Ricochet Robots Reloaded
A Case-study in Multi-shot ASP Solving

Torsten Schaub

University of Potsdam

Outline

1 Multi-shot ASP Solving

2 Ricochet Robots

3 Demonstration

4 Summary

Potassco

Outline

1 Multi-shot ASP Solving

2 Ricochet Robots

3 Demonstration

4 Summary

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*

  Multi-shot solving: *ground* | *solve*

  ➥ *continuously changing logic programs*

Agents, Assisted Living, Robotics, Planning, Query-answering, etc

clingo 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*

  Multi-shot solving: *ground* | *solve*

  ➥ *continuously changing logic programs*

Agents, Assisted Living, Robotics, Planning, Query-answering, etc

clingo 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: *ground* | *solve*

  ➥ *continuously changing logic programs*

- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc

- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: *ground* | *solve*
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: *ground** | *solve**
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*ground** | *solve**)*
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**)*
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**| *theory*)*
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**| *theory* | . . .)*

  ➥ *continuously changing logic programs*

- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc

- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**| *theory* | . . .)*
  - ➥ *continuously changing logic programs*
- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc
- Implementation *clingo* 4

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**| *theory* | . . .)*

  ➥ *continuously changing logic programs*

- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc

- Implementation *clingo 4*

Potassco

Motivation

- Claim ASP is an under-the-hood technology

  That is, in practice, it mainly serves as a solving engine within an encompassing software environment

- Single-shot solving: *ground* | *solve*
- Multi-shot solving: (*input* | *ground** | *solve**| *theory* | . . .)*

  ➥ *continuously changing logic programs*

- Application areas

  Agents, Assisted Living, Robotics, Planning, Query-answering, etc

- Implementation *clingo* 4

Potassco

Clingo = ASP + Control

- ASP

```
#program <name> [ (<parameters>) ]
          #program play(t).
#external <atom> [ :  <body> ]
          #external mark(X,Y,P,t) :  field(X,Y), player(P).
```

- Control

Lua (www.lua.org)

```
prg:solve(), prg:ground(parts), ...
```

Python (www.python.org)

```
prg.solve(), prg.ground(parts), ...
```

- Integration

in ASP: embedded scripting language (#script)
in Lua/Python: library import (import gringo)

Potassco

Clingo = ASP + Control

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
- Control
  - Lua (`www.lua.org`)
    `prg:solve(), prg:ground(parts), ...`
  - Python (`www.python.org`)
    `prg.solve(), prg.ground(parts), ...`
- Integration
  - in ASP: embedded scripting language (`#script`)
  - in Lua/Python: library import (`import gringo`)

Potassco

Clingo = ASP + Control

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
- Control
  - Lua (`www.lua.org`)
    `prg:solve(), prg:ground(parts), ...`
  - Python (`www.python.org`)
    `prg.solve(), prg.ground(parts), ...`
- Integration
  - in ASP: embedded scripting language (`#script`)
  - in Lua/Python: library import (`import gringo`)

Potassco

Clingo = ASP + Control

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
- Control
  - Lua (`www.lua.org`)
    - Example `prg:solve(), prg:ground(parts), ...`
  - Python (`www.python.org`)
    - Example `prg.solve(), prg.ground(parts), ...`
- Integration

  in ASP: embedded scripting language (`#script`)
  in Lua/Python: library import (`import gringo`)

Potassco

Clingo = ASP + Control

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
- Control
  - Lua (`www.lua.org`)
    - Example `prg:solve(), prg:ground(parts), ...`
  - Python (`www.python.org`)
    - Example `prg.solve(), prg.ground(parts), ...`
- Integration

  in ASP: embedded scripting language (`#script`)
  in Lua/Python: library import (`import gringo`)

Potassco

Clingo = ASP + Control

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
- Control
  - Lua (`www.lua.org`)
    - Example `prg:solve()`, `prg:ground(parts)`, ...
  - Python (`www.python.org`)
    - Example `prg.solve()`, `prg.ground(parts)`, ...
- Integration
  - in ASP: embedded scripting language (`#script`)
  - in Lua/Python: library import (`import gringo`)

Potassco

Outline

1 Multi-shot ASP Solving

2 Ricochet Robots

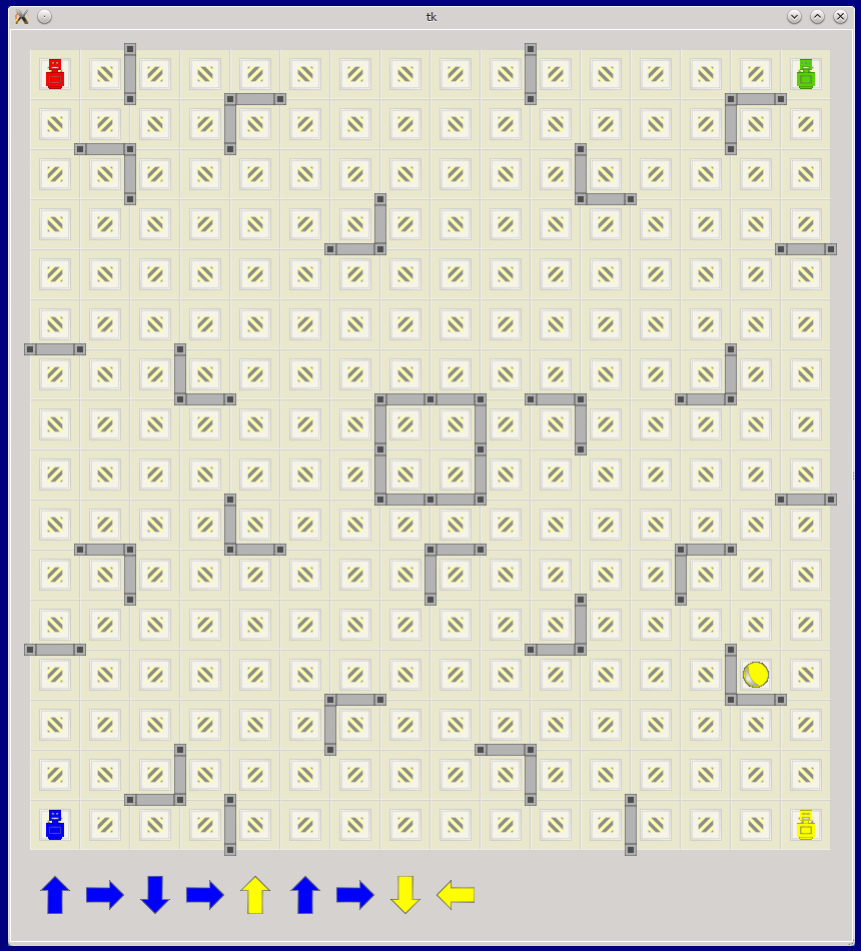
3 Demonstration

4 Summary

Potassco

Alex Rudolph's Ricochet Robots

Solving goal(13) from cornered robots



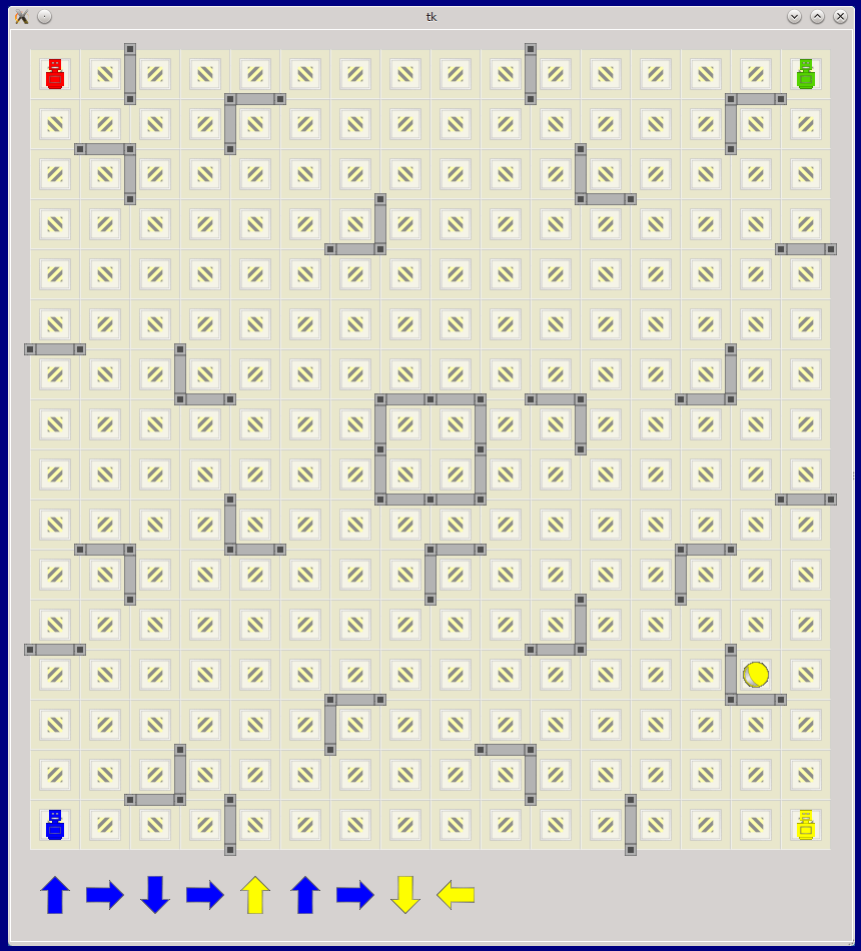
- Four robots roaming
  - horizontally
  - vertically

  up to blocking objects, ricocheting (optionally)
- Goal Robot on target (sharing same color)

Potassco

Alex Rudolph's Ricochet Robots

Solving `goal(13)` from cornered robots



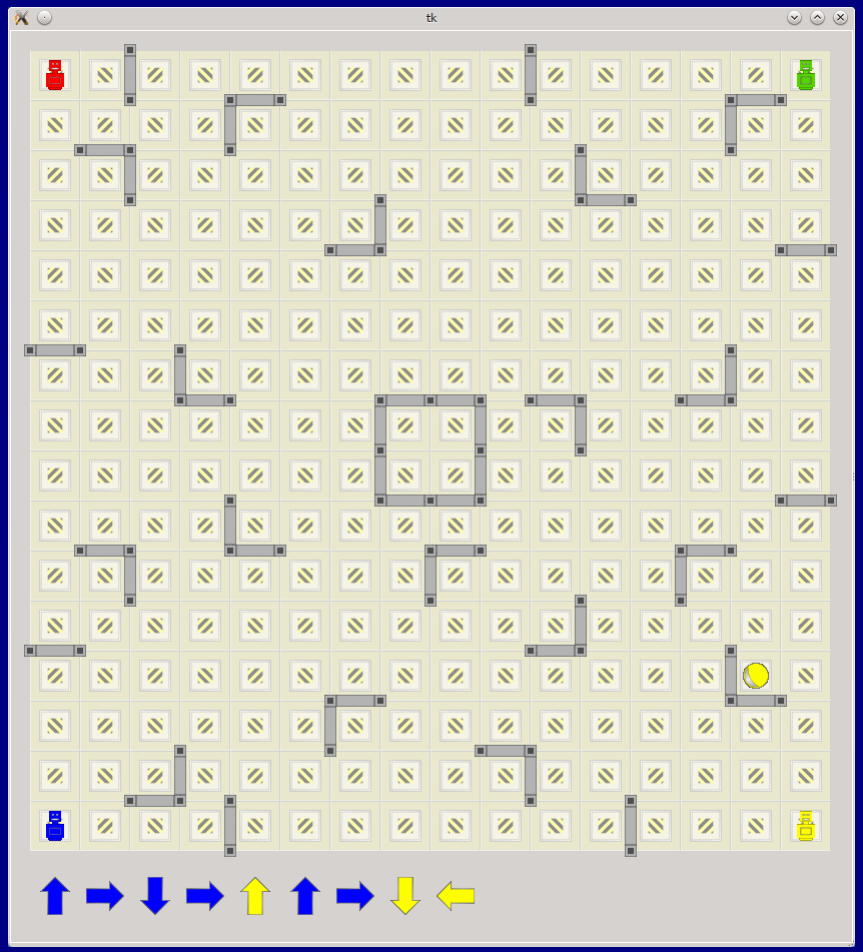
- Four robots roaming
  - horizontally
  - vertically

  up to blocking objects, ricocheting (optionally)
- Goal Robot on target (sharing same color)

Potassco

Alex Rudolph's Ricochet Robots

Solving `goal(13)` from cornered robots



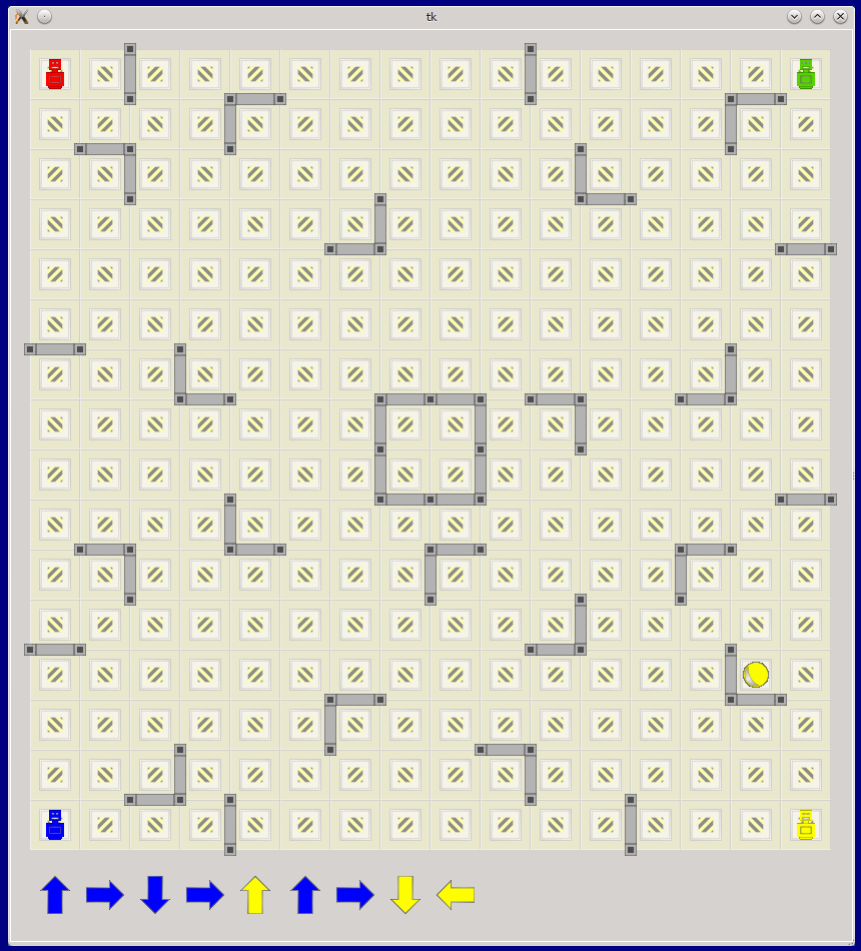
- Four robots roaming
  - horizontally
  - vertically

  up to blocking objects, ricocheting (optionally)
- Goal Robot on target (sharing same color)

Potassco

Alex Rudolph's Ricochet Robots

Solving `goal(13)` from cornered robots

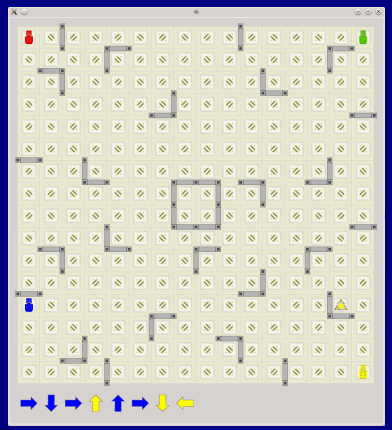


- Four robots roaming
  - horizontally
  - vertically

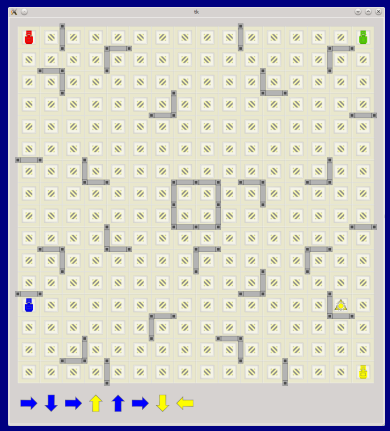
  up to blocking objects, ricocheting (optionally)
- Goal Robot on target (sharing same color)

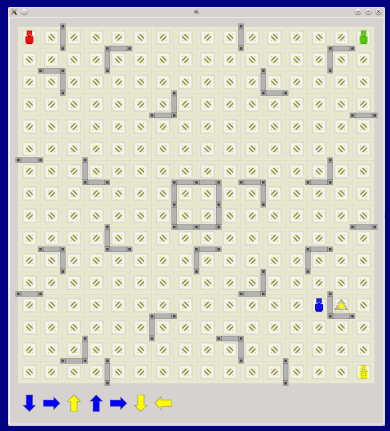
Potassco

Solving goal(13) from cornered robots (ctd)

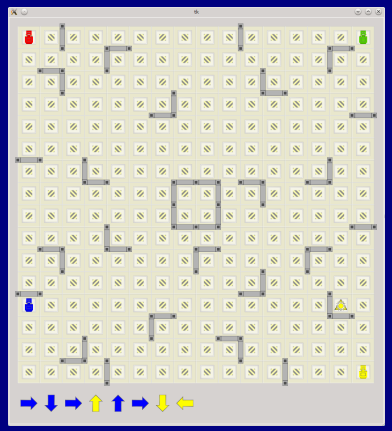
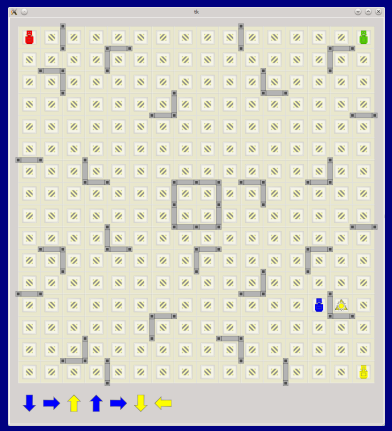
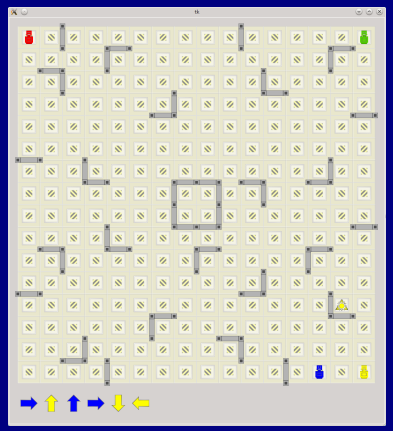


Solving goal(13) from cornered robots (ctd)



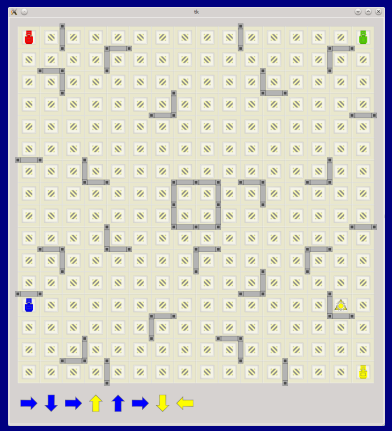
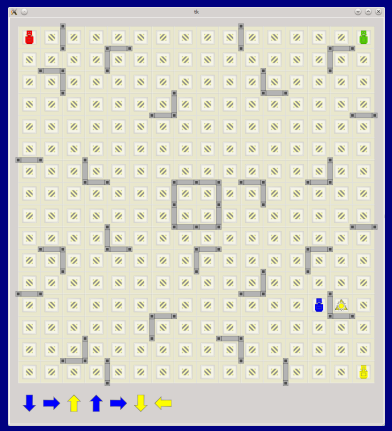
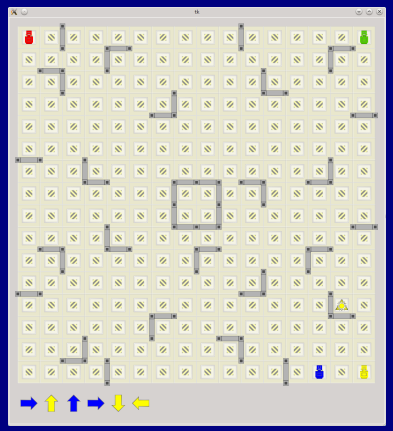
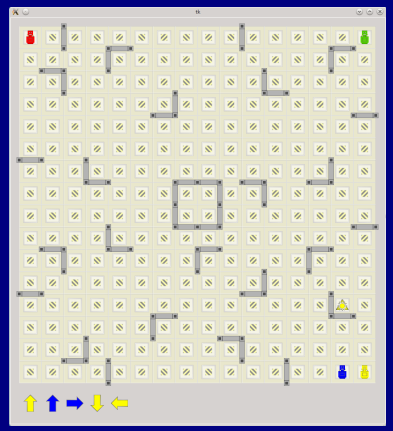


Solving goal(13) from cornered robots (ctd)

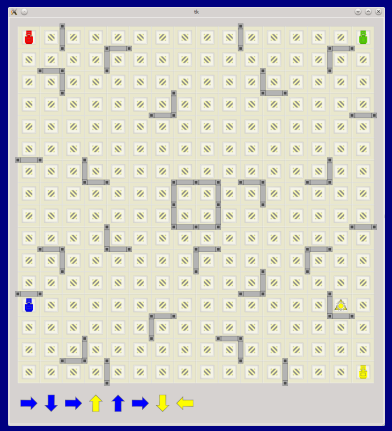
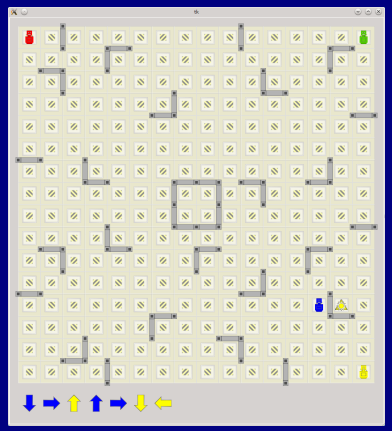
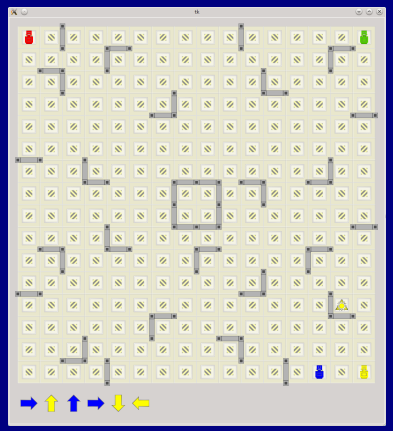
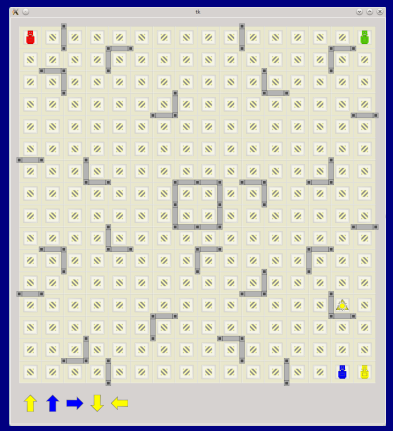
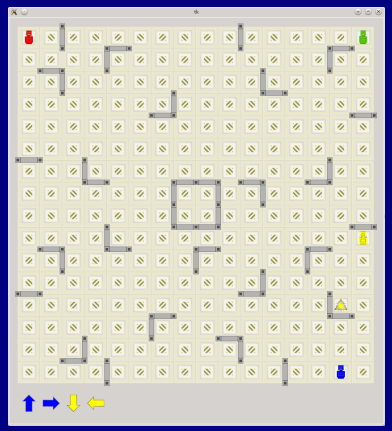
Potassco

Solving goal(13) from cornered robots (ctd)

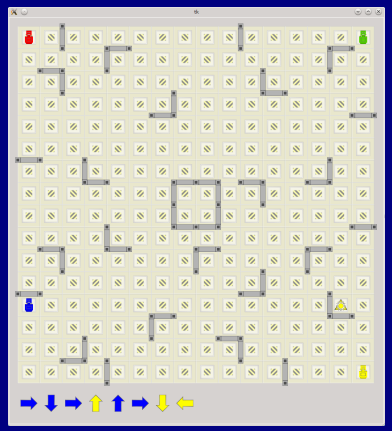
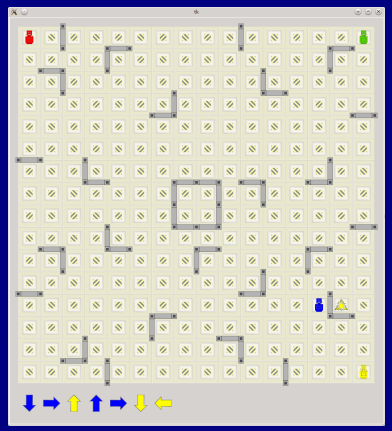
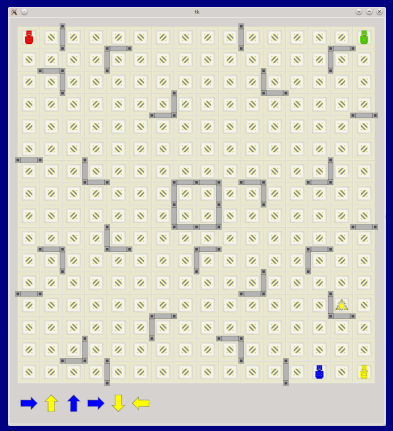
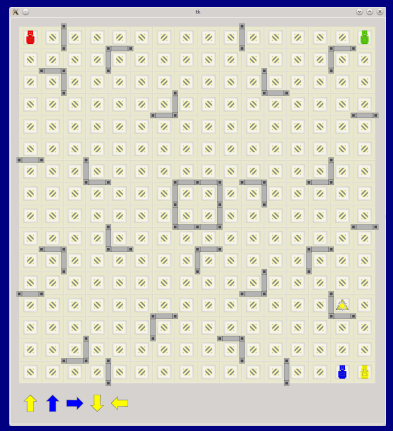
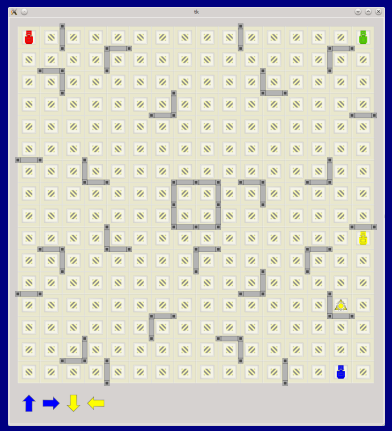
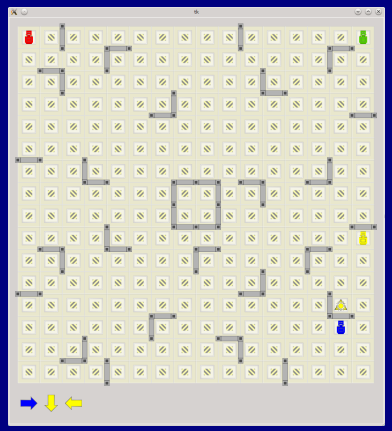
Potassco

Solving goal(13) from cornered robots (ctd)

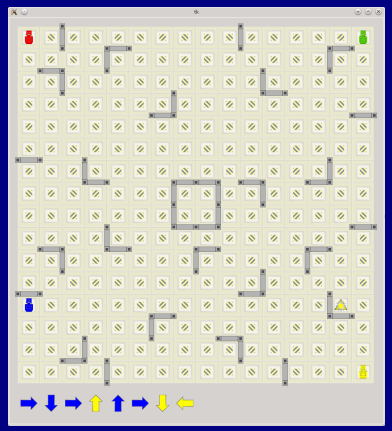
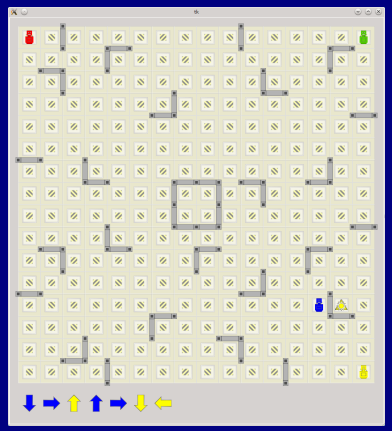
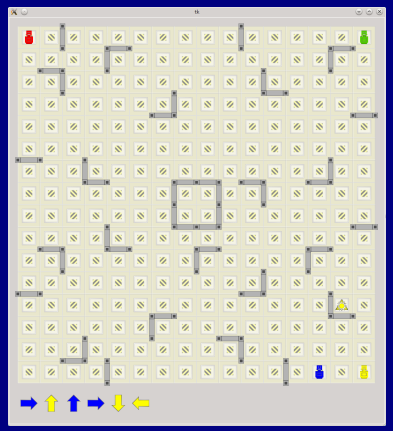
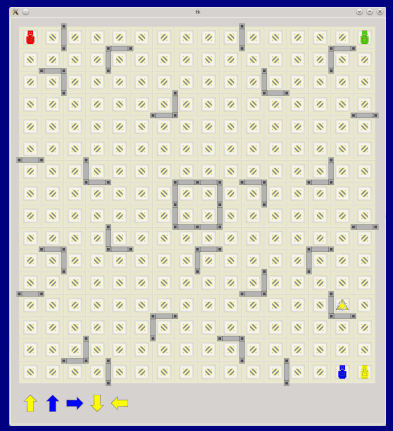
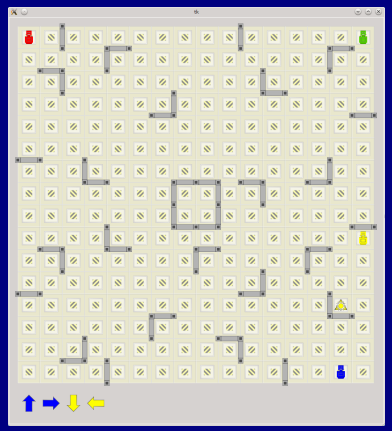
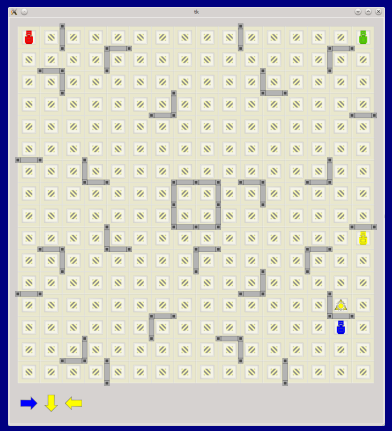
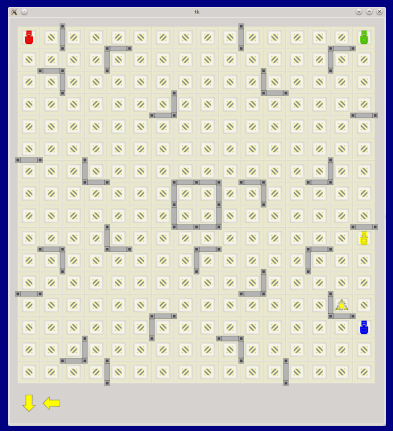






Potassco

Solving goal(13) from cornered robots (ctd)

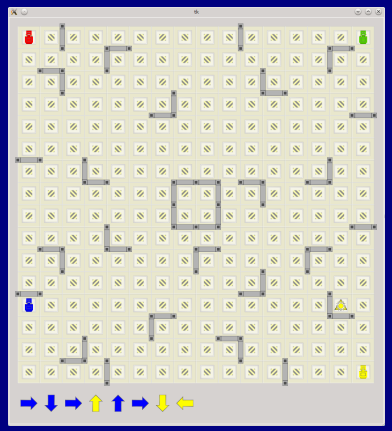
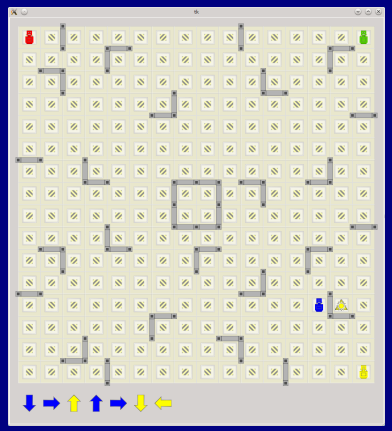
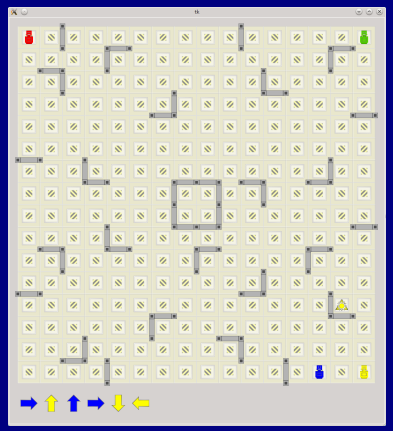
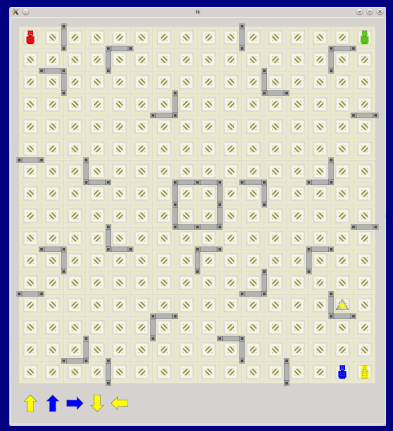
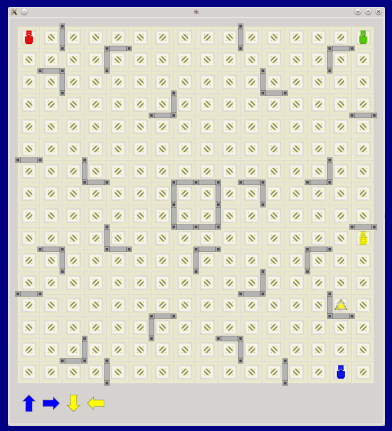
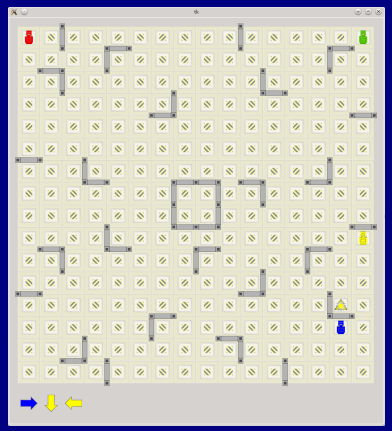
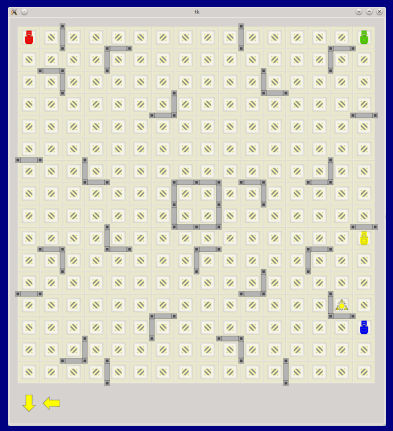
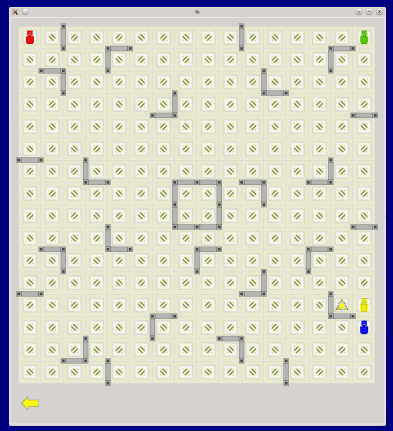







Solving goal(13) from cornered robots (ctd)

Potassco

Solving goal(13) from cornered robots (ctd)

Potassco

board.lp

```
dim(1..16).

barrier( 2, 1, 1, 0).  barrier(13,11, 1, 0).  barrier( 9, 7, 0, 1).
barrier(10, 1, 1, 0).  barrier(11,12, 1, 0).  barrier(11, 7, 0, 1).
barrier( 4, 2, 1, 0).  barrier(14,13, 1, 0).  barrier(14, 7, 0, 1).
barrier(14, 2, 1, 0).  barrier( 6,14, 1, 0).  barrier(16, 9, 0, 1).
barrier( 2, 3, 1, 0).  barrier( 3,15, 1, 0).  barrier( 2,10, 0, 1).
barrier(11, 3, 1, 0).  barrier(10,15, 1, 0).  barrier( 5,10, 0, 1).
barrier( 7, 4, 1, 0).  barrier( 4,16, 1, 0).  barrier( 8,10, 0,-1).
barrier( 3, 7, 1, 0).  barrier(12,16, 1, 0).  barrier( 9,10, 0,-1).
barrier(14, 7, 1, 0).  barrier( 5, 1, 0, 1).  barrier( 9,10, 0, 1).
barrier( 7, 8, 1, 0).  barrier(15, 1, 0, 1).  barrier(14,10, 0, 1).
barrier(10, 8,-1, 0).  barrier( 2, 2, 0, 1).  barrier( 1,12, 0, 1).
barrier(11, 8, 1, 0).  barrier(12, 3, 0, 1).  barrier(11,12, 0, 1).
barrier( 7, 9, 1, 0).  barrier( 7, 4, 0, 1).  barrier( 7,13, 0, 1).
barrier(10, 9,-1, 0).  barrier(16, 4, 0, 1).  barrier(15,13, 0, 1).
barrier( 4,10, 1, 0).  barrier( 1, 6, 0, 1).  barrier(10,14, 0, 1).
barrier( 2,11, 1, 0).  barrier( 4, 7, 0, 1).  barrier( 3,15, 0, 1).
barrier( 8,11, 1, 0).  barrier( 8, 7, 0, 1).
```

Potassco

targets.lp

```
#external goal(1..16).

target(red,     5, 2) :- goal(1).
target(red,    15, 2) :- goal(2).
target(green,   2, 3) :- goal(3).
target(blue,   12, 3) :- goal(4).
target(yellow, 7, 4) :- goal(5).
target(blue,    4, 7) :- goal(6).
target(green, 14, 7) :- goal(7).
target(yellow,11, 8) :- goal(8).
target(yellow, 5,10) :- goal(9).
target(green,   2,11) :- goal(10).
target(red,    14,11) :- goal(11).
target(green, 11,12) :- goal(12).
target(yellow,15,13) :- goal(13).
target(blue,    7,14) :- goal(14).
target(red,     3,15) :- goal(15).
target(blue,   10,15) :- goal(16).

robot(red;green;blue;yellow).
#external pos((red;green;blue;yellow),1..16,1..16).
```

Potassco

ricochet.lp

```
time(1..horizon).
dir(-1,0;1,0;0,-1;0,1).

stop( DX, DY,X,   Y   ) :- barrier(X,Y,DX,DY).
stop(-DX,-DY,X+DX,Y+DY) :- stop(DX,DY,X,Y).

pos(R,X,Y,0) :- pos(R,X,Y).

1 { move(R,DX,DY,T) : robot(R), dir(DX,DY) } 1 :- time(T).
move(R,T) :- move(R,_,_,T).

halt(DX,DY,X-DX,Y-DY,T) :- pos(_,X,Y,T), dir(DX,DY), dim(X-DX), dim(Y-DY),
                           not stop(-DX,-DY,X,Y), T < horizon.

goto(R,DX,DY,X,Y,T) :- pos(R,X,Y,T), dir(DX,DY), T < horizon.
goto(R,DX,DY,X+DX,Y+DY,T) :- goto(R,DX,DY,X,Y,T), dim(X+DX), dim(Y+DY),
                         not stop(DX,DY,X,Y), not halt(DX,DY,X,Y,T).

pos(R,X,Y,T) :- move(R,DX,DY,T), goto(R,DX,DY,X,Y,T-1),
                not goto(R,DX,DY,X+DX,Y+DY,T-1).
pos(R,X,Y,T) :- pos(R,X,Y,T-1), time(T), not move(R,T).

:- target(R,X,Y), not pos(R,X,Y,horizon).

#show move/4.
```

Potassco

Solving goal(13) from cornered robots

```
$ clingo board.lp targets.lp ricochet.lp -c horizon=9 \
       <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
Answer: 1
move(red,0,1,1)     move(red,1,0,2) move(red,0,1,3)    move(red,-1,0,4) move(red,0,1,5) \
move(yellow,0,-1,6) move(red,1,0,7) move(yellow,0,1,8) move(yellow,-1,0,9)
SATISFIABLE

Models       : 1+
Calls        : 1
Time         : 1.895s (Solving: 1.45s 1st Model: 1.45s Unsat: 0.00s)
CPU Time     : 1.880s


$ clingo board.lp targets.lp ricochet.lp -c horizon=8 \
       <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
UNSATISFIABLE

Models       : 0
Calls        : 1
Time         : 2.817s (Solving: 2.41s 1st Model: 0.00s Unsat: 2.41s)
CPU Time     : 2.800s
```

Potassco

Solving goal(13) from cornered robots

```
$ clingo board.lp targets.lp ricochet.lp -c horizon=9 \
       <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
Answer: 1
move(red,0,1,1)     move(red,1,0,2) move(red,0,1,3)    move(red,-1,0,4) move(red,0,1,5) \
move(yellow,0,-1,6) move(red,1,0,7) move(yellow,0,1,8) move(yellow,-1,0,9)
SATISFIABLE

Models       : 1+
Calls        : 1
Time         : 1.895s (Solving: 1.45s 1st Model: 1.45s Unsat: 0.00s)
CPU Time     : 1.880s


$ clingo board.lp targets.lp ricochet.lp -c horizon=8 \
       <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
UNSATISFIABLE

Models       : 0
Calls        : 1
Time         : 2.817s (Solving: 2.41s 1st Model: 0.00s Unsat: 2.41s)
CPU Time     : 2.800s
```

Potassco

Solving goal(13) from cornered robots

```
$ clingo board.lp targets.lp ricochet.lp -c horizon=9 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
Answer: 1
move(red,0,1,1)     move(red,1,0,2) move(red,0,1,3)    move(red,-1,0,4) move(red,0,1,5) \
move(yellow,0,-1,6) move(red,1,0,7) move(yellow,0,1,8) move(yellow,-1,0,9)
SATISFIABLE

Models       : 1+
Calls        : 1
Time         : 1.895s (Solving: 1.45s 1st Model: 1.45s Unsat: 0.00s)
CPU Time     : 1.880s


$ clingo board.lp targets.lp ricochet.lp -c horizon=8 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
UNSATISFIABLE

Models       : 0
Calls        : 1
Time         : 2.817s (Solving: 2.41s 1st Model: 0.00s Unsat: 2.41s)
CPU Time     : 2.800s
```

Potassco

Solving goal(13) from cornered robots

```
$ clingo board.lp targets.lp ricochet.lp -c horizon=9 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
Answer: 1
move(red,0,1,1)     move(red,1,0,2) move(red,0,1,3)    move(red,-1,0,4) move(red,0,1,5) \
move(yellow,0,-1,6) move(red,1,0,7) move(yellow,0,1,8) move(yellow,-1,0,9)
SATISFIABLE

Models       : 1+
Calls        : 1
Time         : 1.895s (Solving: 1.45s 1st Model: 1.45s Unsat: 0.00s)
CPU Time     : 1.880s


$ clingo board.lp targets.lp ricochet.lp -c horizon=8 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")

clingo version 4.5.0
Reading from board.lp ...
Solving...
UNSATISFIABLE

Models       : 0
Calls        : 1
Time         : 2.817s (Solving: 2.41s 1st Model: 0.00s Unsat: 2.41s)
CPU Time     : 2.800s
```

Potassco

optimization.lp

```
goon(T) :- target(R,X,Y), T = 0..horizon, not pos(R,X,Y,T).

:- move(R,DX,DY,T-1), time(T), not goon(T-1), not move(R,DX,DY,T).

#minimize{ 1,T : goon(T) }.
```

Potassco

Solving goal(13) from cornered robots

```
$ clingo board.lp targets.lp ricochet.lp optimization.lp -c horizon=20 --quiet=1,0 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")
clingo version 4.5.0
Reading from board.lp ...
Solving...
Optimization: 20
Optimization: 19
Optimization: 18
Optimization: 17
Optimization: 16
Optimization: 15
Optimization: 14
Optimization: 13
Optimization: 12
Optimization: 11
Optimization: 10
Optimization: 9
Answer: 12
move(blue,0,-1,1)   move(blue,1,0,2)    move(yellow,0,-1,3) move(blue,0,1,4)    move(yellow,-1,0,5) \
move(blue,1,0,6)    move(blue,0,-1,7)   move(yellow,1,0,8)  move(yellow,0,1,9)  move(yellow,0,1,10) \
move(yellow,0,1,11) move(yellow,0,1,12) move(yellow,0,1,13) move(yellow,0,1,14) move(yellow,0,1,15) \
move(yellow,0,1,16) move(yellow,0,1,17) move(yellow,0,1,18) move(yellow,0,1,19) move(yellow,0,1,20)
OPTIMUM FOUND

Models       : 12
  Optimum    : yes
Optimization : 9
Calls        : 1
Time         : 16.145s (Solving: 15.01s 1st Model: 3.35s Unsat: 2.02s)
CPU Time     : 16.080s
```

Potassco

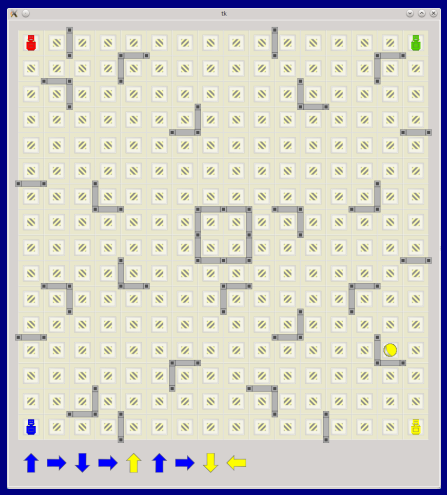
Solving goal(13) from cornered robots

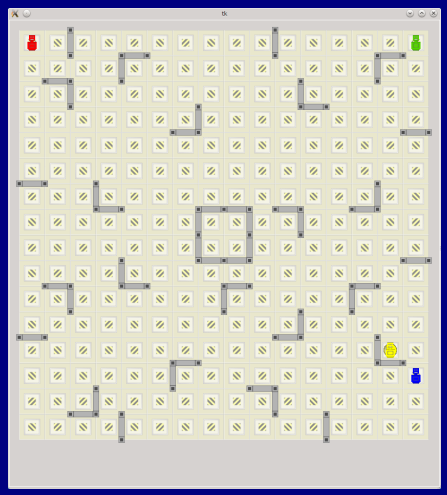
```
$ clingo board.lp targets.lp ricochet.lp optimization.lp -c horizon=20 --quiet=1,0 \
        <(echo "pos(red,1,1). pos(green,16,1). pos(blue,1,16). pos(yellow,16,16).   goal(13).")
clingo version 4.5.0
Reading from board.lp ...
Solving...
Optimization: 20
Optimization: 19
Optimization: 18
Optimization: 17
Optimization: 16
Optimization: 15
Optimization: 14
Optimization: 13
Optimization: 12
Optimization: 11
Optimization: 10
Optimization: 9
Answer: 12
move(blue,0,-1,1)   move(blue,1,0,2)    move(yellow,0,-1,3) move(blue,0,1,4)    move(yellow,-1,0,5) \
move(blue,1,0,6)    move(blue,0,-1,7)   move(yellow,1,0,8)  move(yellow,0,1,9)  move(yellow,0,1,10) \
move(yellow,0,1,11) move(yellow,0,1,12) move(yellow,0,1,13) move(yellow,0,1,14) move(yellow,0,1,15) \
move(yellow,0,1,16) move(yellow,0,1,17) move(yellow,0,1,18) move(yellow,0,1,19) move(yellow,0,1,20)
OPTIMUM FOUND

Models       : 12
  Optimum    : yes
Optimization : 9
Calls        : 1
Time         : 16.145s (Solving: 15.01s 1st Model: 3.35s Unsat: 2.02s)
CPU Time     : 16.080s
```

Potassco

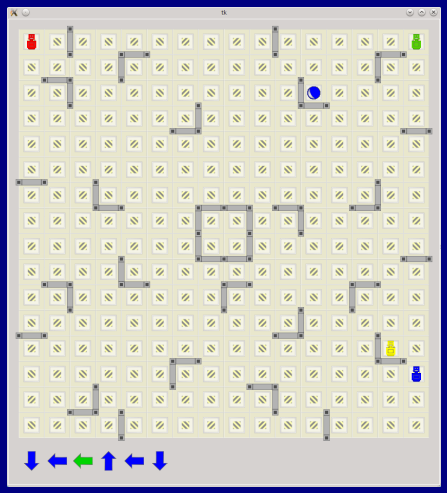
Playing in rounds

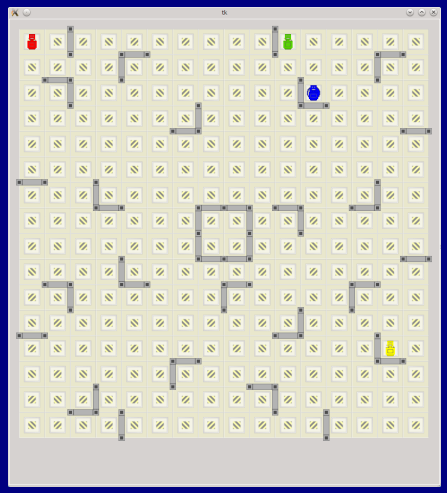
Round 1: `goal(13)`





Round 2: `goal(4)`





Potassco

Control loop

1. Create an operational *clingo* object
2. Load and ground the logic programs encoding Ricochet Robot (relative to some fixed `horizon`) within the control object
3. While there is a goal, do the following
   1. Enforce the initial robot positions
   2. Enforce the current goal
   3. Solve the logic program contained in the control object

Potassco

Ricochet Robot Player

ricochet.py

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Variables of interest

- `last_positions` holds the starting positions of the robots for each turn
- `last_solution` holds the last solution of a search call
  (Note that callbacks cannot return values directly)
- `undo_external` holds a list containing the current goal and starting positions to be cleared upon the next step
- `horizon` holds the maximum number of moves to find a solution
- `ctl` holds the actual object providing an interface to the grounder and solver; it holds all state information necessary for multi-shot solving

Potassco

Ricochet Robot Player
Setup and control loop

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

Setup and control loop

```
horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]),
             Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]),
             Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]),
             Fun("goal",  [4]),
             Fun("goal",  [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

1. Initializing variables
2. Creating a player object (wrapping a *clingo* object)
3. Playing in rounds

Potassco

Setup and control loop

```
>> horizon   = 15
>> encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
>> positions = [Fun("pos", [Fun("red"),     1,  1]),
>>              Fun("pos", [Fun("blue"),    1, 16]),
>>              Fun("pos", [Fun("green"),  16,  1]),
>>              Fun("pos", [Fun("yellow"), 16, 16])]
>> sequence  = [Fun("goal", [13]),
>>              Fun("goal",  [4]),
>>              Fun("goal",  [7])]
```

```
player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

1. Initializing variables
2. Creating a player object (wrapping a *clingo* object)
3. Playing in rounds

Potassco

Setup and control loop

```
   horizon   = 15
   encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
   positions = [Fun("pos", [Fun("red"),     1,  1]),
                Fun("pos", [Fun("blue"),    1, 16]),
                Fun("pos", [Fun("green"),  16,  1]),
                Fun("pos", [Fun("yellow"), 16, 16])]
   sequence  = [Fun("goal", [13]),
                Fun("goal",  [4]),
                Fun("goal",  [7])]

>> player = Player(horizon, positions, encodings)
   for goal in sequence:
       print player.solve(goal)
```

1. Initializing variables
2. Creating a player object (wrapping a *clingo* object)
3. Playing in rounds

Potassco

Setup and control loop

```
   horizon   = 15
   encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
   positions = [Fun("pos", [Fun("red"),     1,  1]),
                Fun("pos", [Fun("blue"),    1, 16]),
                Fun("pos", [Fun("green"),  16,  1]),
                Fun("pos", [Fun("yellow"), 16, 16])]
   sequence  = [Fun("goal", [13]),
                Fun("goal",  [4]),
                Fun("goal",  [7])]

   player = Player(horizon, positions, encodings)
>> for goal in sequence:
>>     print player.solve(goal)
```

1. Initializing variables
2. Creating a player object (wrapping a *clingo* object)
3. Playing in rounds

Potassco

Setup and control loop

```
horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]),
             Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]),
             Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]),
             Fun("goal",  [4]),
             Fun("goal",  [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

1. Initializing variables
2. Creating a player object (wrapping a *clingo* object)
3. Playing in rounds

Potassco

Ricochet Robot Player

__init__

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

__init__

```
def __init__(self, horizon, positions, files):
    self.last_positions = positions
    self.last_solution = None
    self.undo_external = []
    self.horizon = horizon
    self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
    for x in files:
        self.ctl.load(x)
    self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

__init__

```
    def __init__(self, horizon, positions, files):
>>      self.last_positions = positions
>>      self.last_solution = None
>>      self.undo_external = []
>>      self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

__init__

```
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
>>      self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

__init__

```
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
>>      for x in files:
>>          self.ctl.load(x)
        self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

__init__

```
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
>>      self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

__init__

```
def __init__(self, horizon, positions, files):
    self.last_positions = positions
    self.last_solution = None
    self.undo_external = []
    self.horizon = horizon
    self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
    for x in files:
        self.ctl.load(x)
    self.ctl.ground([("base", [])])
```

1. Initializing variables
2. Creating *clingo* object
3. Loading encoding and instance
4. Grounding encoding and instance

Potassco

Ricochet Robot Player
solve

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

solve

```
def solve(self, goal):
    for x in self.undo_external:
        self.ctl.assign_external(x, False)
    self.undo_external = []
    for x in self.last_positions + [goal]:
        self.ctl.assign_external(x, True)
        self.undo_external.append(x)
    self.last_solution = None
    self.ctl.solve(on_model=self.on_model)
    return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

solve

```
    def solve(self, goal):
>>          for x in self.undo_external:
>>              self.ctl.assign_external(x, False)
            self.undo_external = []
            for x in self.last_positions + [goal]:
                self.ctl.assign_external(x, True)
                self.undo_external.append(x)
            self.last_solution = None
            self.ctl.solve(on_model=self.on_model)
            return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

solve

```
    def solve(self, goal):
            for x in self.undo_external:
                self.ctl.assign_external(x, False)
>>          self.undo_external = []
>>          for x in self.last_positions + [goal]:
>>              self.ctl.assign_external(x, True)
>>              self.undo_external.append(x)
            self.last_solution = None
            self.ctl.solve(on_model=self.on_model)
            return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

solve

```
    def solve(self, goal):
            for x in self.undo_external:
                self.ctl.assign_external(x, False)
            self.undo_external = []
            for x in self.last_positions + [goal]:
                self.ctl.assign_external(x, True)
                self.undo_external.append(x)
>>          self.last_solution = None
>>          self.ctl.solve(on_model=self.on_model)
>>          return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

solve

```
def solve(self, goal):
    for x in self.undo_external:
        self.ctl.assign_external(x, False)
    self.undo_external = []
    for x in self.last_positions + [goal]:
        self.ctl.assign_external(x, True)
        self.undo_external.append(x)
    self.last_solution = None
    self.ctl.solve(on_model=self.on_model)
    return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

solve

```
def solve(self, goal):
    for x in self.undo_external:
        self.ctl.assign_external(x, False)
    self.undo_external = []
    for x in self.last_positions + [goal]:
        self.ctl.assign_external(x, True)
        self.undo_external.append(x)
    self.last_solution = None
    self.ctl.solve(on_model=self.on_model)
    return self.last_solution
```

1. Unsetting previous external atoms (viz. previous goal and positions)
2. Setting next external atoms (viz. next goal and positions)
3. Computing next stable model
   by passing user-defined `on_model` method

Potassco

Ricochet Robot Player
on_model

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

on_model

```
def on_model(self, model):
      self.last_solution = model.atoms()
      self.last_positions = []
      for atom in model.atoms(Model.ATOMS):
          if (atom.name() == "pos" and
                  len(atom.args()) == 4 and
                  atom.args()[3] == self.horizon):
              self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

on_model

```
    def on_model(self, model):
>>          self.last_solution = model.atoms()
            self.last_positions = []
            for atom in model.atoms(Model.ATOMS):
                if (atom.name() == "pos" and
                        len(atom.args()) == 4 and
                        atom.args()[3] == self.horizon):
                    self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

on_model

```
    def on_model(self, model):
          self.last_solution = model.atoms()
>>        self.last_positions = []
>>        for atom in model.atoms(Model.ATOMS):
>>            if (atom.name() == "pos" and
>>                    len(atom.args()) == 4 and
>>                    atom.args()[3] == self.horizon):
>>                self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

on_model

```
    def on_model(self, model):
          self.last_solution = model.atoms()
>>        self.last_positions = []
>>        for atom in model.atoms(Model.ATOMS):
>>            if (atom.name() == "pos" and
>>                    len(atom.args()) == 4 and
>>                    atom.args()[3] == self.horizon):
>>                self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

on_model

```
def on_model(self, model):
      self.last_solution = model.atoms()
      self.last_positions = []
      for atom in model.atoms(Model.ATOMS):
          if (atom.name() == "pos" and
                  len(atom.args()) == 4 and
                  atom.args()[3] == self.horizon):
              self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

on_model

```
def on_model(self, model):
      self.last_solution = model.atoms()
      self.last_positions = []
      for atom in model.atoms(Model.ATOMS):
          if (atom.name() == "pos" and
                  len(atom.args()) == 4 and
                  atom.args()[3] == self.horizon):
              self.last_positions.append(Fun("pos", atom.args()[:-1]))
```

1. Storing stable model
2. Extracting atoms (viz. last robot positions)
   by adding `pos(R,X,Y)` for each `pos(R,X,Y,horizon)`

Potassco

ricochet.py

```
from gringo import Control, Model, Fun

class Player:
    def __init__(self, horizon, positions, files):
        self.last_positions = positions
        self.last_solution = None
        self.undo_external = []
        self.horizon = horizon
        self.ctl = Control(['-c', 'horizon={0}'.format(self.horizon)])
        for x in files:
            self.ctl.load(x)
        self.ctl.ground([("base", [])])

    def solve(self, goal):
        for x in self.undo_external:
            self.ctl.assign_external(x, False)
        self.undo_external = []
        for x in self.last_positions + [goal]:
            self.ctl.assign_external(x, True)
            self.undo_external.append(x)
        self.last_solution = None
        self.ctl.solve(on_model=self.on_model)
        return self.last_solution

    def on_model(self, model):
        self.last_solution = model.atoms()
        self.last_positions = []
        for atom in model.atoms(Model.ATOMS):
            if (atom.name() == "pos" and len(atom.args()) == 4 and atom.args()[3] == self.horizon):
                self.last_positions.append(Fun("pos", atom.args()[:-1]))

horizon   = 15
encodings = ["board.lp", "targets.lp", "ricochet.lp", "optimization.lp"]
positions = [Fun("pos", [Fun("red"),     1,  1]), Fun("pos", [Fun("blue"),    1, 16]),
             Fun("pos", [Fun("green"),  16,  1]), Fun("pos", [Fun("yellow"), 16, 16])]
sequence  = [Fun("goal", [13]), Fun("goal", [4]), Fun("goal", [7])]

player = Player(horizon, positions, encodings)
for goal in sequence:
    print player.solve(goal)
```

Potassco

Let's play!

```
$ python ricochet.py
[move(red,0,1,1), move(yellow,-1,0,14), move(yellow,-1,0,12), move(yellow,-1,0,11),
 move(yellow,-1,0,9), move(red,1,0,7), move(red,1,0,2), move(yellow,-1,0,10),
 move(yellow,-1,0,13), move(yellow,-1,0,15), move(red,-1,0,4), move(yellow,0,-1,6),
 move(red,0,1,3), move(red,0,1,5), move(yellow,0,1,8)]
[move(blue,0,1,15), move(blue,0,1,11), move(blue,0,1,8), move(blue,0,1,3),
 move(blue,1,0,2), move(blue,0,1,9), move(blue,-1,0,7), move(blue,0,1,10),
 move(blue,0,1,13), move(blue,-1,0,4), move(blue,0,-1,1), move(blue,0,-1,6),
 move(green,-1,0,5), move(blue,0,1,12), move(blue,0,1,14)]
[move(green,1,0,15), move(green,1,0,8), move(green,1,0,5), move(green,1,0,4),
 move(green,1,0,3), move(green,1,0,10), move(green,1,0,7), move(green,1,0,12),
 move(green,1,0,9), move(green,1,0,2), move(green,1,0,11), move(green,1,0,13),
 move(green,1,0,6), move(green,1,0,14), move(green,0,1,1)]

$ python robotviz
```

Potassco

Let's play!

```
$ python ricochet.py
[move(red,0,1,1), move(yellow,-1,0,14), move(yellow,-1,0,12), move(yellow,-1,0,11),
 move(yellow,-1,0,9), move(red,1,0,7), move(red,1,0,2), move(yellow,-1,0,10),
 move(yellow,-1,0,13), move(yellow,-1,0,15), move(red,-1,0,4), move(yellow,0,-1,6),
 move(red,0,1,3), move(red,0,1,5), move(yellow,0,1,8)]
[move(blue,0,1,15), move(blue,0,1,11), move(blue,0,1,8), move(blue,0,1,3),
 move(blue,1,0,2), move(blue,0,1,9), move(blue,-1,0,7), move(blue,0,1,10),
 move(blue,0,1,13), move(blue,-1,0,4), move(blue,0,-1,1), move(blue,0,-1,6),
 move(green,-1,0,5), move(blue,0,1,12), move(blue,0,1,14)]
[move(green,1,0,15), move(green,1,0,8), move(green,1,0,5), move(green,1,0,4),
 move(green,1,0,3), move(green,1,0,10), move(green,1,0,7), move(green,1,0,12),
 move(green,1,0,9), move(green,1,0,2), move(green,1,0,11), move(green,1,0,13),
 move(green,1,0,6), move(green,1,0,14), move(green,0,1,1)]

$ python robotviz
```

Potassco

Let's play!

```
$ python ricochet.py
[move(red,0,1,1), move(yellow,-1,0,14), move(yellow,-1,0,12), move(yellow,-1,0,11),
 move(yellow,-1,0,9), move(red,1,0,7), move(red,1,0,2), move(yellow,-1,0,10),
 move(yellow,-1,0,13), move(yellow,-1,0,15), move(red,-1,0,4), move(yellow,0,-1,6),
 move(red,0,1,3), move(red,0,1,5), move(yellow,0,1,8)]
[move(blue,0,1,15), move(blue,0,1,11), move(blue,0,1,8), move(blue,0,1,3),
 move(blue,1,0,2), move(blue,0,1,9), move(blue,-1,0,7), move(blue,0,1,10),
 move(blue,0,1,13), move(blue,-1,0,4), move(blue,0,-1,1), move(blue,0,-1,6),
 move(green,-1,0,5), move(blue,0,1,12), move(blue,0,1,14)]
[move(green,1,0,15), move(green,1,0,8), move(green,1,0,5), move(green,1,0,4),
 move(green,1,0,3), move(green,1,0,10), move(green,1,0,7), move(green,1,0,12),
 move(green,1,0,9), move(green,1,0,2), move(green,1,0,11), move(green,1,0,13),
 move(green,1,0,6), move(green,1,0,14), move(green,0,1,1)]

$ python robotviz
```

Potassco

Outline

1 Multi-shot ASP Solving

2 Ricochet Robots

3 Demonstration

4 Summary

Potassco

Just do it!

Potassco

Outline

1 Multi-shot ASP Solving

2 Ricochet Robots

3 Demonstration

4 Summary

Potassco

Summary

- Case-study is an exemplar for the interplay of ASP and Python
- Illustration of *clingo* 4 approach

- `http://potassco.sourceforge.net`
  - ☞ gringo/clingo distribution `/examples/clingo/robots/`

Potassco