

Week 5: Modelling in STRIPS and PDDL

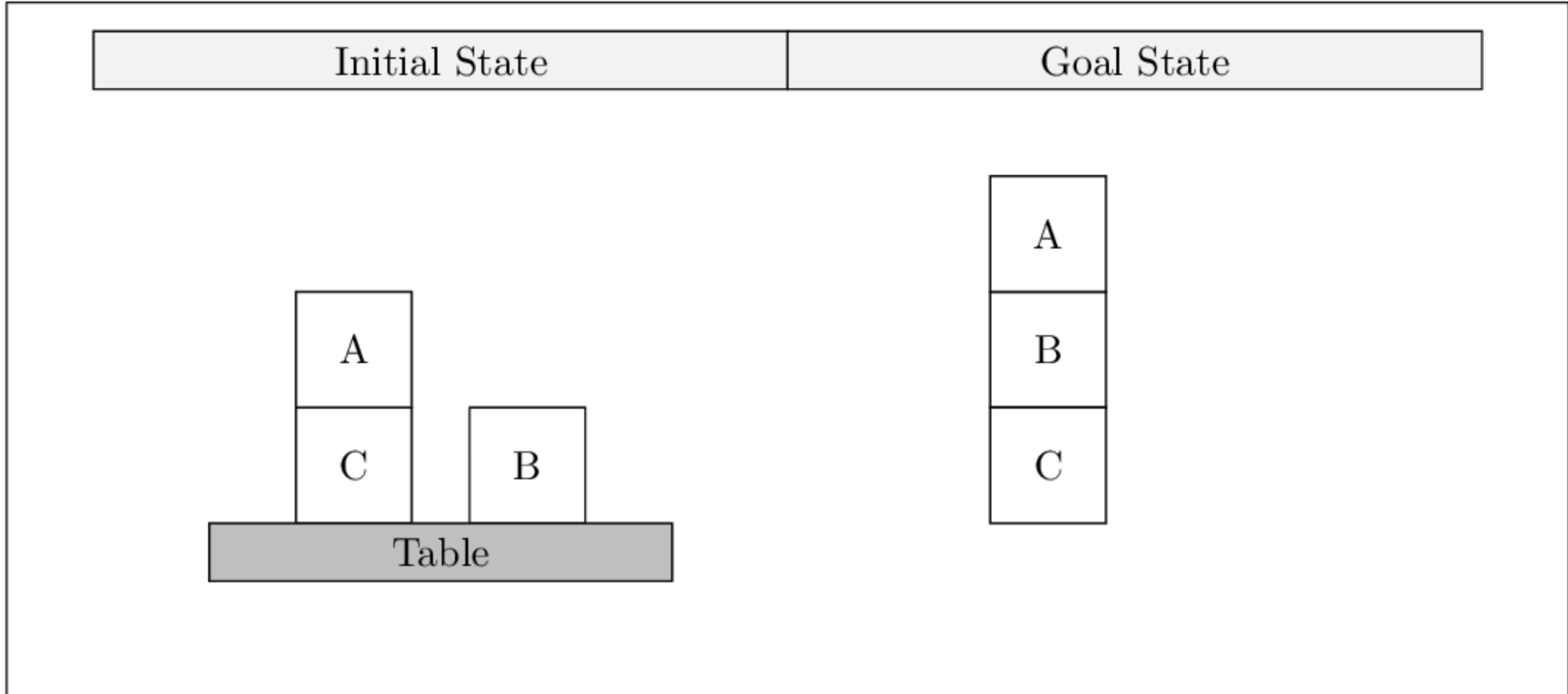
COMP90054 – AI Planning for Autonomy

Key concepts

- How to model a problem in STRIPS
- PDDL (Problem Domain Definition Language)

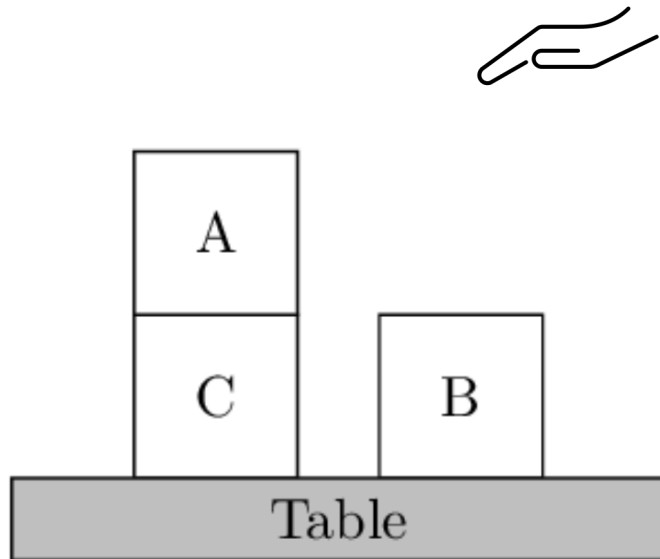
Problem 1: STRIPS

Model Blocks-World as a STRIPS problem $P = \langle F, O, I, G \rangle$. You need to define the set of facts F , the set of operators O , the goal facts G and the initial facts I . You must also define the pre, add, and del functions.



Problem 1

Initial State

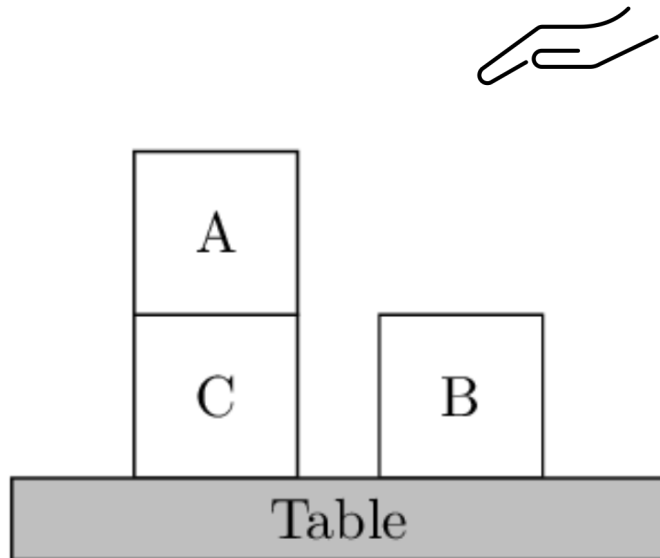


$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y),$
 $\text{onTable}(x),$
 $\text{clear}(x),$
 $\text{holding}(x),$
 $\text{handEmpty} \mid$
 $x, y \in \{A, B, C\}$
 $\}$

Problem 1

Initial State



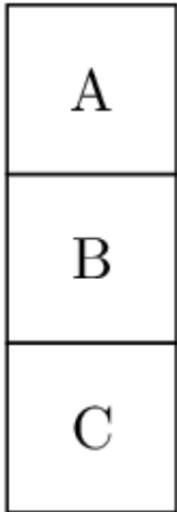
$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y),$
 $\text{onTable}(x),$
 $\text{clear}(x),$
 $\text{holding}(x),$
 $\text{handEmpty} \mid$
 $x, y \in \{A, B, C\}$
 $\}$

$I = \{ \text{on}(A, C), \text{onTable}(C), \text{onTable}(B), \text{clear}(A), \text{clear}(B), \text{handEmpty} \}$

Problem 1

Goal State



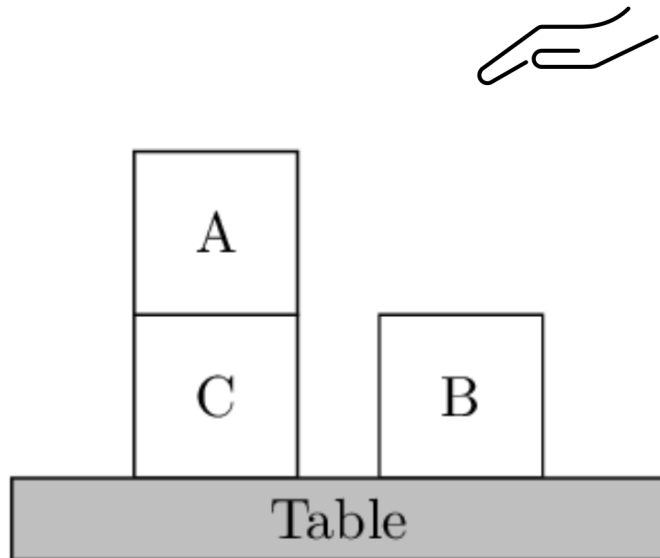
$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y),$
 $\text{onTable}(x),$
 $\text{clear}(x),$
 $\text{holding}(x),$
 $\text{handEmpty} \mid$
 $x, y \in \{A, B, C\}$
 $\}$

$G = \{ \text{on}(A, B), \text{on}(B, C) \}$

Problem 1

Initial State



$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y), \text{onTable}(x), \text{clear}(x), \text{holding}(x), \text{armFree} \mid x, y \in \{A, B, C\} \}$

Operator $o \in O$ represented by

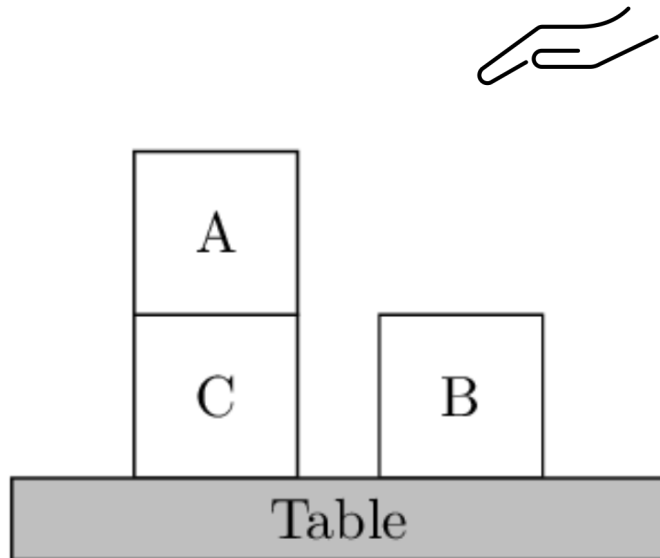
1. the **Add** list $\text{Add}(o) \subseteq F$
2. the **Delete** list $\text{Del}(o) \subseteq F$
3. the **Precondition** list $\text{Pre}(o) \subseteq F$

Define Operators

1. Pick up a block from the table **pickup(x)**
2. Pick up a block from another block **unstack(x)**
3. Put down a block on the table **putdown(x)**
4. Put down a block on another block **stack(x, y)**

Problem 1

Initial State



$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y), \text{onTable}(x), \text{clear}(x), \text{holding}(x), \text{handEmpty} \mid x, y \in \{A, B, C\} \}$

Operator $o \in O$ represented by

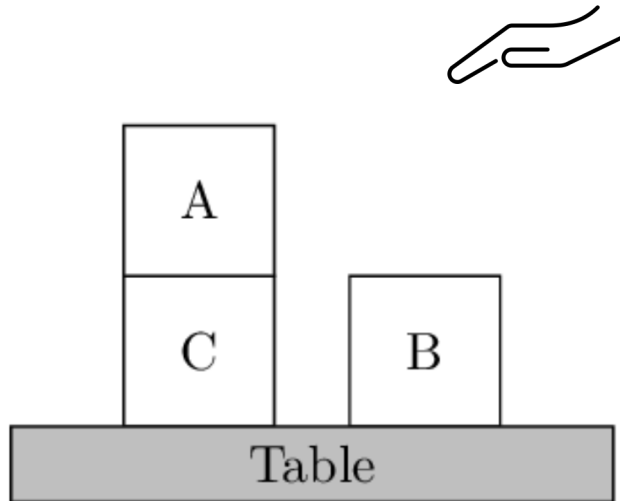
1. the **Add** list $\text{Add}(o) \subseteq F$
2. the **Delete** list $\text{Del}(o) \subseteq F$
3. the **Precondition** list $\text{Pre}(o) \subseteq F$

Define Operators

1. Pick up a block from the table **pickup(x)**
 - Prec: $\text{onTable}(x), \text{clear}(x), \text{handEmpty}$
 - Add: $\text{holding}(x)$
 - Del: $\text{onTable}(x), \text{clear}(x), \text{handEmpty}$

Problem 1

Initial State



$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y), \text{onTable}(x), \text{clear}(x), \text{holding}(x), \text{handEmpty} \mid x, y \in \{A, B, C\} \}$

Operator $o \in O$ represented by

1. the **Add** list $\text{Add}(o) \subseteq F$
2. the **Delete** list $\text{Del}(o) \subseteq F$
3. the **Precondition** list $\text{Pre}(o) \subseteq F$

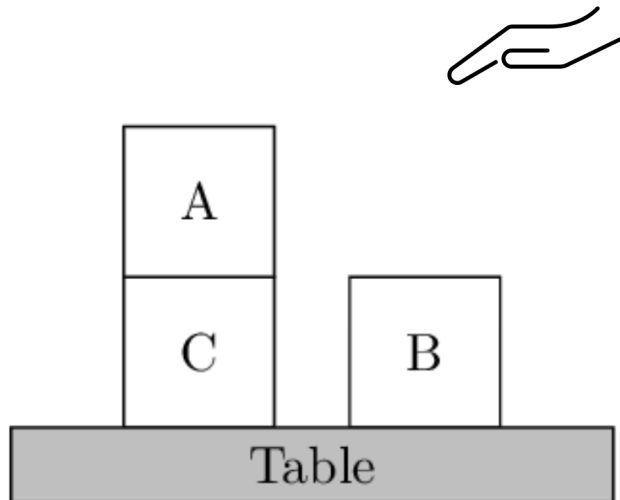
Define Operators

2. Pick up a block from another block **unstack(x)**

- Prec: $\text{on}(x, y), \text{clear}(x), \text{handEmpty}$
- Add: $\text{holding}(x), \text{clear}(y)$
- Del: $\text{on}(x, y), \text{clear}(x), \text{handEmpty}$

Problem 1

Initial State



$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y), \text{onTable}(x), \text{clear}(x), \text{holding}(x), \text{handEmpty} \mid x, y \in \{A, B, C\} \}$

Operator $o \in O$ represented by

1. the **Add** list $\text{Add}(o) \subseteq F$
2. the **Delete** list $\text{Del}(o) \subseteq F$
3. the **Precondition** list $\text{Pre}(o) \subseteq F$

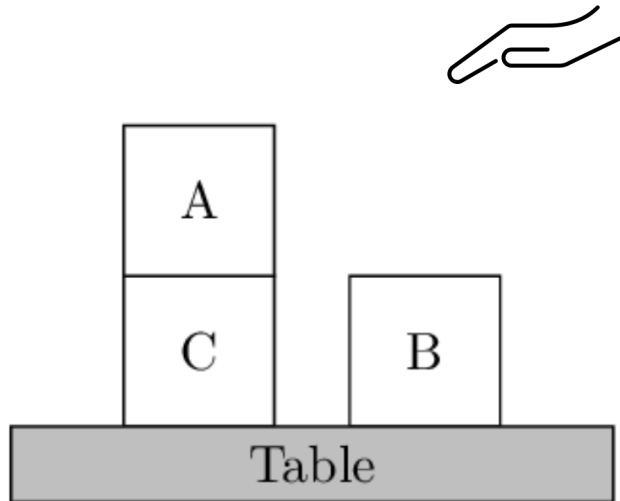
Define Operators

3. Put down a block on the table **putdown(x)**

- Prec: $\text{holding}(x)$
- Add: $\text{clear}(x), \text{onTable}(x), \text{handEmpty}$
- Del: $\text{holding}(x)$

Problem 1

Initial State



$P = \langle F, O, I, G \rangle$

$F = \{ \text{on}(x, y), \text{onTable}(x), \text{clear}(x), \text{holding}(x), \text{handEmpty} \mid x, y \in \{A, B, C\} \}$

Operator $o \in O$ represented by

1. the **Add** list $\text{Add}(o) \subseteq F$
2. the **Delete** list $\text{Del}(o) \subseteq F$
3. the **Precondition** list $\text{Pre}(o) \subseteq F$

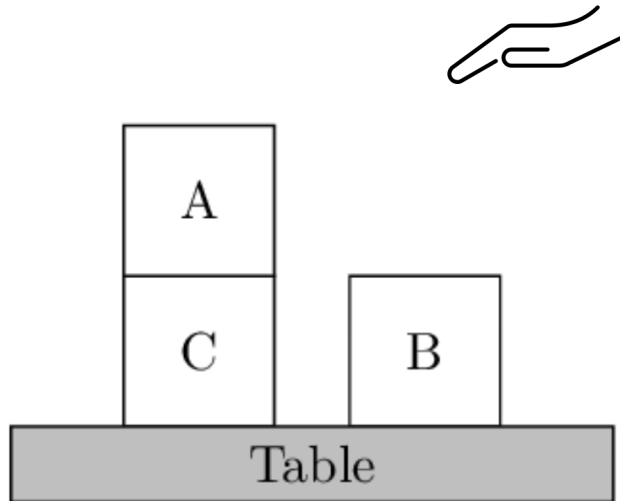
Define Operators

4. Put down a block on another block **stack(x, y)**

- Prec: $\text{holding}(x), \text{clear}(y)$
- Add: $\text{clear}(x), \text{on}(x, y), \text{handEmpty}$
- Del: $\text{clear}(y), \text{holding}(x)$

Problem 1

Initial State



Define Operators

$O = \{$

pickup(x)

- Prec: onTable(x), clear(x), handEmpty
- Add: holding(x)
- Del: onTable(x), clear(x), handEmpty

unstack(x)

- Prec: on(x, y), clear(x), handEmpty
- Add: holding(x), clear(y)
- Del: on(x, y), clear(x), handEmpty

putdown(x)

- Prec: holding(x)
- Add: clear(x), onTable(x), handEmpty
- Del: holding(x)

stack(x, y)

- Prec: holding(x), clear(y)
- Add: clear(x), on(x,y), handEmpty
- Del: clear(y), holding(x)

}

Problem 2: PDDL

1. A domain file that has predicates and actions
2. A problem file that has objects, initial state and goal

TSP: https://editor.planning.domains/#read_session=zp1j883xR9

Problem 2: PDDL

```
1 (define (domain tsp)
2   (:requirements :typing)
3   (:types node)
4
5   ;; Define the facts in the problem
6   ;; "?" denotes a variable, "-" a type
7   (:predicates
8     (at ?pos - node)
9     (connected ?start ?end - node)
10    (visited ?end - node)
11  )
12
13  ;; Define the action(s)
14  (:action move
15    :parameters (?start ?end - node)
16    :precondition (and
17      (at ?start)
18      (connected ?start ?end)
19    )
20    :effect (and
21      (at ?end)
22      (visited ?end)
23      (not (at ?start))
24    )
25  )
26 )
```

Handwritten notes: A red 'F' with an arrow pointing to line 7. A red '0' with an arrow pointing to line 19.

```
1 (define (problem tsp-01)
2   (:domain tsp)
3   (:objects Sydney Adelaide Brisbane Perth Darwin - node)
4
5   ;; Define the initial situation
6   (:init (connected Sydney Brisbane)
7     (connected Brisbane Sydney)
8     (connected Adelaide Sydney)
9     (connected Sydney Adelaide)
10    (connected Adelaide Perth)
11    (connected Perth Adelaide)
12    (connected Adelaide Darwin)
13    (connected Darwin Adelaide)
14    (at Sydney)
15  )
16  (:goal
17    (and
18      (at Sydney)
19      (visited Sydney)
20      (visited Adelaide)
21      (visited Brisbane)
22      (visited Perth)
23      (visited Darwin)
24    )
25  )
26 )
```

Handwritten notes: A red 'I' with an arrow pointing to the (:init) block. A red 'G' with an arrow pointing to the (:goal) block.

Problem 2

TSP: https://editor.planning.domains/#read_session=zp1j883xR9

$F = \{ \text{on}(x, y),$
 $\text{onTable}(x),$
 $\text{clear}(x),$
 $\text{holding}(x),$
 $\text{handEmpty} \mid x, y \in \{A, B, C\}$
 $\}$

$I = \{ \text{on}(A, C), \text{onTable}(C), \text{onTable}(B), \text{clear}(A), \text{clear}(B), \text{handEmpty} \}$

$G = \{ \text{on}(A, B), \text{on}(B, C) \}$

$O = \{$

pickup(x)

- Prec: $\text{onTable}(x), \text{clear}(x), \text{handEmpty}$
- Add: $\text{holding}(x)$
- Del: $\text{onTable}(x), \text{clear}(x), \text{handEmpty}$

unstack(x)

- Prec: $\text{on}(x, y), \text{clear}(x), \text{handEmpty}$
- Add: $\text{holding}(x), \text{clear}(y)$
- Del: $\text{on}(x, y), \text{clear}(x), \text{handEmpty}$

putdown(x)

- Prec: $\text{holding}(x)$
- Add: $\text{clear}(x), \text{onTable}(x), \text{handEmpty}$
- Del: $\text{holding}(x)$

stack(x, y)

- Prec: $\text{holding}(x), \text{clear}(y)$
 - Add: $\text{clear}(x), \text{on}(x, y), \text{handEmpty}$
 - Del: $\text{clear}(y), \text{holding}(x)$
- }

Planimation Plugin

<https://github.com/planimation/documentation>

Solution with 4 actions

http://editor.planning.domains/#read_session=iOEg2OeV24