CogSysI Lecture 3: State-Space Planning

Intelligent Agents

Ute Schmid (lecture)
Emanuel Kitzelmann (practice)

Applied Computer Science, Bamberg University

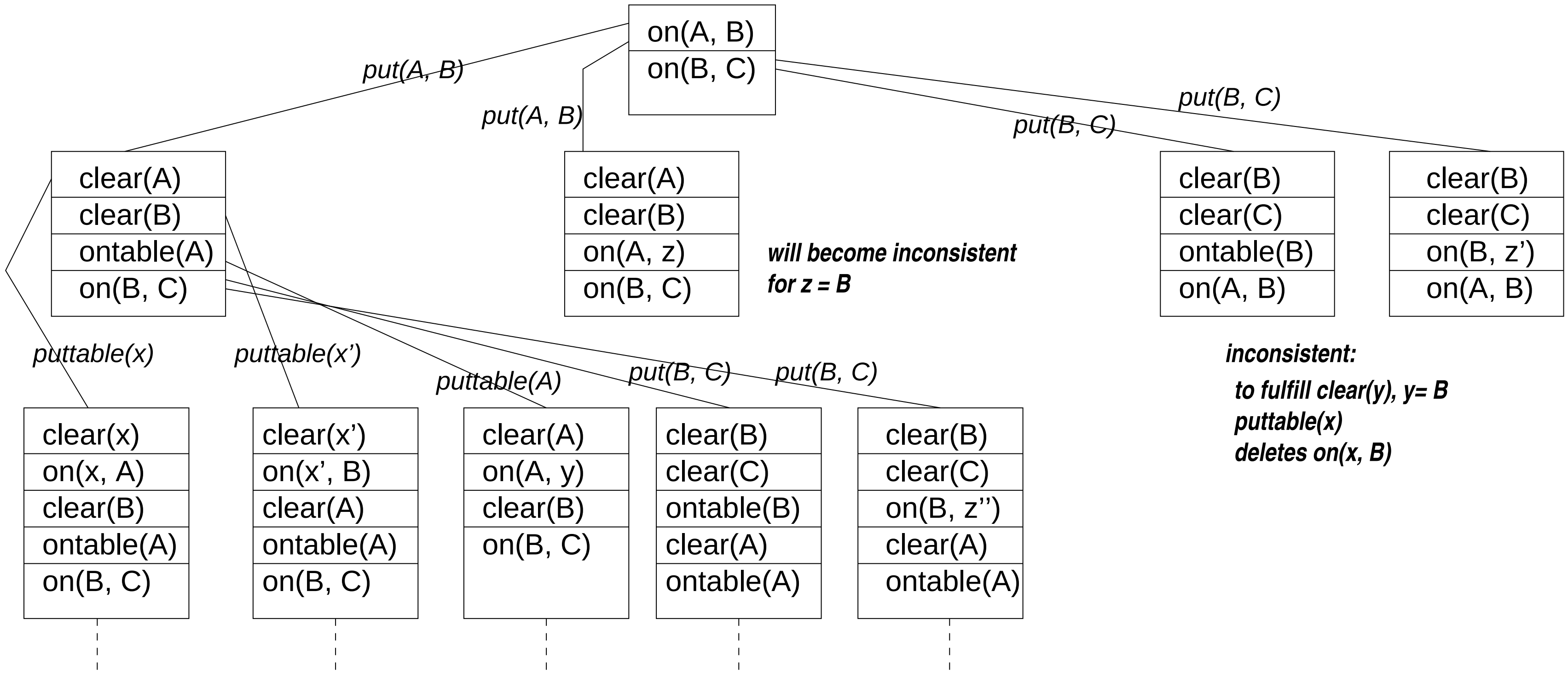
Extensions to the slides for chapter 4 of Dana Nau

last change: May 6, 2008

Remarks on Backward Planning

- Also called regression planning
- Advantage: typically smaller search trees
- Problem: inconsistent states can be produced
  can e.g. be detected by including axioms (domain knowledge!)
- Graphplan strategy: build a Planning Graph by forwards search (polynomial effort) and extract the plan from the graph backwards (exponential effort, as usual for planning)

Backward Planning cont.



STRIPS

- by Fikes & Nilsson (1971), "**St**anford **R**esearch **I**nstitute **P**roblem **S**olver"
- classical example: moving boxes between rooms ("Strips World")
- Originally: representation formalism (relying on CWA)and planning algorithm
  today: "STRIPS planning" refers to classical representation without extensions and not to a specific algorithm
- STRIPS algorithm: a linear (and therefore incomplete) approach
- compare to: General Problem Solver (GPS), a cognitively motivated problem solving algorithm which is also linear and therefore incomplete

STRIPS Algorithm

- Backward-search with a kind of hill climbing strategy
- In each recursive call only such subgoals are relevant which are preconditions of the last operator added
- Consequence: considerable reduction of branching, but resulting in incompleteness
- Linear planning: organizing subgoals in a stack
- Non-linear planning: organizing subgoals in a set, interleaving of goals

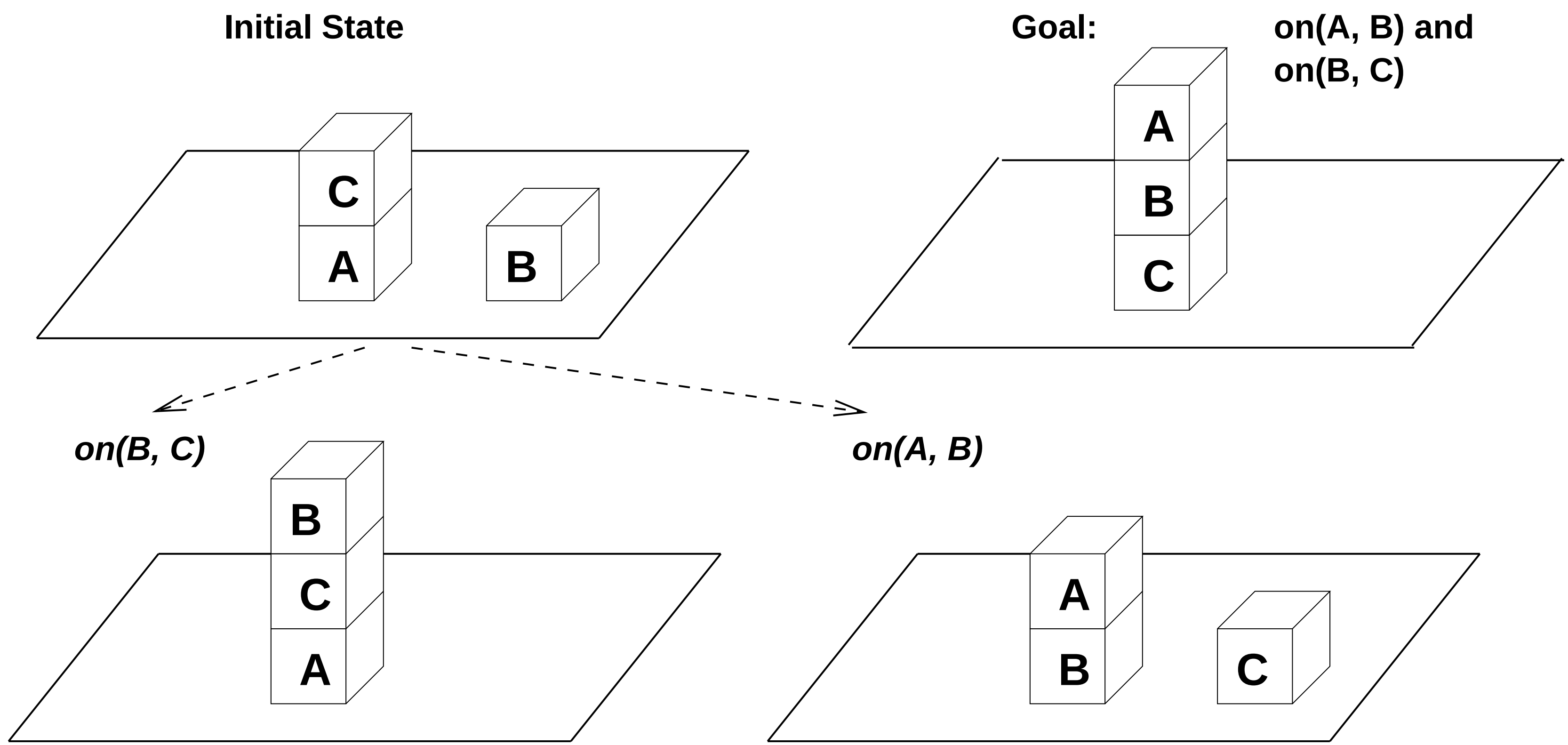
STRIPS Algorithm

STRIPS(O, s, g)

- $\Pi \leftarrow$ empty plan
- loop
  - if s satisfies g then return Π
  - $A \leftarrow \{a | a$ is a ground instance of an operator in O, and a is relevant for $g\}$
  - if $A = \emptyset$ then return failure
  - nondeterministically choose any action $a \in A$
  - $\Pi' \leftarrow$ STRIPS(O, s, precond(a))
  - if $\Pi' = failure$ then return failure
    ;; if we get here, then Π' achieves precond(a) from s
  - $s \leftarrow \gamma(s, \Pi')$;; s now satisfies precond(a)
  - $s \leftarrow \gamma(s, a)$
  - $\Pi \leftarrow \Pi.\Pi'.a$

Incompleteness of Linear P.

The Sussman Anomaly



Sussman Anomaly

Linear planning corresponds to dealing with goals organized in a stack:

[on(A, B), on(B, C)]

try to satisfy goal *on(A, B)*

solve sub-goals *[clear(A), clear(B)]*[a]

all sub-goals hold after *puttable(C)*

apply *put(A, B)*

goal *on(A, B)* is reached

try to satisfy goal *on(B, C)*.

---

[a] We ignore the additional subgoal *ontable(A)* rsp. *on(A, z)* here.

Interleaving of Goals

- Non-linear planning allows that a sequence of planning steps dealing with one goal is interrupted to deal with another goal.
- For the Sussman Anomaly, that means that after block C is put on the table pursuing goal *on(A, B)*, the planner switches to the goal *on(B, C)*.
- Non-linear planning corresponds to dealing with goals organized in a set.
- The correct sequence of goals might not be found immediately but involve backtracking.

Interleaving of Goals cont.

{on(A, B), on(B, C)}

try to satisfy goal *on(A, B)*

    {clear(A), clear(B), on(A, B), on(B, C)}

    clear(A) and *clear(B)* hold after *puttable(C)*

try to satisfy goal *on(B, C)*

apply *put(B, C)*

try to satisfy goal *on(A, B)*

apply *put(A, B)*.

Rocket Domain

(Veloso)

- Objects: n boxes, Positions (Earth, Moon), one Rocket
- Operators: load/load a box, move the Rocket (oneway: only from earth to moon, no way back!)
- Linear planning: to reach the goal, that Box1 is on the Moon, load it, shoot the Rocket, unload is, now no other Box can be transported!

The Running Gag of CogSysI

Question: How many AI people does it take to change a lightbulb?
Answer: At least 81.

The Planning Group (4)

- One to define STRIPS-style operators for lightbulb changing
- One to show that linear planning is not adequate
- One to show that nonlinear planning is adequate
- One to show that people don't plan; they simply react to lightbulbs