

*A Closer Look at Causal Links:*  
**Complexity Results for Delete-Relaxation  
in Partial Order Causal Link (POCL) Planning**

**Pascal Bercher**

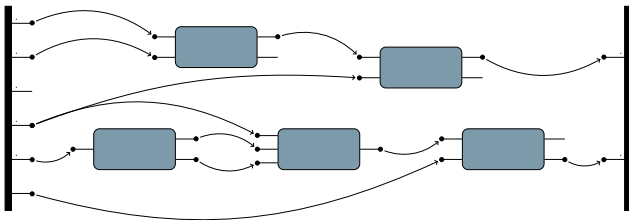
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- Most planning systems generate *action sequences* as solutions!
- But plans may be just *partially ordered* in general.



- Here, causal links connect preconditions and effects.

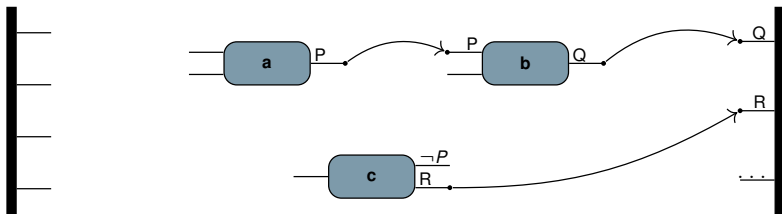
## POCL Plans

Why would we use POCL plans in the first place?

- In planning algorithms based on POCL plans:
  - Temporal planning due to parallelism
  - Some hierarchical approaches (some including time!)
  - For solving classical problems (not state of the art anymore)
- Some plan *encodings* (e.g., via SAT) rely on causal links.
  - To solve planning problems
  - For plan optimization

## POCL Plans

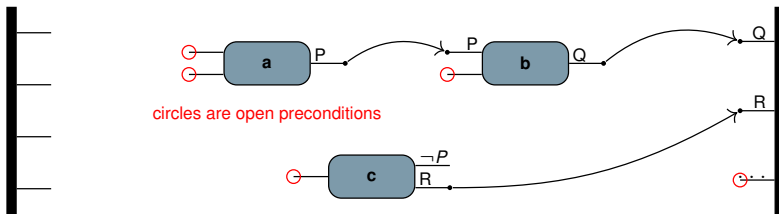
- POCL plans, slightly more formally:



- When is a POCL plan a solution?

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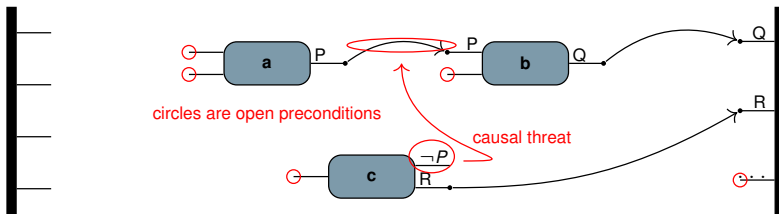
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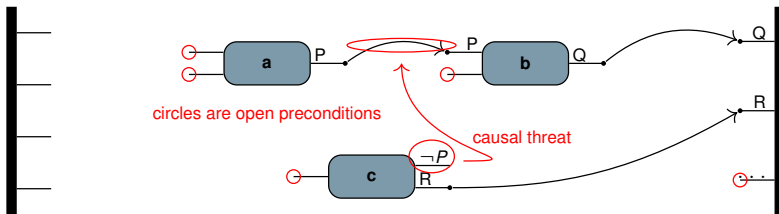
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## POCL Plans

- POCL plans, slightly more formally:



- When is a POCL plan a solution?
  - When all preconditions are supported by a causal link, and
  - there are no causal threats.Threats can be resolved by adding ordering constraints:
  - Promotion: move *c* before *a*
  - Demotion: move *c* behind *b*

## Decision Problem

**Input:** A POCL plan  $P$ .

**Question:** Can  $P$  be refined into a solution?  
(I.e., via the insertion of actions, links, and orderings)

We study the computation complexity of deciding this question under various restrictions for  $P$  and the actions to be inserted!



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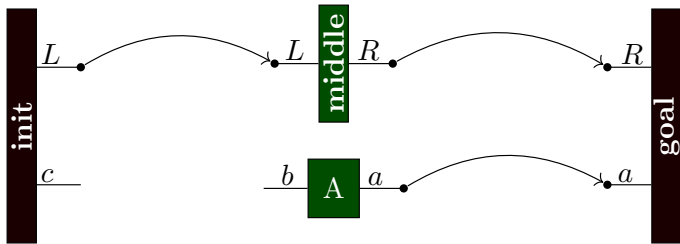
- (Delete-)relax the domain, i.e., the actions to insert.  
→ Decidable in  $P$  for classical problems!
- Relax the current plan/search node:
  - Delete-relax its actions
  - Ignore its causal links

Prize question: *How* to ignore existing causal links?

**Major contribution:**

- New problem relaxation that respects existing causal links despite delete relaxation!

## Example for Respecting Causal Links

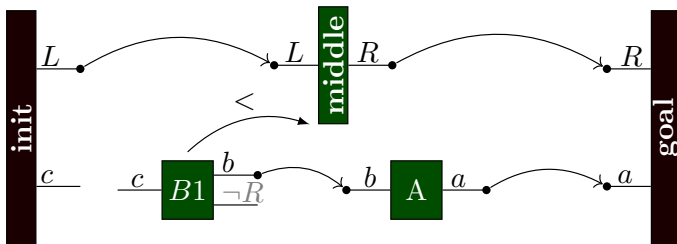


Additional actions:  $\frac{-c}{\text{B1}} \frac{b}{\neg R}$        $\frac{-c}{\text{B2}} \frac{b}{\neg L}$

Where could these actions be inserted:

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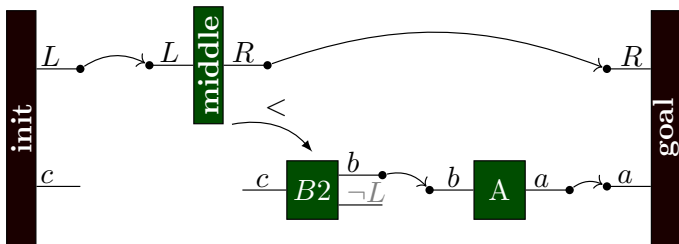


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Want to see the proofs? → See you at the poster! :)