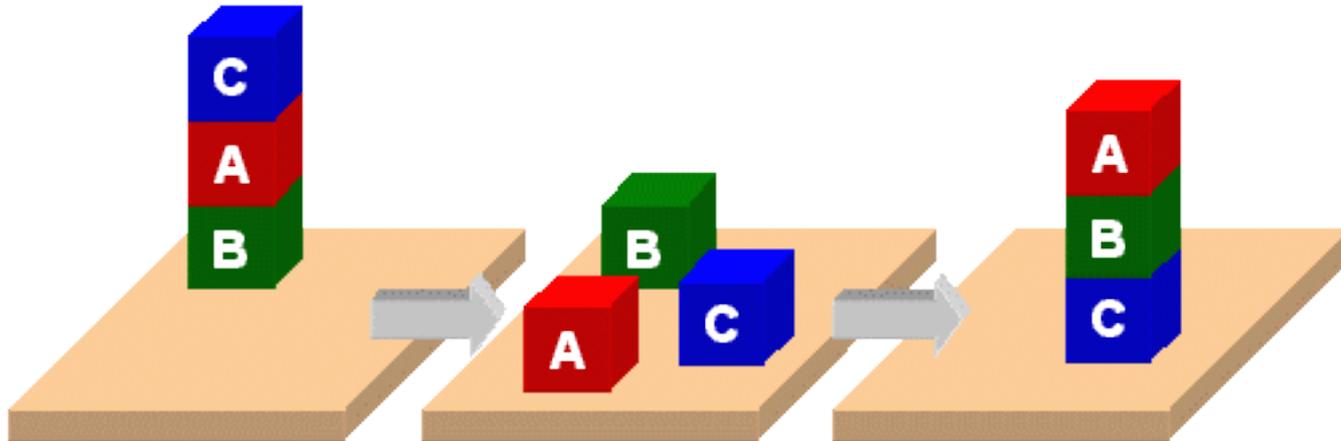


HW5: Planning



PDDL

- Planning Domain Description Language
- Based on STRIPS with various extensions
- Originally defined by Drew McDermott (Yale) and others
- Used in the biennial International Planning Competition (IPC) series
- Many planners use it as a standard input

PDDL Representation

- A task specified via two files: **domain file** and **problem file**
- **Problem file** gives objects, initial state, and goal state
- **Domain file** gives predicates and operators; these may be re-used for different problem files
- **Domain file** corresponds to the transition system, the **problem files** constitute instances in that system

Blocks World Domain File



```
(define (domain hw5)
  (:requirements :strips)
  (:constants red green blue yellow)
  (:predicates (on ?x ?y) (on-table ?x) (block ?x) ... (clean ?x))
  (:action pick-up
    :parameters (?obj1)
    :precondition (and (clear ?obj1) (on-table ?obj1)
                       (arm-empty))
    :effect (and (not (on-table ?obj1))
                 (not (clear ?obj1))
                 (not (arm-empty))
                 (holding ?obj1)))
  ... more actions ...)
```

(define (problem 00)

 (:domain hw5)

 (:objects A B C)

 (:init (arm-empty)

 (block A)

 (color A red)

 (on-table A)

 (block B)

 (on B A)

 (block C)

 (on C B)

 (clear C))

 (:goal (and (on A B) (on B C))))

Blocks Word Problem File



Blackbox planner



- Blackbox planner converts STRIPS-like problems into Boolean satisfiability problems
- Input given in PDDL (domain and problem)
- Solves with a variety of satisfiability engines
- Open source; executables for Linux, Mac, Windows from <http://bit.ly/BBpddl>
 - Do *blackbox -help* for options
 - Installed on gl as *~finin/pub/blackbox*

Blackbox planner



```
> git clone https://github.com/UMBC-CMSC-471-01-SP2016/hw5.git
```

```
...
```

```
> cd hw5; ls
```

```
domain.pddl p00.pddl p0.pddl p1.pddl p2.pddl p3.pddl p4.pddl README.md session.txt
```

```
> ~finin/pub/blackbox -o domain.pddl -f p00.pddl
```

```
blackbox version 43
```

```
...
```

```
Loading domain file: domain.pddl
```

```
Loading fact file: p00.pddl
```

```
...
```

```
Begin plan
```

```
1 (unstack c b)
```

```
2 (put-down c)
```

```
3 (unstack b a)
```

```
4 (stack b c)
```

```
5 (pick-up a)
```

```
6 (stack a b)
```

```
End plan
```

```
...
```

```
Total elapsed time: 0.01 seconds
```

```
...
```

(1) Extend the domain: new objects

- **Paint sprayers.** Each sprayer can only paint in one color (e.g., red, green, blue).
- **Paint cans.** A paint can holds only one color of paint.
- **Brushes.** A brush can either be clean or loaded with paint of a particular color.
- **Water bucket.** A water bucket is used to wash brushes.

(2) Extend the domain: new actions

- painting an object with a sprayer
- painting an object with a brush and can
- loading a brush with paint of a given color
- washing a brush, making it clean

Action preconditions

- To paint an object, it must be on the table and clear
- Painting with a sprayer: just pick it up and spray
- To paint something a color with a brush, it must be loaded with paint of that color.
- To load paint brush with a color, you must be holding brush, brush must be clean and there must be a paint can with that color that is clear. When a brush is loaded with a color it is not clean.
- To wash a brush, making it clean, you must have a water bucket that has nothing on it (i.e., is clear) and you have to be holding the brush

Problem p1.ppd

;; There is only one block, A, which is on the table. A can with
;; red paint is on the table. There is a clean brush on the
;; table. Our goal is to have A be red and the arm empty.

```
(define (problem 1)
```

```
  (:domain hw6)
```

```
  (:objects .... )
```

```
  (:init (arm-empty)
```

```
    ... block A on the table with nothing on it ...
```

```
    ... a red paint can on the table with nothing on it ...
```

```
    ... a clean brush is on the table with nothing on it ...
```

```
  )
```

```
  (:goal (and (arm-empty)
```

```
    ... A is red ... )))
```