Arguments in Favor of Allowing a Modeler to Constrain Action Repetitions

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Pipeline To Find Plans Fast

refine ↻

task ⟶ encoding ⟶ planner ⟶ plan

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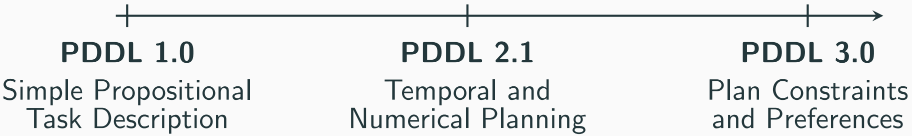
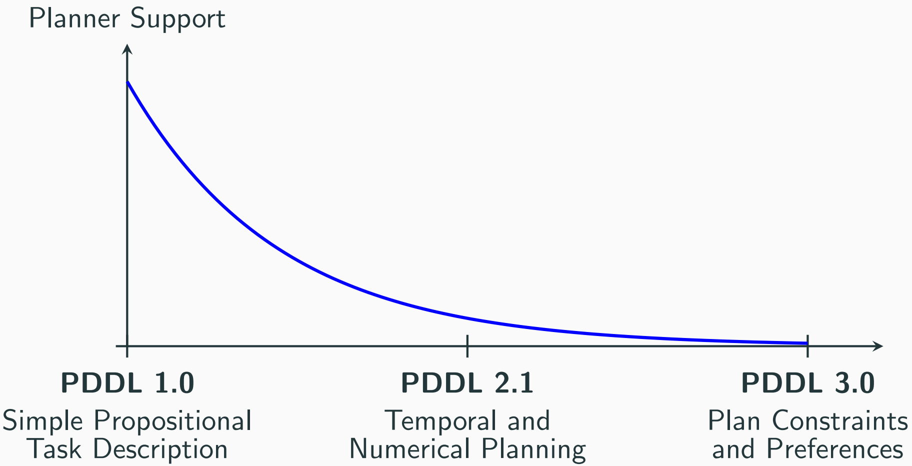
Why can't I just be given a better encoding?

PDDL Feature Scale



PDDL Feature Scale vs Feature Support



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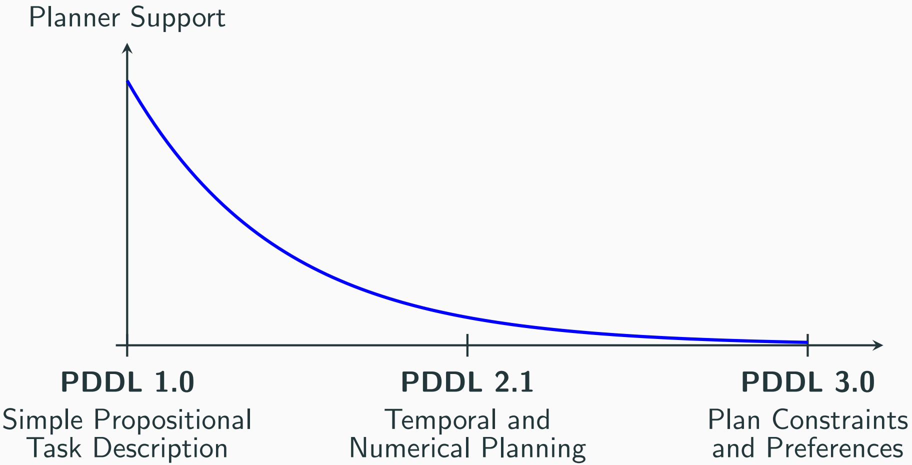
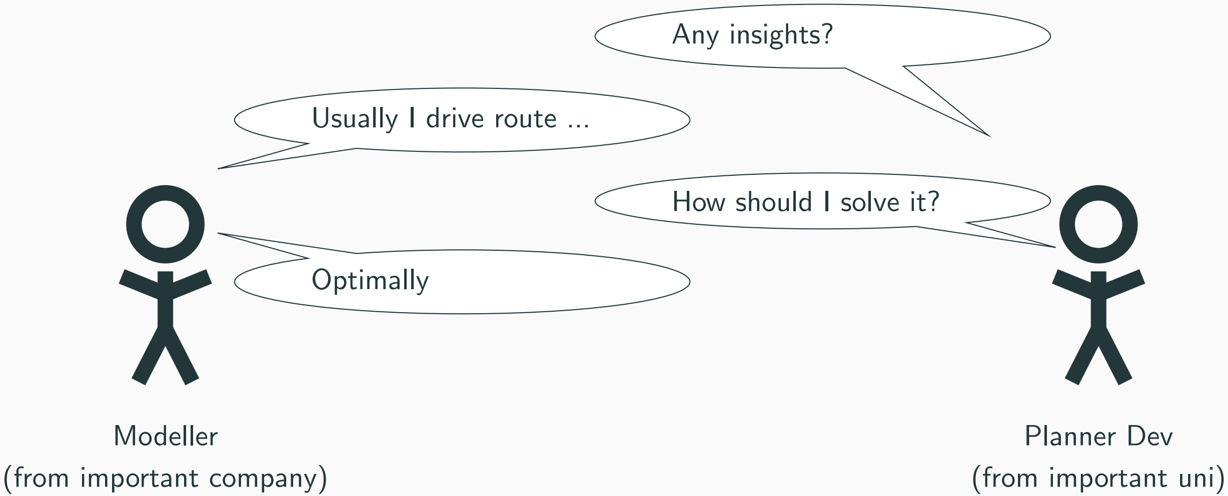


Observation: For solver support we want simple descriptions.

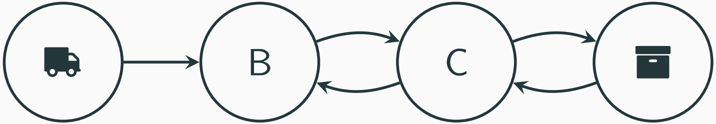
So just don't be lazy right?



One simple constraint:

A bound on action repetitions!

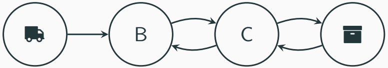
Transport Domain



Truck t_1 at A

Package p_1 at D

Peliminaries



Assume Ground STRIPS representation

- Facts $\{at(pkg, D),\ at(tr, A),\ in(pkg, tr), ...\}$
- Actions with $a = (pre(a), add(a), del(a))$ to $load_{tr,pkg,l}$, $pickup_{tr,pkg,l}$, $drive_{tr}$
- Initial State $\{at(tr, A), at(pkg, D)\}$
- Goal $\{at(pkg, B)\}$

Complexity question: Is there a plan for a given task?

Bounding Action Repetitions

Definition (Bound Map)

A plan π respects a bound map $b : A \to \mathbb{N} \cup \{\infty\}$ iff for every action $a \in A$ the number of occurrences of a in π does not exceed $b(a)$.

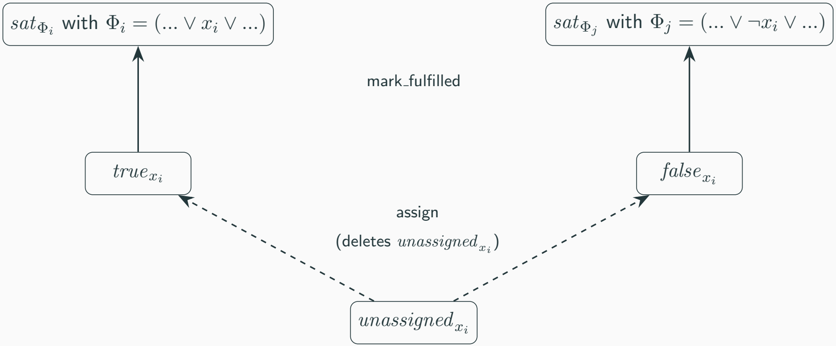
Theorem

Deciding whether there is a plan for a classical planning task that respect bound b, where each $b(a)$ is at most some constant $k \in \mathbb{N}^+$, is NP-complete.

Proof

Hardness (for $k = 1$):

Reduction from 3-SAT with formula $\Phi = \Phi_1 \wedge \cdots \wedge \Phi_n$ (Bylander, 1994)



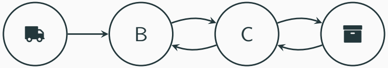
Membership:

Plan length bounded by $\sum_{a \in A} b(a)$ (polynomial) $\Rightarrow$ Guess and check

Bounding Plans vs Bounding Actions

Why not just bound the plan length then? (Remember $\sum_{a \in A} b(a)$)

- Remember:



  Anybody can see that a package can be delivered directly without first placing it at your neighbor's door.

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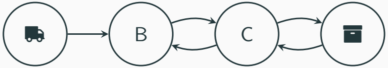

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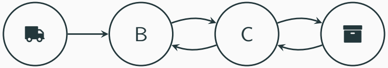
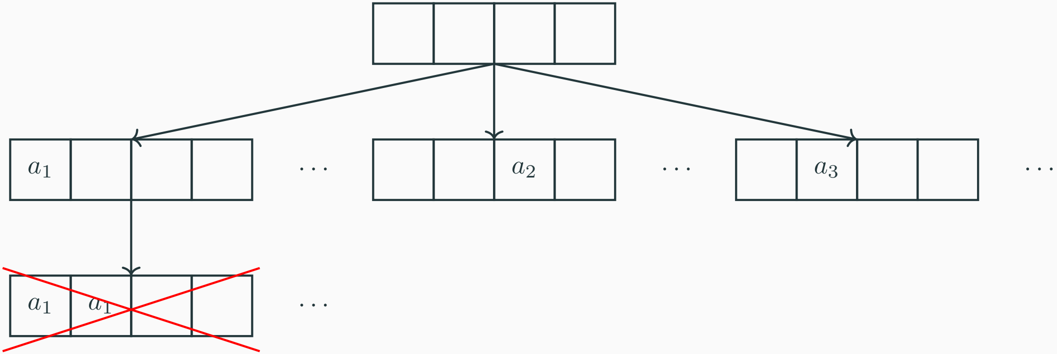


  Anybody can see that a package can be delivered directly without first placing it at your neighbor's door.
- I doubt that the bound on total plan length is obvious to the average human being.
- At least for constraint solvers this helps **a lot** more.

High Level Constraint Search (SAT, ILP, ...)



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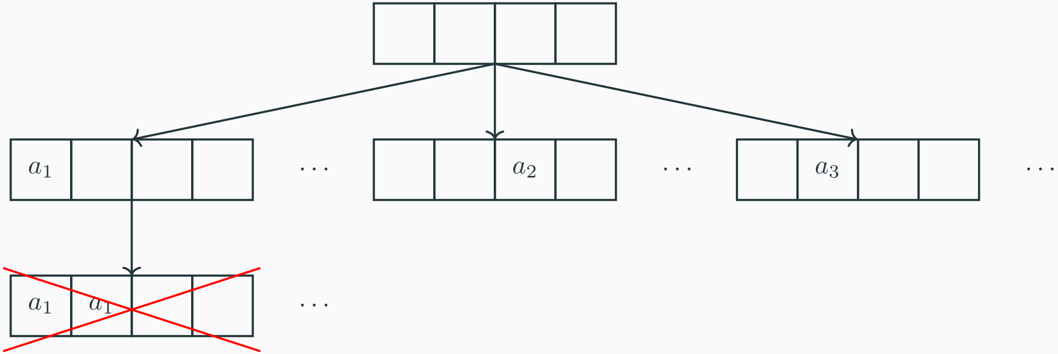

(The total plan length would not prune this node.)

But what if you can not bound action repetitions?

Simple Actions

Definition

An action $a \in A$ is *simple* if it has exactly one fact $f \in F$ in its precondition and delete list, i.e., $\{f\} = pre(a) = del(a)$, and every add effect $f' \in add(a)$ is poly-mutex[1] with f.

E.g.:

$Drive(t, from, to)$: pre: $at(t, from)$

add: $at(t, to)$

del: $at(t, from)$

[1] A mutex relation we can determine in polynomial time.

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E.g.:

$$Drive(t, from, to): \quad \text{pre: } at(t, from)$$
$$\text{add: } at(t, to)$$
$$\text{del: } at(t, from)$$

Allows tracking that you have been at some position at some point, e.g.: TSP or Visitall

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Simple Actions

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Deciding plan existence for a planning task with simple actions is NP-complete.

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Theorem

Deciding whether there is a plan for a classical planning where all non-simple actions a occur at most $k \in \mathbb{N}^+$ times is NP-complete.

Preliminary Experiments

(Automatically) encode model with simple actions into Minizinc. (Visitall, TSP, ...)

- If actions are bounded to be repeated at most 1 times:
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- Isn't the case for state of the art planner (like Scorpion).
- Includes all IPC tasks for Visitall.

Thank You :)