Tight Bounds for Hybrid Planning

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MITRE

Introduction

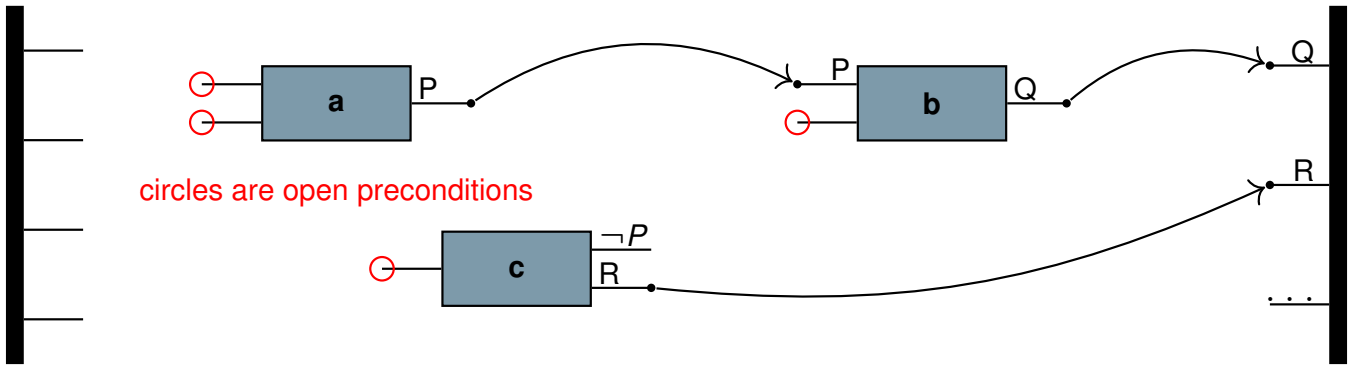
Overview

In this paper we study:

- A hierarchical approach to planning, more specifically:
  - An extension of Hierarchical Task Network (HTN) planning
  - Hybrid planning: HTN planning with causal links
- Specifically, we investigate the computational complexity of
  - The *plan existence problem* = Does there exist a solution?
  - The *plan verification problem* = Does plan P solve the problem?

Hybrid Planning

Introduction to Actions and Causal Links



- Partial Order Causal Link (POCL) plans are partially ordered
- Causal dependencies are represented using causal links
- For solution POCL plans,
  - all preconditions must be supported by a causal link, and

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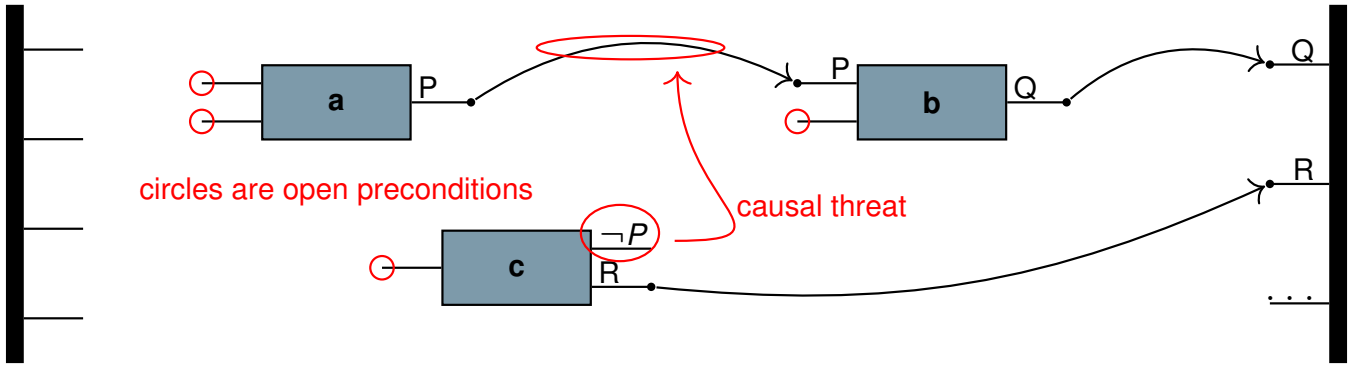

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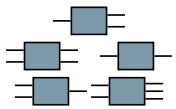
  - all causal threats must be resolved

Introduction to HTN Planning

primitive tasks



compound tasks

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

- F a set of facts
- P a set of primitive task names
- $\delta : P \rightarrow (2^F)^3$ the task name mapping
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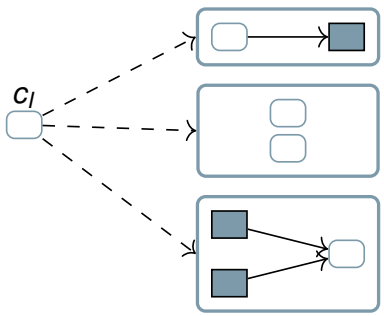

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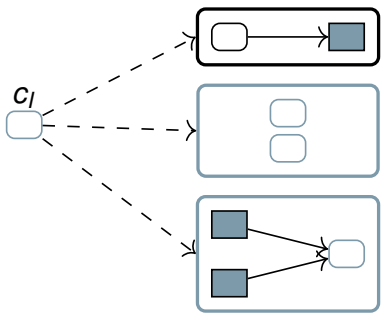

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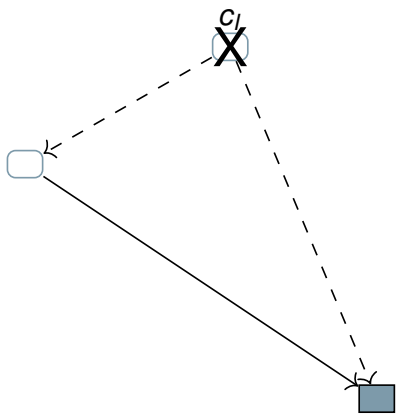

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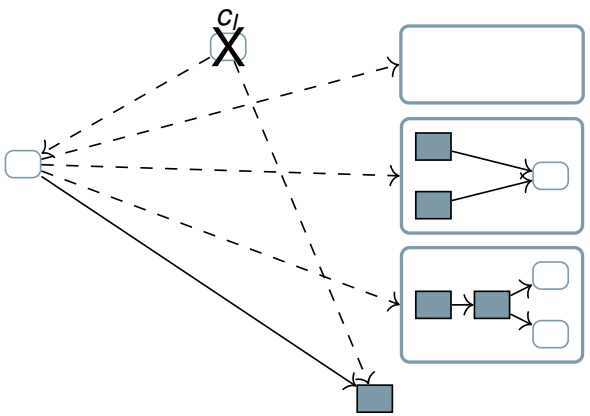

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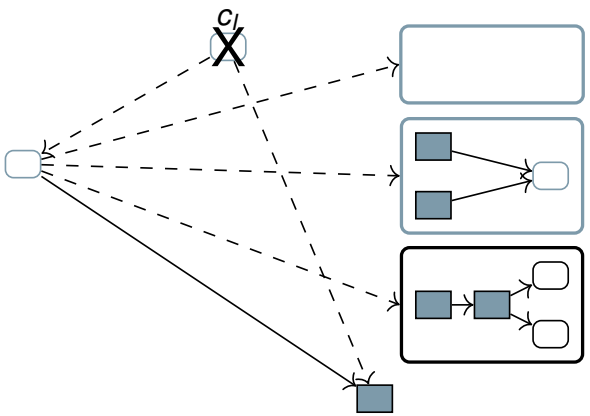

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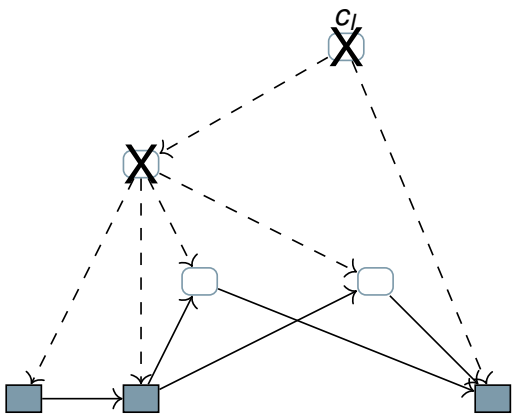

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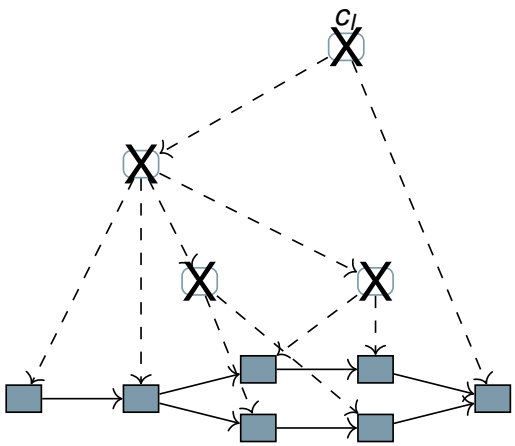

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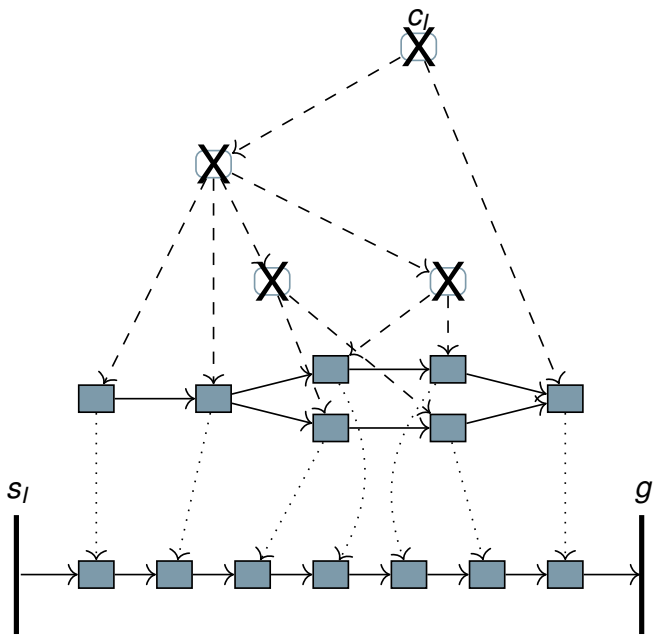

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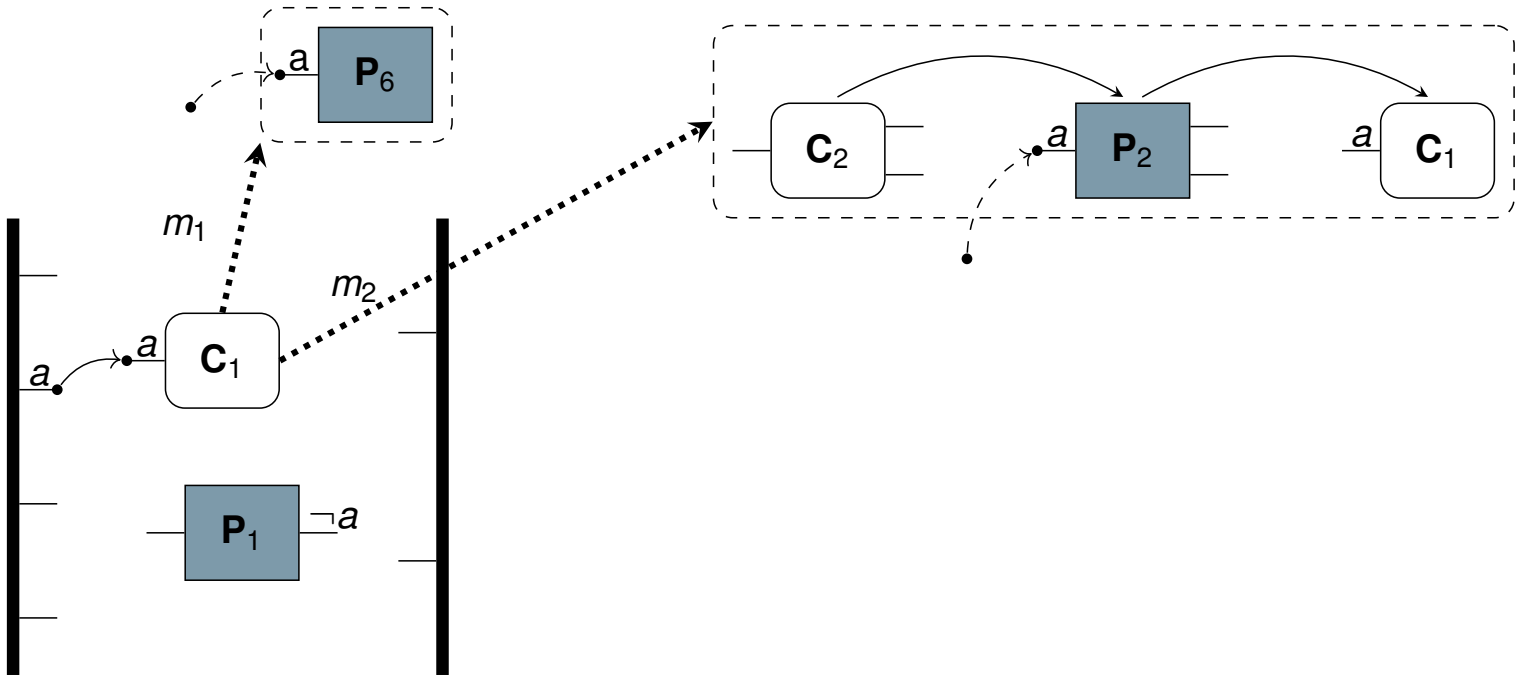
- $s_I \in 2^F$ the initial state
- $g \subseteq F$ the (optional) goal description

A solution task network *tn* must:

- be a refinement of c_I,
- only contain primitive tasks, and
- have an executable linearization.

Hybrid Planning Problem Example



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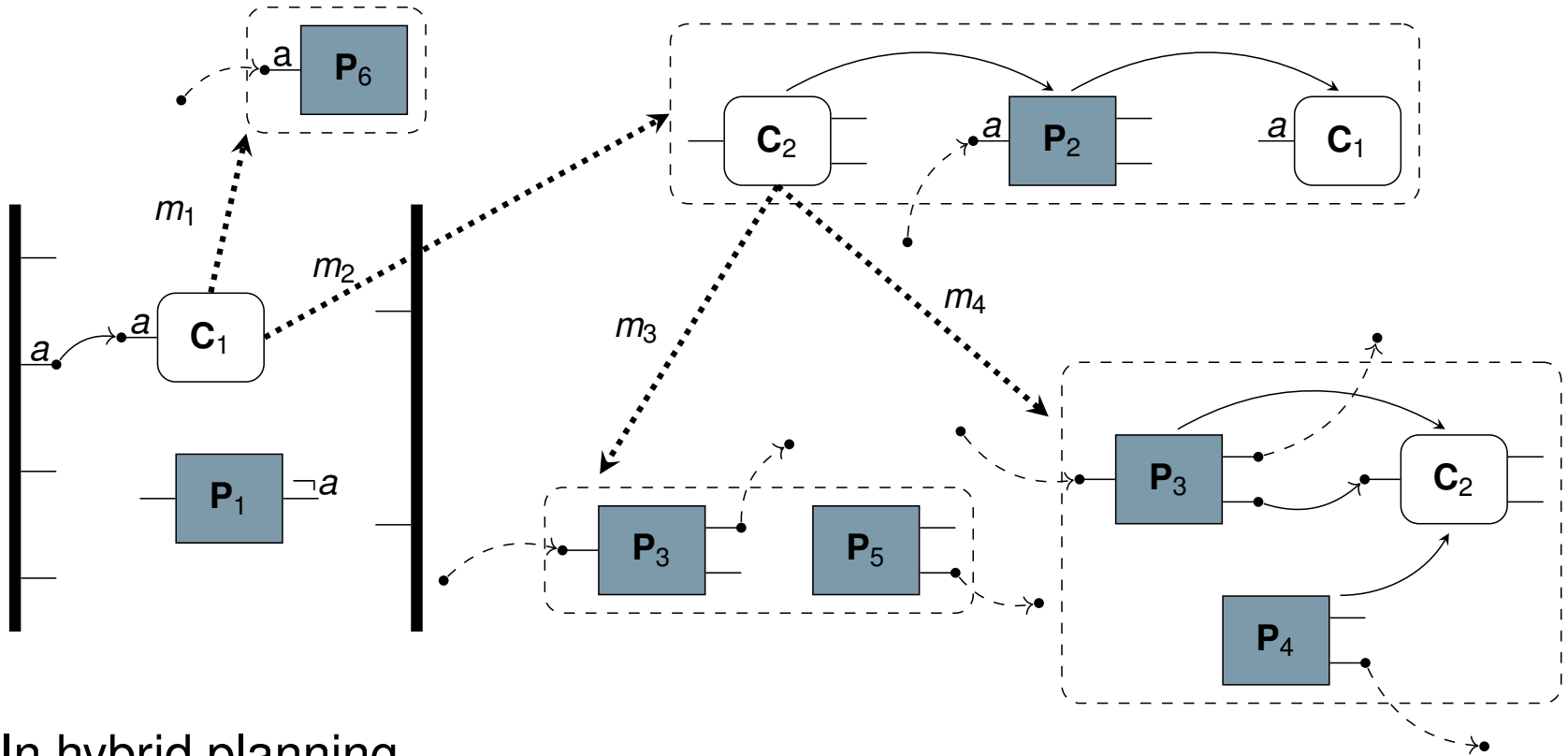

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Complexity Results

Main messages:

1. Causal links don't increase computational complexity
   - We took all membership proofs from HTN planning and showed how to adapt them to still work despite the inheritance of causal links (no entirely new proofs were required)
   - Various complexity classes are covered: (N)P, (N)EXPTIME, PSPACE, EXPSPACE – all the same as in HTN planning
2. Plan verification is already NP-complete in the absence of a task hierarchy (i.e., if the initial plan is already primitive)

For the actual proofs check out our paper or see you at the poster

Thank you for listening!