Planning Techniques: POP

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Objectives

Specific Objectives

- Understand POP techniques

Source

- D. Weld. An Introduction to Least Commitment Planning. AI Magazine, 1994
- Eva Onaindia De La Rivaherrera. Planificación Automática. Videos. UPV. https://media.upv.es/

Outline

- Motivation

- Definition

- POP tree

- UCPOP

- Conclusions

Motivation

- Having a totally ordered list of steps is restrictive

- Can we only do something if it's necessary?

- POP uses the principle of least commitment: never making a choice unless required to do so

Outline

- Motivation
- **Definition**
- POP tree
- UCPOP
- POP planners
- Conclusions

Definition (I)

- Perform PSS
- Partial Plan: $\mathcal{P} = (\mathcal{A}, \mathcal{O}, \mathcal{L}, \mathcal{OC}, \mathcal{UL})$ Action, Ordering constraints, causal Link, Open Conditions (flaws), Unsafe Links
- Backward search
- Each node has:
  - Partially instantiated actions
  - Set of constraints
  - Process stops if the solution is found, after several refinements (adding new operators)

Definition (II)

- The planning algorithm implements the *least commitment* technique
  - Only essential planning decisions are saved because it is not necessary to commit
  - The causal link structure is responsible for storing them
    - *3 fields: producer, consumer and the proposition*
  - As can be actions that threaten it, we can apply:
    - Demotion: add the restriction before the step that threats it
    - Promotion: add the restriction after the step that threats it
    - Separation: add the restriction to the variable binding
    - Confrontation: add the negation to the conditional effects

    $$A_p \xrightarrow{Q} A_c$$

- Examples: UCPOP, Cassandra, ZENO, VHPOP
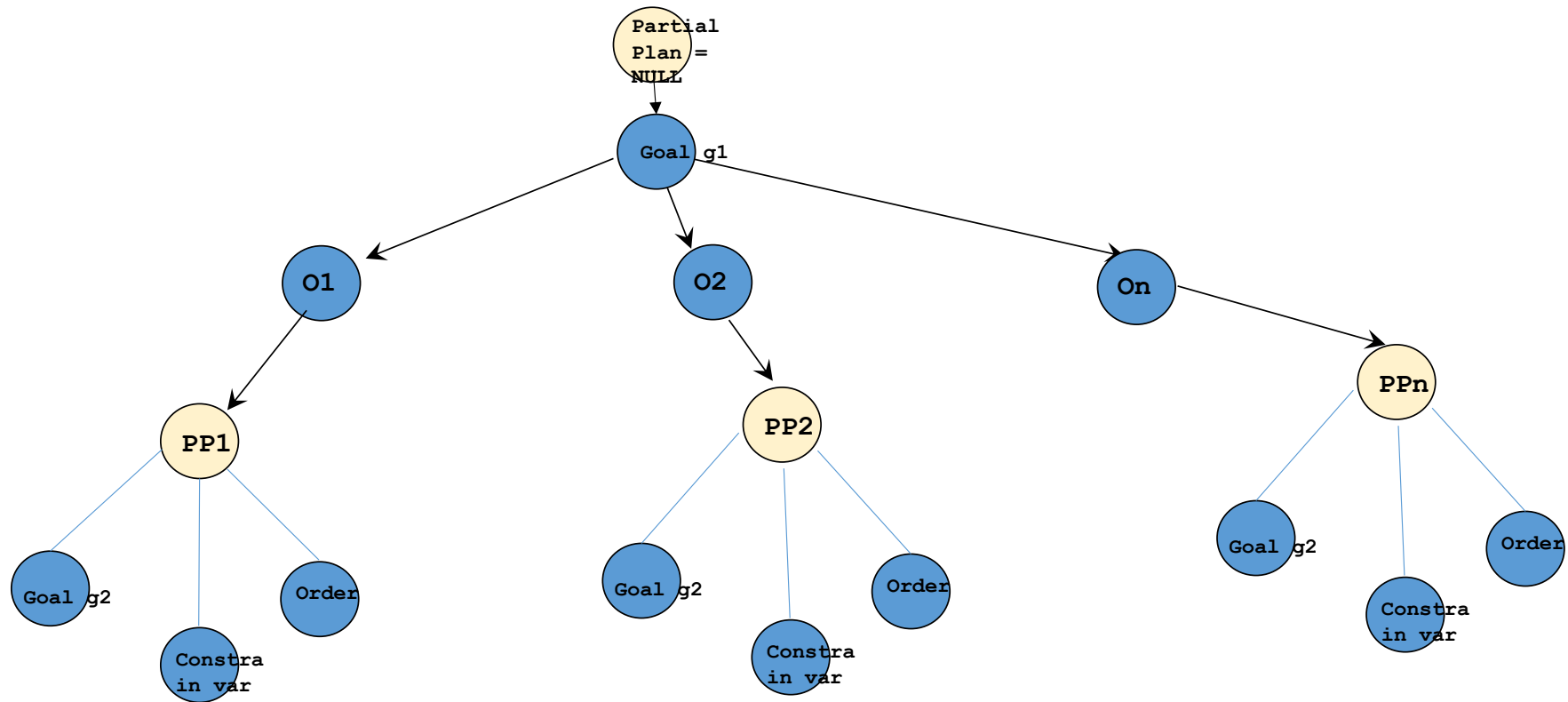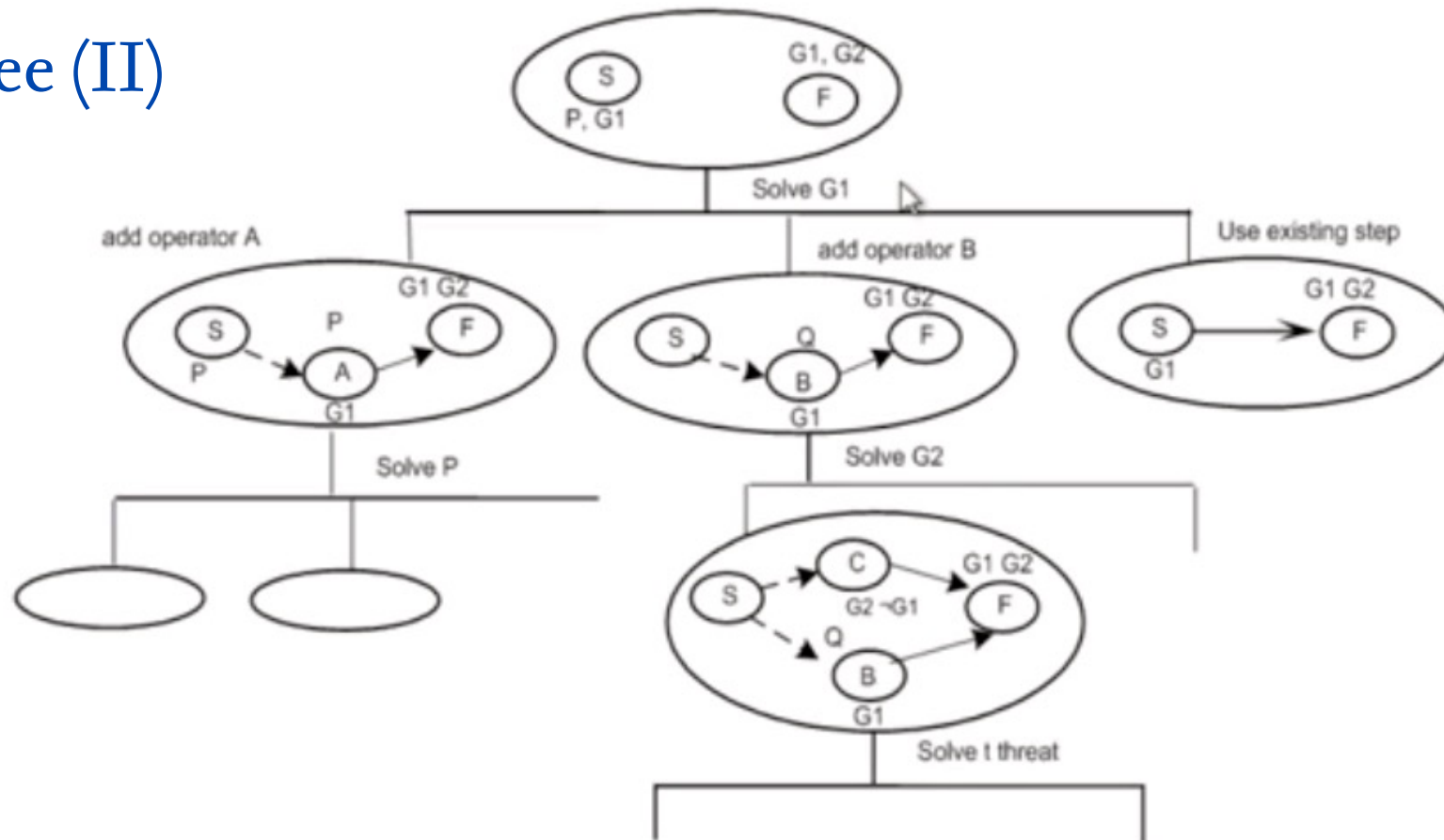
Outline

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POP tree (I)

POP tree (II)

POP tree (III)

- The initial plan is created from the initial state description and the goal description by creating two "pseudo-steps:"
  - Start
    - P: none
    - E: all positive literals defining the initial state
  - Finish
    - P: literals defining the conjunctive goal to be achieved
    - E: none
- Then creating the initial plan as: Start --------> Finish
- Searching for a Solution in Plan Space

Outline

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- **POP planners**
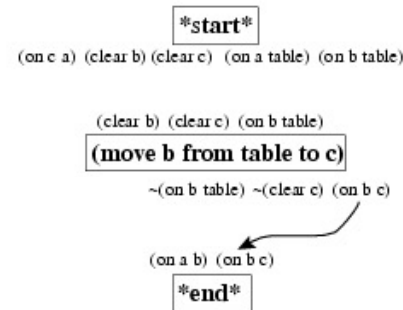- UCPOP
- Conclusions

POP Planners

- UCPOP
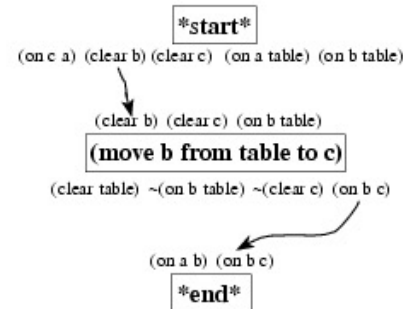- Cassandra
- ZENO
- VHPOP

Outline

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- Definition

- POP tree

- POP planners
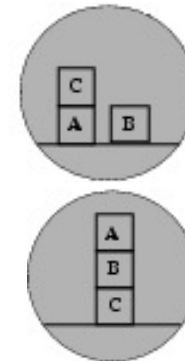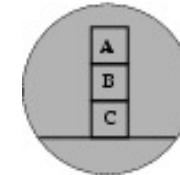
- **UCPOP: example**

- Conclusions

UCPOP (I)


```
                              *start*
    (on c a)  (clear b) (clear c)  (on a table) (on b table)


              (clear b)  (clear c)  (on b table)
              (move b from table to c)
                ~(on b table)  ~(clear c)  (on b c)


                  (on a b)  (on b c)
                     *end*
```
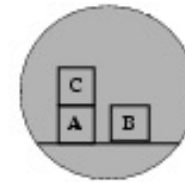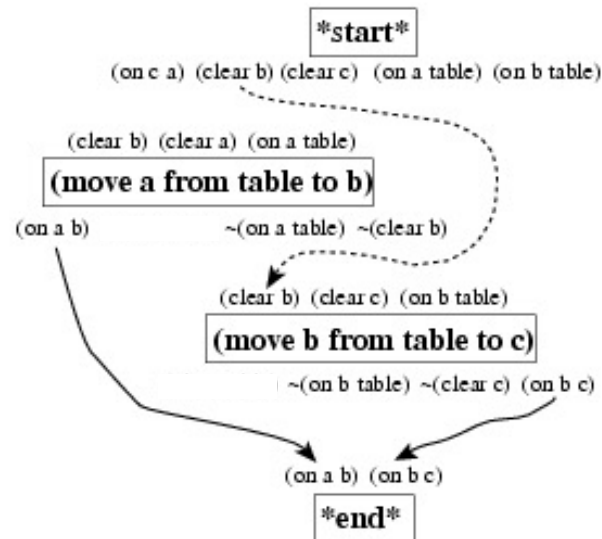
After adding a causal link to support (on B C), the plan is as shown and agenda contains {(clear B) (clear C) (on B Table) (on A B)} as open propositions.

```
                      *start*
    (on c a)  (clear b) (clear c)  (on a table) (on b table)

              (clear b)  (clear c)  (on b table)
              (move b from table to c)
    (clear table)  ~(on b table)  ~(clear c)  (on b c)


                  (on a b)  (on b c)
                     *end*
```

After adding a causal link to support (clear B), the plan has two causal links and agenda is set to {(clear C) (on B Table) (on A B)}.

UCPOP (II)
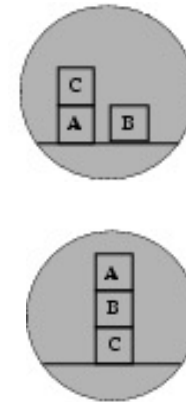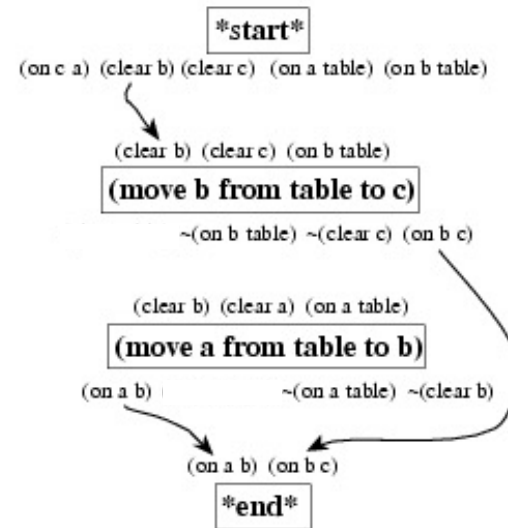

start

(on c a) (clear b) (clear c) (on a table) (on b table)

(clear b) (clear a) (on a table)
(move a from table to b)

(on a b)   ~(on a table) ~(clear b)

(clear b) (clear c) (on b table)
(move b from table to c)

~(on b table) ~(clear c) (on b c)

(on a b) (on b c)
end

Since the `move-A` action could possibly precede the `move-B` action,
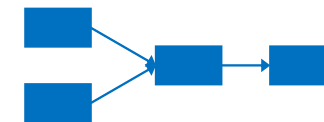it threatens the link labeled (`clear B`) as indicated by the dashed line.

UCPOP (III)

start

(on c a) (clear b) (clear c) (on a table) (on b table)

(clear b) (clear c) (on b table)

(move b from table to c)

~(on b table) ~(clear c) (on b c)

(clear b) (clear a) (on a table)

(move a from table to b)

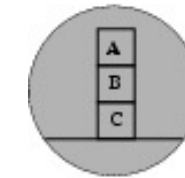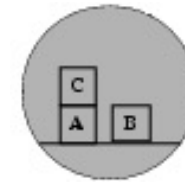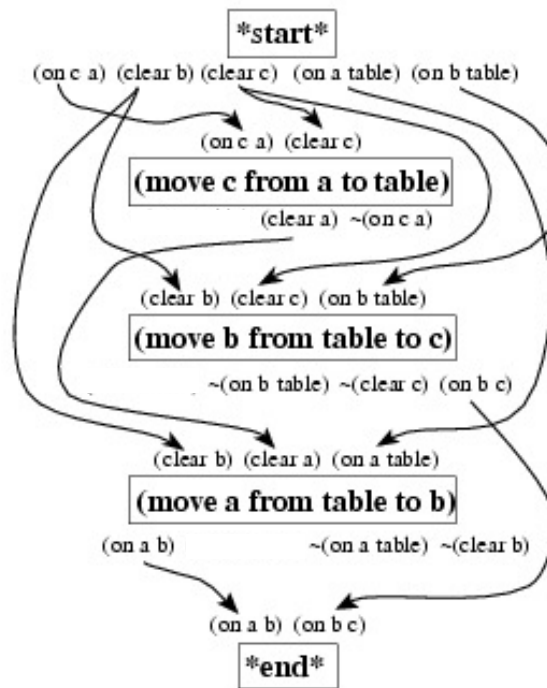(on a b)   ~(on a table) ~(clear b)

(on a b) (on b c)

end

After promoting the threatening action, the plan's actions are totally ordered.

UCPOP (IV)

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Conclusions

- Idea
  - Work on several subgoals independently
  - Solve them with subplans
  - Combine the subplans
  - Flexibility in ordering the subplans

- *Least Commitment* strategy: delaying a choice during search

- Causal links lead to early pruning of portions of the search space because of irresolvable conflicts

ToDo example

- Goal: Set the table, i.e., on(Tablecloth) ^ out(Glasses) ^ out(Plates) ^ out(Silverware)

- Initial State: clear(Table)

- Operators:
  - Lay-tablecloth
    P: clear(Table)
    E: on(Tablecloth), ~clear(Table)
  - Put-out(x)
    P: none
    E: out(x), ~clear(Table)