A Survey on Hierarchical Planning –
One Abstract Idea, Many Concrete Realizations

Pascal Bercher[1] and Ron Alford[2] and Daniel Höller[1]

[1]Institute of Artificial Intelligence, Ulm University, Germany
[2]MITRE, McLean, Virginia, USA

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ulm university universität uulm

MITRE

Non-hierarchical Planning in a Nutshell

A classical problem description consists of:

- Given an initial state s_I,
- a portfolio of the system's available actions, and
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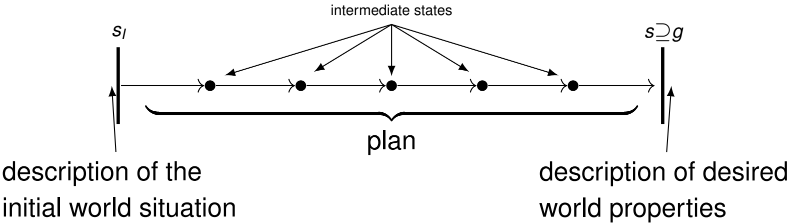
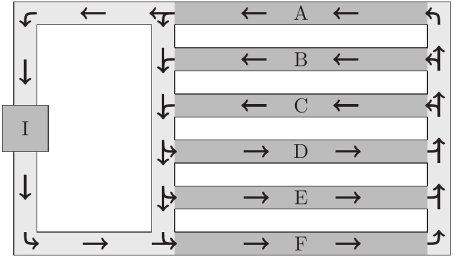
→ A *plan* that transforms s_I into g.



Planning Applications: Intelligent Factories



The Scanalyzer Domain

– automatic greenhouse logistic management

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Planning Applications: Intelligent Assistants

Sink devices:

- Television (requires video)
- Amplifier (requires audio)

Source devices:

- Blu-ray player
- Satellite receiver
  (both produce audio & video)

Action Definition in the Home Theater Domain

Planning problems are usually defined in terms of a description language based on a first-order predicate logic.

- States are sets of (ground) propositions, e.g.,
  $s = \{HasPort(AMPLIFIER, HDMI),$
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- Actions are defined by preconditions and effects, e.g.,

  plugin(*?cable, ?device, ?port****)***

  precondition: $HasPort(?device, ?port) \wedge$
  $HasPort(?cable, ?port) \wedge$
  $\nexists ?cable' : IsConnected(?device, ?cable', ?port)$

  effect: $IsConnected(?device, ?cable, ?port)$

  (Signal flow not shown for the sake of simplicity)

A Survey on *Hierarchical* Planning – Motivation

Hierarchical planning extends classical planning by hierarchies:

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- Plans can be presented *more abstract* by relying on task hierarchies.
- Standard solutions or search advice can be modeled.
- More control on the generated solutions using structures similar to formal grammars.

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⇝ Our focus: Survey of recent hierarchical problem classes.

Problem Class: Hierarchical Task Network (HTN) Planning

$$\mathcal{P} = (V, P, \delta, C, M, s_I, c_I)$$

- V a set of state variables.

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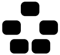
primitive
tasks



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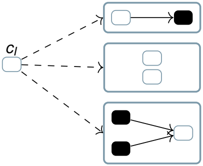

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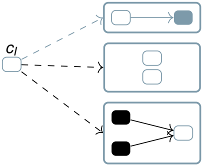

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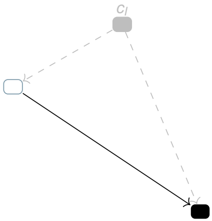

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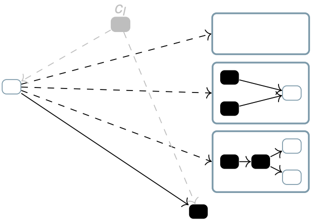

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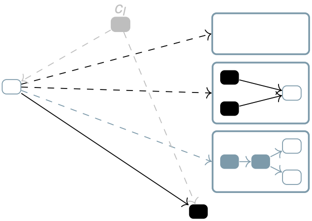

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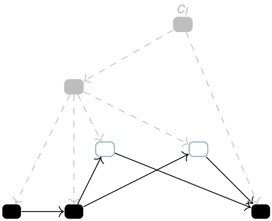

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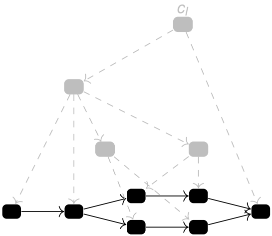

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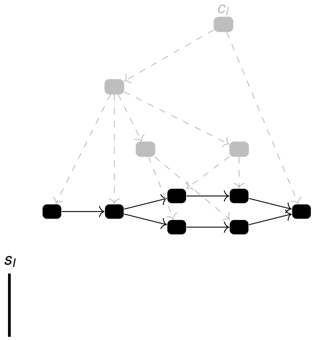

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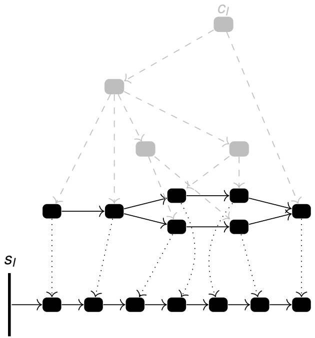

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- have an executable linearization.

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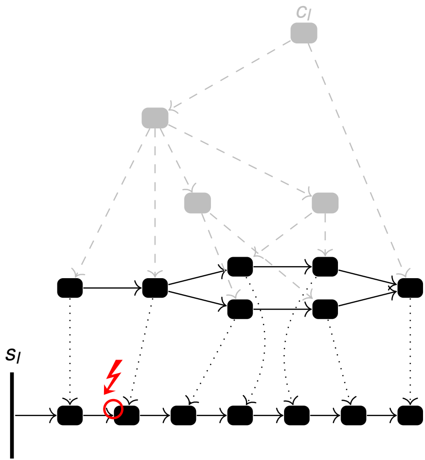
- Still, every classical problem can be encoded as an HTN problem, but HTN planning is more expressive.
- In the general case, it is undecidable to determine whether an HTN problem has a solution.
- The paper also – *very briefly* – explains all standard algorithms for solving HTN problems.

Optional Feature: Task Insertion



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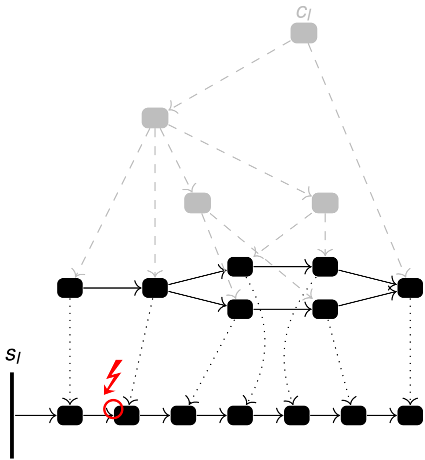

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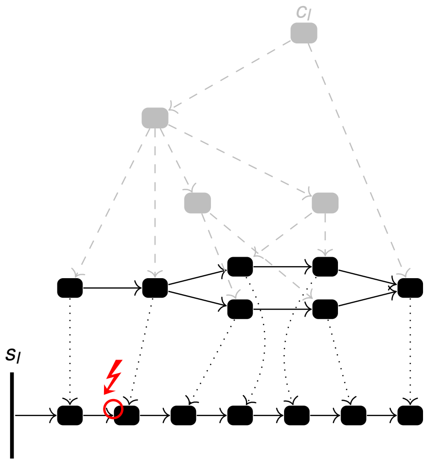

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- Allowing Task Insertion in HTN planning results in the problem class called *TIHTN planning*.

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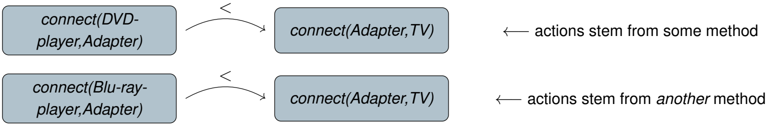
Optional Feature: Task Sharing

Task Sharing allows to eliminate duplicates that might just be modeling artifacts:



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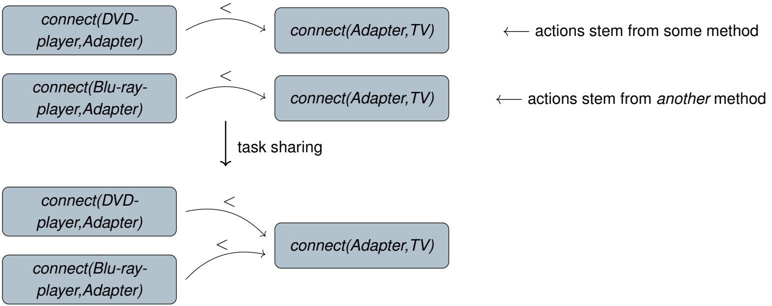

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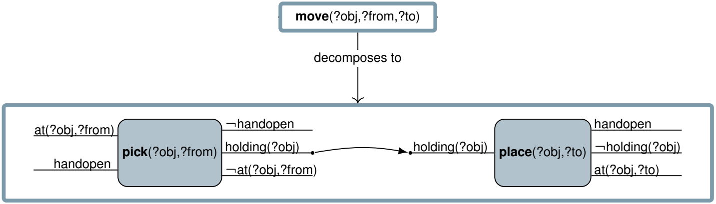

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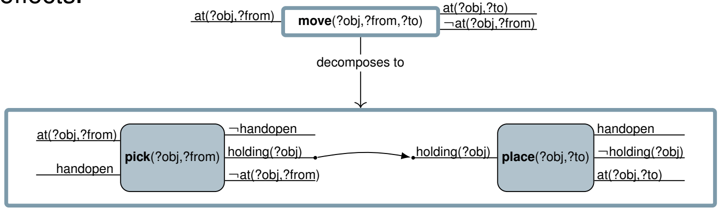

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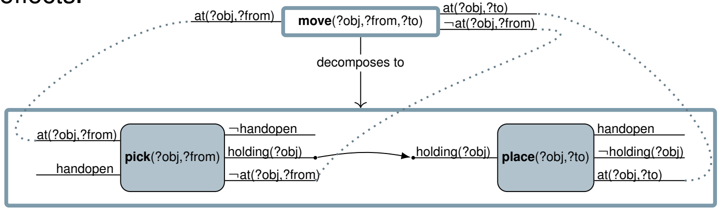

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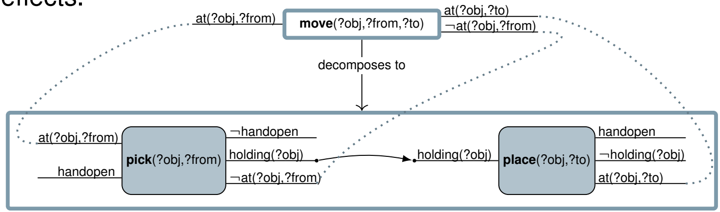

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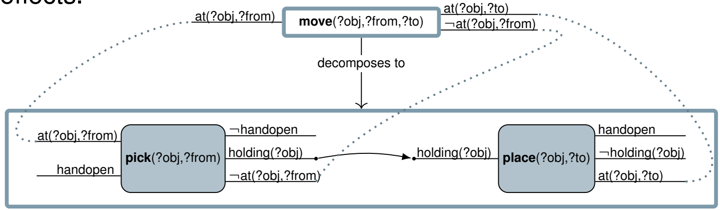

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- Some of these formalizations feature an initial task network, others do not.

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- We discussed the impact of the different problem classes/features on the set of solutions.
- We provided a brief explanation of all standard algorithms for solving HTN problems.