



Feedback on the use of PDDL solvers in an industrial R&D context

Johann Dreo

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Feedback on the use of PDDL solvers in an industrial R&D context

Johann Dreo

Message



Happy planning solvers users



Not happy with:

**No on-demand binding between model
and action costs**

Debugging of domains too hard

Team

▶ 2007 - 2013 - 2020

- ▶ 1) develop solvers
- ▶ 2) applications

▶ Research & Technology

- ▶ Decision & Optimization lab.,
 - ▶ Johann Dreo,
 - ▶ Pierre Savéant.

▶ Others

- ▶ INRIA : March Schoenauer
- ▶ ONERA : Vincent Vidal

▶ Former students/postdocs

- ▶ Jacques Bibai
- ▶ Caner Candan
- ▶ Mátyás Brendel
- ▶ Mostepha R. Khouadjia
- ▶ Alexandre Quemy

Divide-and-Evolve (DAE)

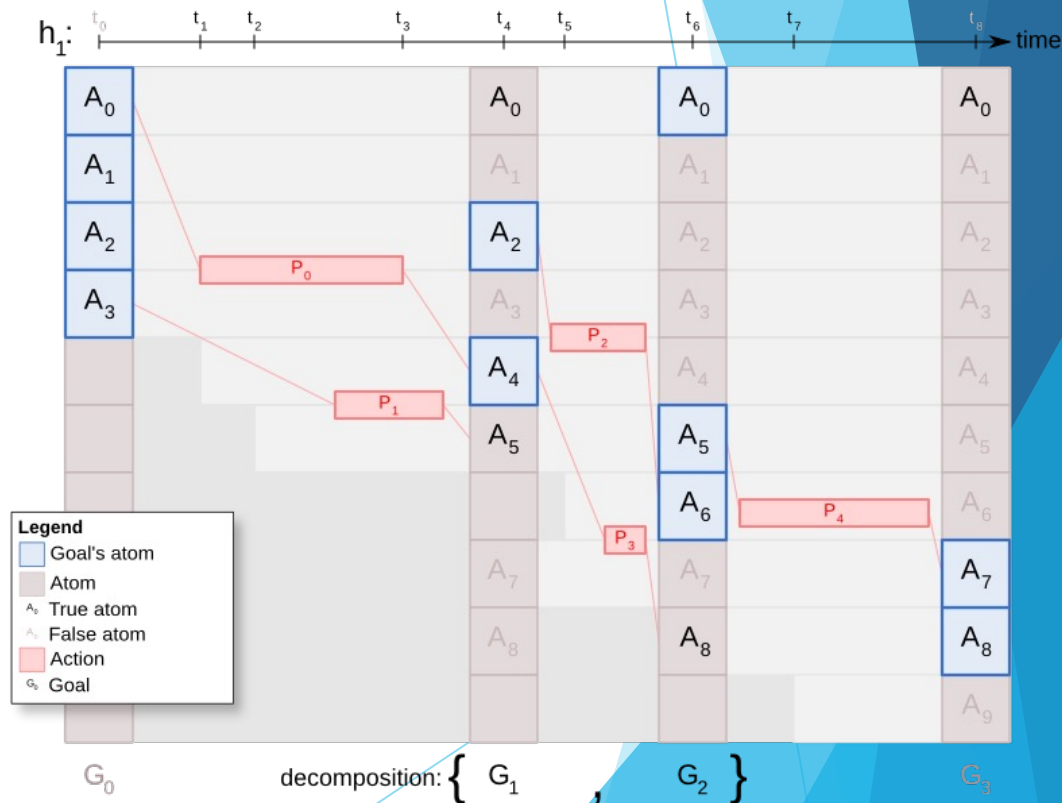
► Divide And Evolve

- Black-box heuristic for problem decomposition
- YAHSP for subproblem solving

► 2010 : silver medal at GECCO Hummies awards

- Competing against human planner

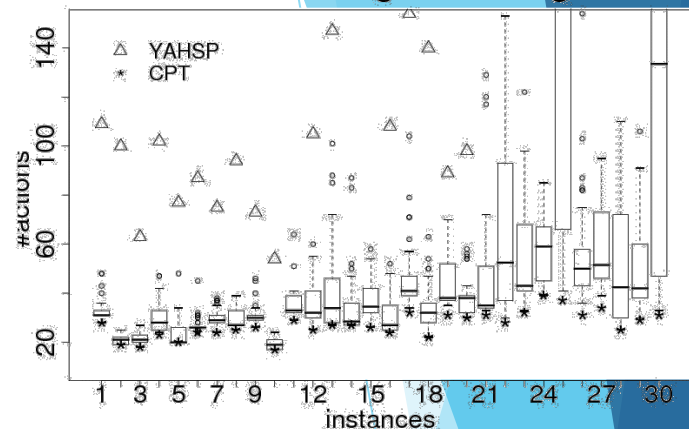
► 2011 : (one of the) winner in temporal satisficing track at IPC



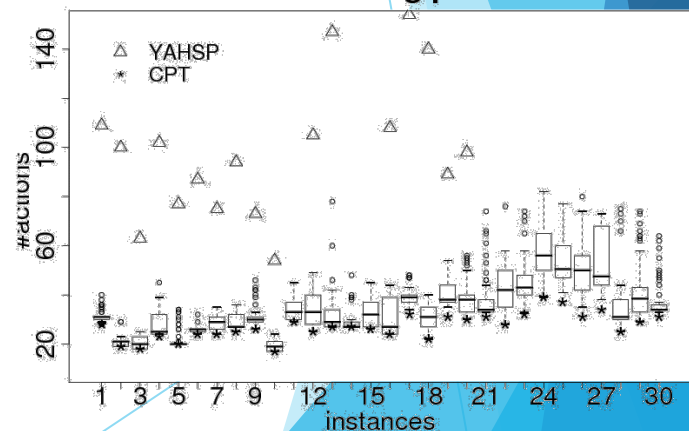
Research: 2007 - 2013

- ▶ DAE-CPT
- ▶ DAE-YAHSP2
- ▶ DAE-YAHSP3
- ▶ Automatic configuration of DAE
 - ▶ Using racing
 - ▶ Using generic optimization
- ▶ Multi-objective optimization
 - ▶ And PDDL (Zeno) benchmark

Gold miner: global racing



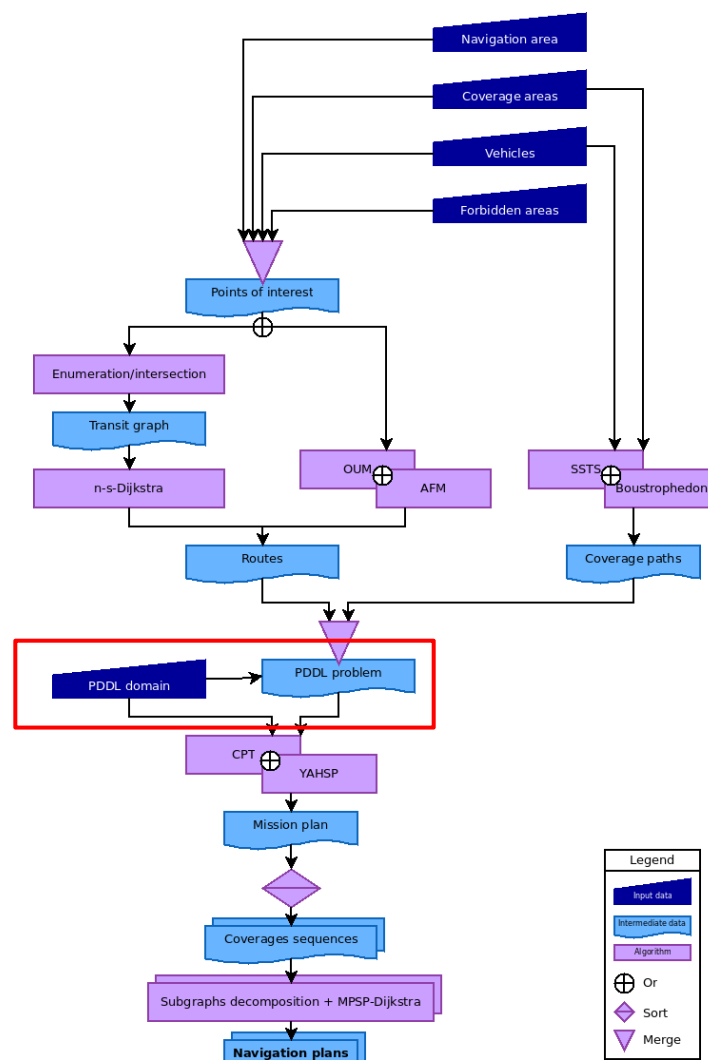
Gold miner: racing per instance



Applications: 2013 - 2020

- ▶ **Multi-vehicles mission planning**
(\approx resources displacement on geographic graphs)
 - ▶ Emergency vehicles in heavy traffic
 - ▶ Delivery during resource-scare crisis
 - ▶ Aerial drone mission planning
 - ▶ Multi-aerial drones surveillance system
 - ▶ Underwater uncrewed multi-vehicles mission planning
 - ▶ Multi-types uncrewed multi-vehicles mission planning
- ▶ Always various actions (more than just "move", e.g. scan, pick, ...)
- ▶ Not always required concurrency

Multi-vehicles planning



Well known Pro & Cons of Planning Modelling

► Advantages

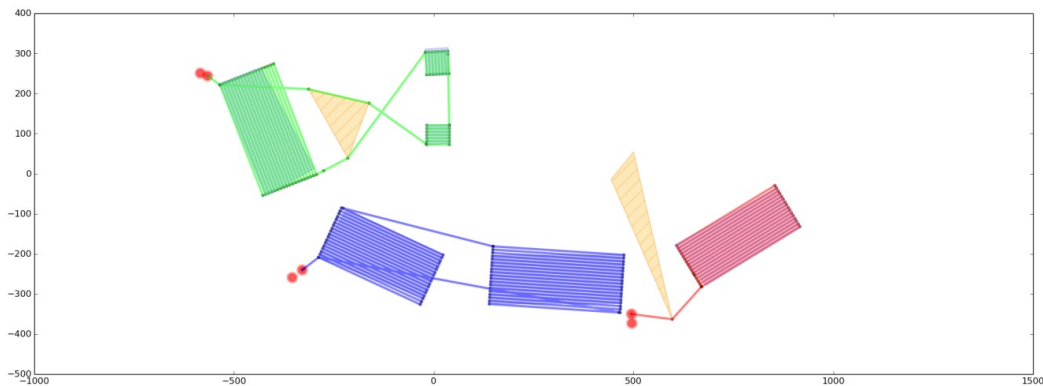
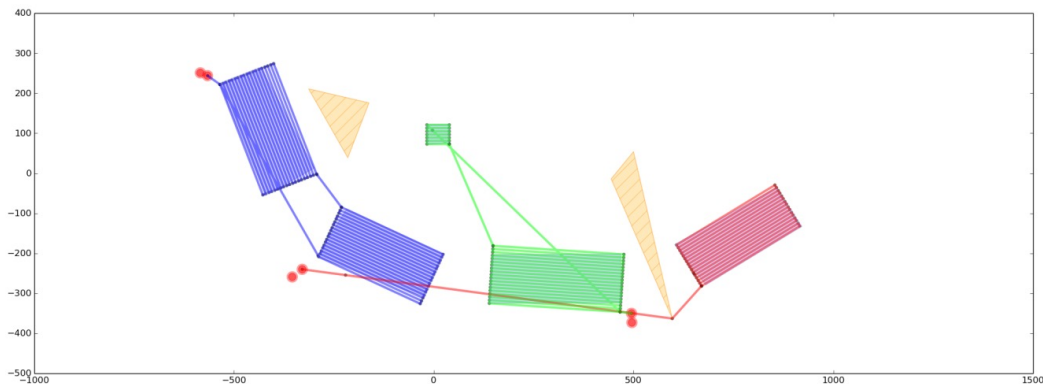
- Optimal is always better than humans
- Satisficing is often good enough
- In practice, fast enough to compute many real-life instance sizes if the model is coarse enough

► Drawbacks

- Poor correlation in decision space

Drawbacks of planning model

- Poor correlation in decision space



Well known Pro & Cons of Planning Modelling

► Advantages

- Optimal is always better than humans
- Satisficing is often good enough
- In practice, fast enough to compute many real-life instance sizes if the model is coarse enough

► Drawbacks

- Poor correlation in decision space
- Optimal runtime is unpredictable
- Satisficing quality is unpredictable
- Do not scale well with instance size

User expectations VS reality

► Expectations

- Model once, solve many instances
- Model by domain experts, of-the-shelf solvers
- Atomic costs computation is the bottleneck
- Separation of model and solver

► Reality

- Problem landscapes diversity is HUGE
- Domain experts is a VERY scarce resource
- Hard to embed in solvers/models for on-demand computation.
- PDDL itself is not scalable enough

Example PDDL domain

```
(define (domain domain_surveillance_v0)

  (:requirements :typing :durative-actions)

  (:types

    Vehicle - Object

    Type_A - Vehicle

    Type_B - Vehicle

    Location - Object

    Point Area - Location

    Start Wait - Point

  )

  (:functions

    ; Time to move from x to y
    (move_time ?x - Location ?y - Location)

    ; Time to scan area m
    (scan_time ?m - Area)

  )

)
```

```
(:predicates

  ; Vehicle d is located at location x
  (located ?d - Vehicle ?x - Location)

  ; Vehicle d is not already busy
  (available ?d - Vehicle)

  ; Sensor activation
  (sensor_on ?d - Vehicle)
  (sensor_off ?d - Vehicle)

  ; Vehicle position relatively to surface.
  (underwater ?d - Vehicle)
  (abovewater ?d - Vehicle)

  ; Area m is scanned / not scanned
  (revealed ?m - Area) ; scanned
  (concealed ?m - Area) ; not scanned

  ; NOTE: At init an goal, we cannot use the "not" operator,
  ; thus we must have two predicates for the state of areas

  ; in order to specify a switch of status:

  ; areas are concealed in the init and revealed in the goal.

)
```

Example PDDL domain

```
; dive

(:durative-action dive
  :parameters (?d - Vehicle)
  :duration (= ?duration 10)
  :condition (and
    (at start (available ?d) ) ; the vehicle is not doing something else
    (at start (abovewater ?d)) ; the vehicle is above surface
    (at start (sensor_off ?d)) ; not allowed to use sensor while diving
    ; NOTE: you cannot use the "not" operator in a condition.
  )
  :effect (and
    (at start (not (available ?d))) ; the vehicle is doing something from the very beginning
    (over all (not (available ?d))) ; the vehicle is doing something during the action

    (at end      (available ?d) ) ; the vehicle is no more doing something
    (at end      (underwater ?d) ) ; the vehicle is under water
    (at end (not (abovewater ?d))) ; the vehicle is not above surface
  )
) ; dive

; [...]
```

Example PDDL instance

```
(define (problem {{NAME}}) (:domain
surveillance_v0)

  (:objects [...] )

  (:init

    {{#VEHICLES}}

    (located {{NAME}} {{TAKEOFF}})

    (available {{NAME}})

    {{/VEHICLES}}

    {{#MISSIONS}}

    (concealed {{NAME}})

    {{/MISSIONS}}

    {{#MOVES}}

    (= (move_time {{FROM}} {{TO}})
{{TIME}})

    {{/MOVES}}

    {{#MISSIONS}}

    (= (scan_time {{NAME}})
{{SCAN_TIME}})

    {{/MISSIONS}}

  ) ; init
```

```
(:goal

  (and

    {{#MISSIONS}}

    (revealed {{NAME}})

    {{/MISSIONS}}

  )

) ; goal

(:metric minimize (total-time))

)
```

```
; Time 0.024
```

; Makespan 41.81

```
0 : ( move_drone d2 s2 m1 ) [10]
```

7.28 : (scan_mission d0 m2) [24]

11.95 : (scan_mission d1 m3) [32]

Classical modeller story line

- ▶ **Start from a close-enough existing PDDL domain**
- ▶ **Rename objects and predicates**
- ▶ **Try to add new actions and constraints**
 - ▶ Parse error in solver, but error message does not help
 - ▶ Try other solvers, various error messages (or none)
 - ▶ Random guesses
- ▶ **Make an instance template**
 - ▶ Does not scale because cost function is static
 - ▶ And pre-computations leads to combinatorial explosion
- ▶ **Call me to complain**

The problem with PDDL

- ▶ **Modelling itself is hard**

- ▶ Generic modelling problems
- ▶ Fidelity/Rapidity compromise
- ▶ Scalability of search space

- ▶ **Modelling in PDDL is even harder**

- ▶ (The language syntax is not a problem)
- ▶ (Plan validation is good enough)
- ▶ **The lack of some kind of "compiler" is the main problem**
- ▶ Using solvers to gain feedback is almost ineffective

Conclusion

- ▶ **Happy with:**

- ▶ Algorithmics
- ▶ Performances
- ▶ Modelling features

- ▶ **Not happy (to the best of our knowledge) with:**

- ▶ **No lazy binding** between model and action costs computation functions
- ▶ **Debugging of domains** is too hard
 - ▶ Ad-hoc model conversion within solvers?

johann.dreo@pasteur.fr