-violated VisitParis)))

  would weight fuel use as ten times more significant than violations of the VisitParis constraint

- Another example of multiple ones:

  (:constraints (and (preference p1 (always (clean truck1))) (preference p2 (and (at end (at package2 Paris)) (sometime (clean truck1)))) (preference p3 (...)) ...))

- Combine metrics and preferences

  (:metric (+ (* 10 (is-violated p1)) (* 5 (is-violated p2)) (is-violated p3)))

PDDL3.X examples

- We want three jobs completed. We would prefer to take a coffee-break and that we take it when everyone else takes it (at coffee-time) rather than at any time. We would also like to finish reviewing a paper, but it is less important than taking a break. Finally, we would like to be finished so that we can get home at a reasonable time, and this matters more than finishing the review or having a sociable coffee break

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Conclusions

- No model of time in classical planning
- PDDL 2.1 follows non-conservative time model
- What (actions) + When (execution time)
  - Actions synchronization
  - Actions overlapping
  - New optimization criteria
    - Planning steps vs. plan duration (*makespan*)
- PDDL2.X is extended: PDDL3.X
- Represent plan with soft constraints & goals
  - Best quality plan satisfy "as much as possible" the soft constraints & goals