Plan-Space Search/POP

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Plan-Space Search

- Also known as Partial-Order Planning – POP
- GraphPlan is an (old) instance of such

Plan-Space Search

Search state

- State is a partial plan
  - Actions
  - Ordering (partial)
  - Causal links

Plan-Space Search

Search state

- Causal link $a_1 \xrightarrow{q} a_2$
  - q is an add effect of a_1
  - q is a precondition of a_2
- When a_2 added, add the causal link

Plan-Space Search

Search

- Search by refinements of the partial plan
  - Adding an action
  - Adding an ordering constraint
  - Adding a causal link to already added action
  - ...

How to select refinements?

Based on threats!

- Threat (example)
  - Action a_t such that
    - $a_1 < a_t < a_2$ is consistent with the ordering
    - there is a causal link $a_1 \xrightarrow{q} a_2$
    - a_t deletes q
- Solution
  - enforce different ordering, either
    - $a_t < a_1$
    - $a_2 < a_t$

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How to select refinements?

More threats

- Unsatisfied precondition
  - remove the action, or add some that satisfies it
- Mutex action
  - impose ordering, or remove one of the actions
- ...

Advantages of Plan-Space Search

- Easily extensible to richer action models
  - Concurrent actions
  - Durative/Temporal actions
  - Multiagent planning
- Easily extensible to partially grounded actions
  - move-truck-?-B
  - can decide later
- Lower branching factor (sometimes)

Disadvantages of Plan-Space Search

- Significantly more complex algorithm
  - Detection and resolution of threats
  - Higher per-node cost
- Problematic adaptation of heuristic
  - Most heuristics are state-based, but what is the state of a POP plan?

Forward-chaining POP

- Solution to the problem with heuristics
- Add only actions for which all preconditions can be satisfied
  - (with a causal link from already present actions)
  - Resulting state of the plan can be determined and used for heuristic computation