

BDI on Time

“the future of BDI is in the future”

end of May 2023

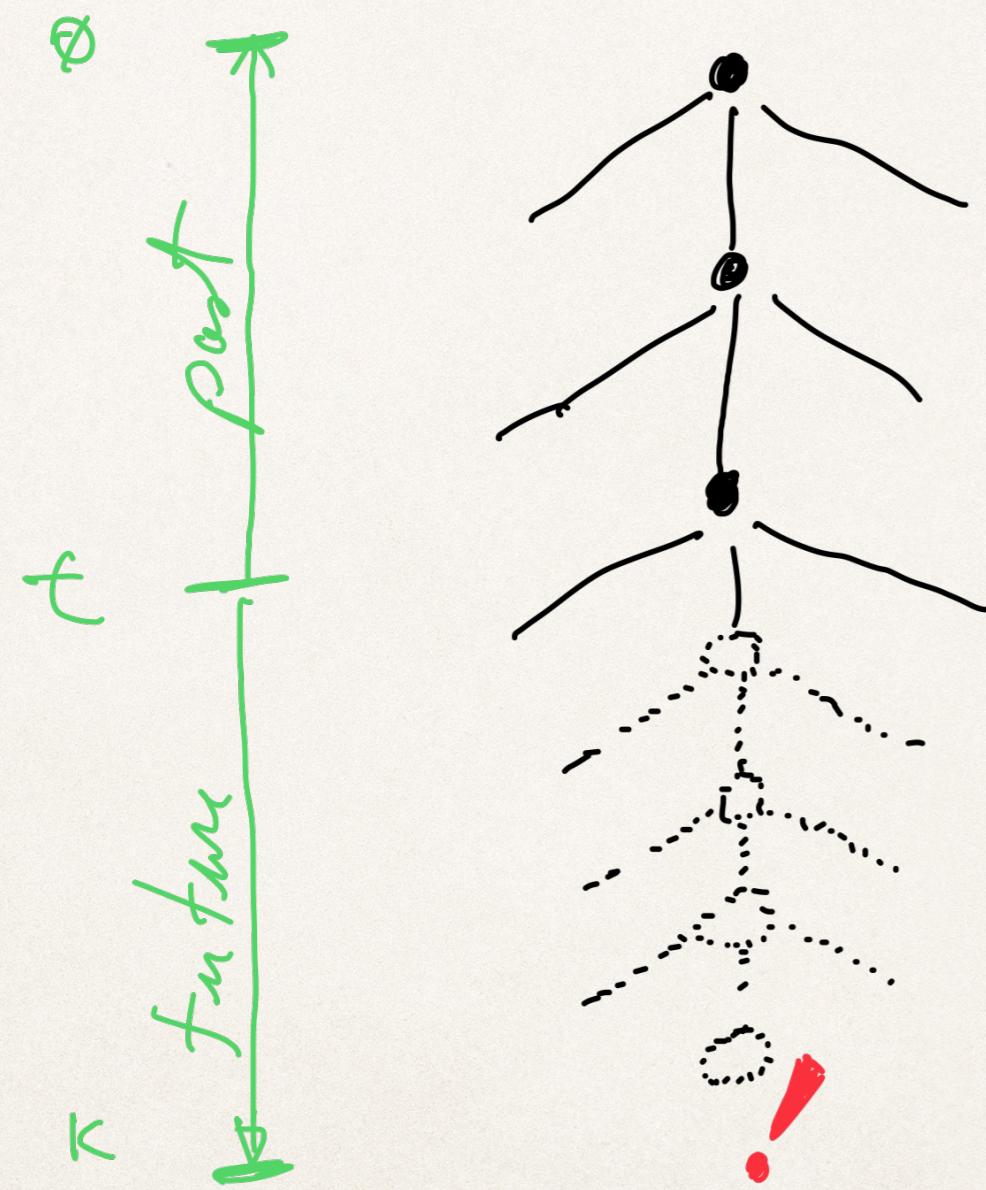
Agenda

- ✿ simulating the future
- ✿ agent deliberation based on future
- ✿ (initial) experiments
- ✿ single & multi-agent

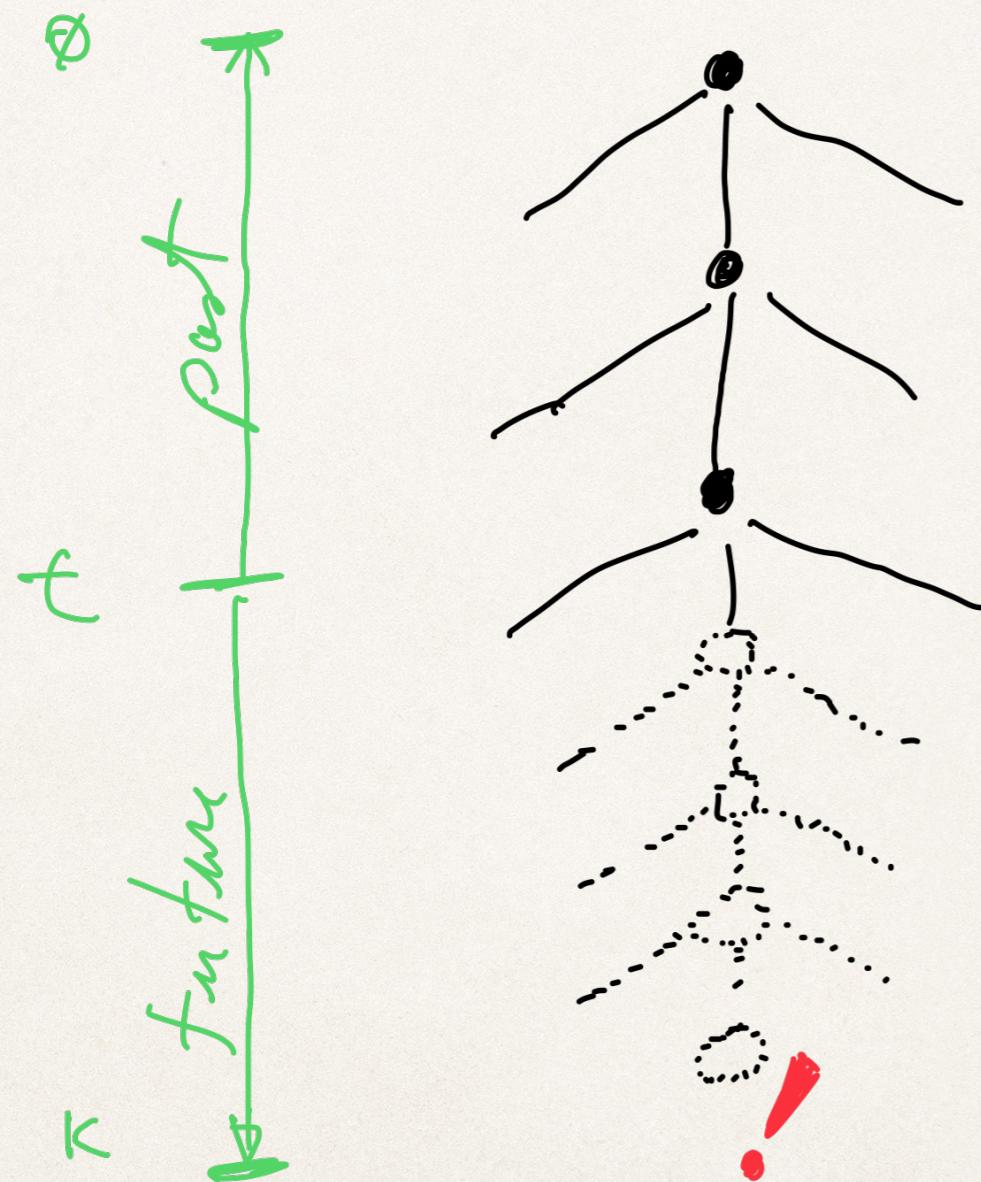
Motivations To Consider Future & BDI

- ✿ BDI agents may do better (rational) decisions by *looking ahead*
- ✿ Foresee problems
- ✿ Realize better options
- ✿ ...

Future Simulation



Future Simulation



environment transitions

$$e : S \times A \rightarrow S$$

agent policy (as ordered options)

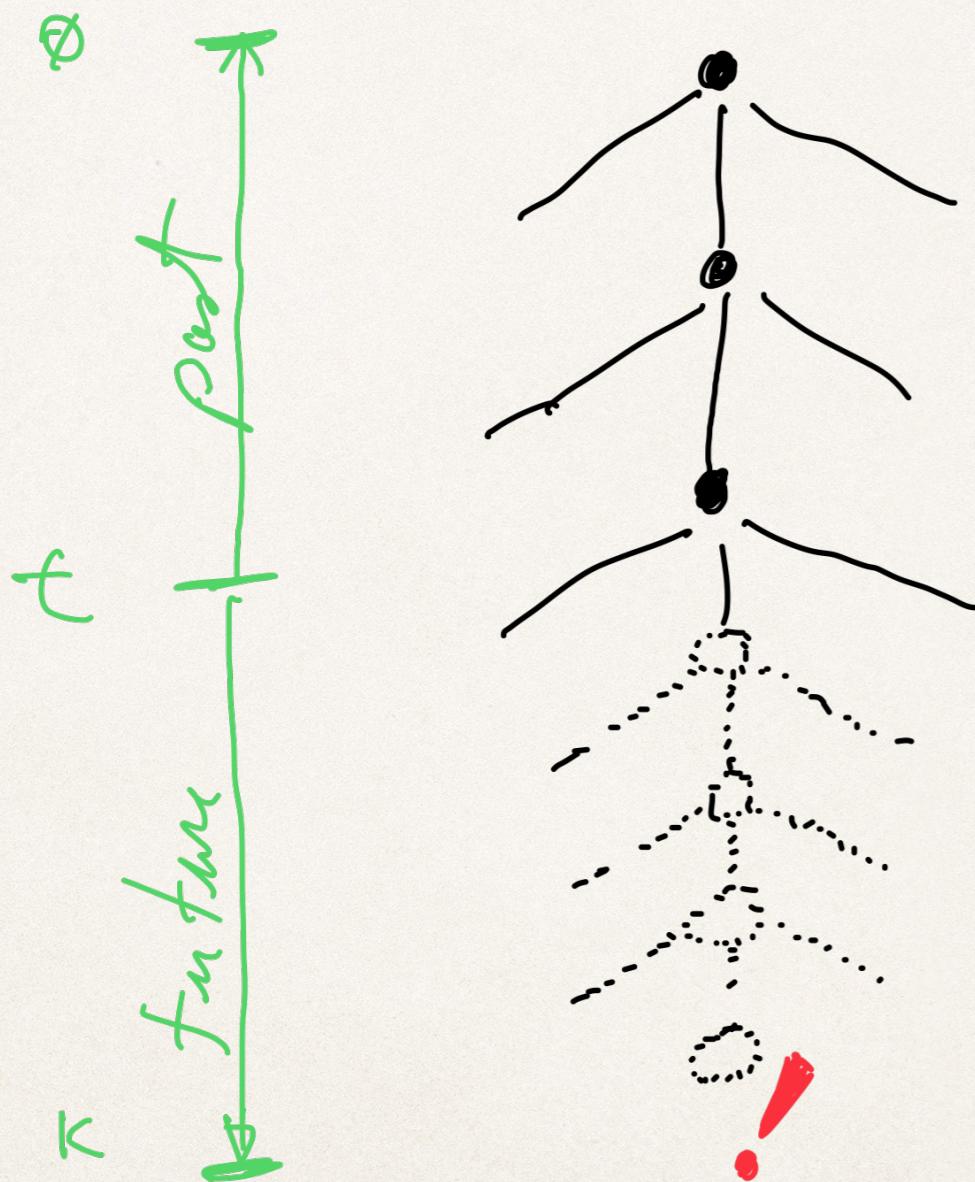
$$\pi : S \rightarrow A^n$$

future state at k

$$f : S \times \mathbb{N} \times \mathbb{N} \rightarrow S$$

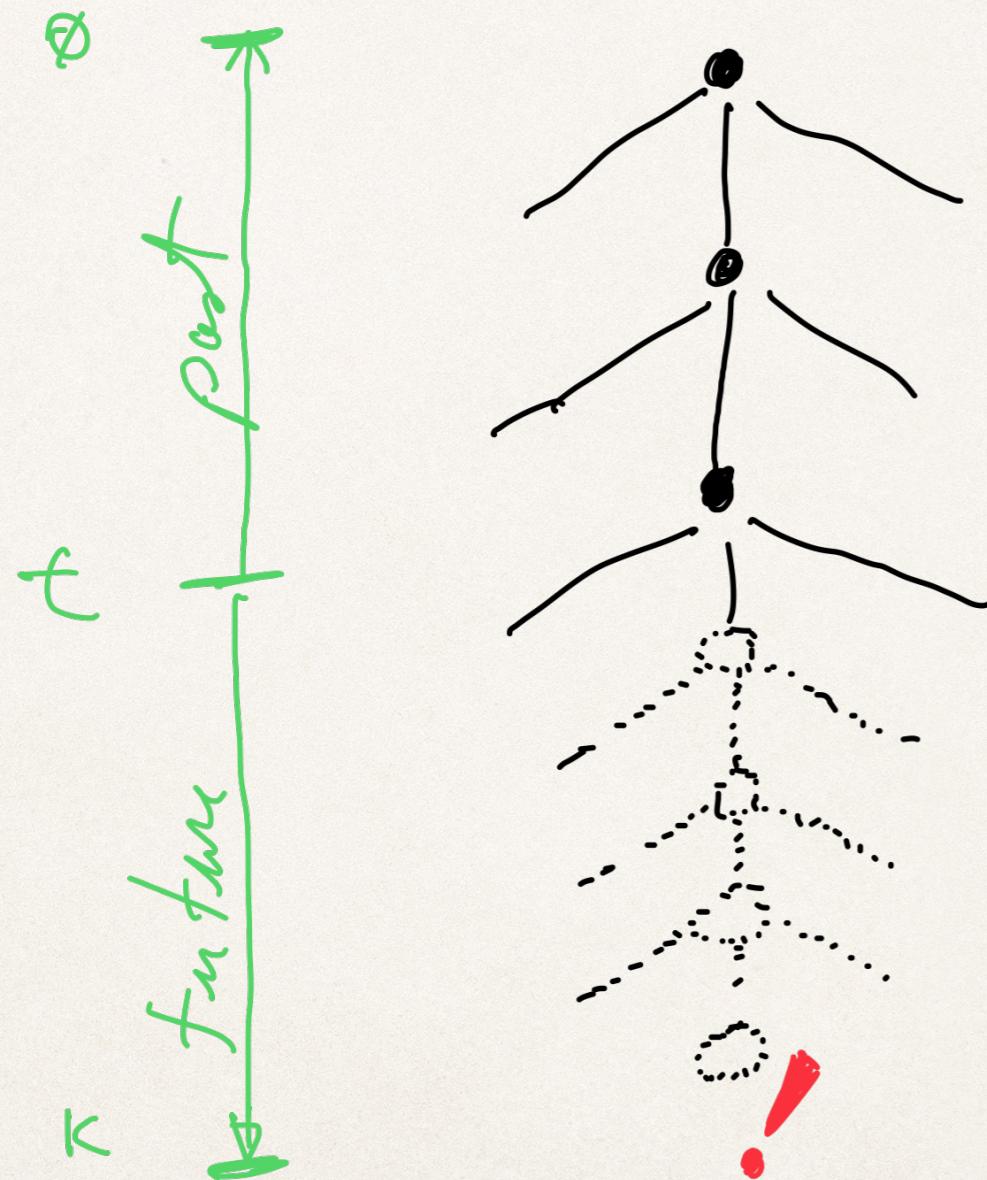
$$f(s, t, k) = \begin{cases} s & \text{if } t = k \\ f(e(s, \pi(s)_1), t + 1, k) & \text{if } t < k \end{cases}$$

Types of Problem



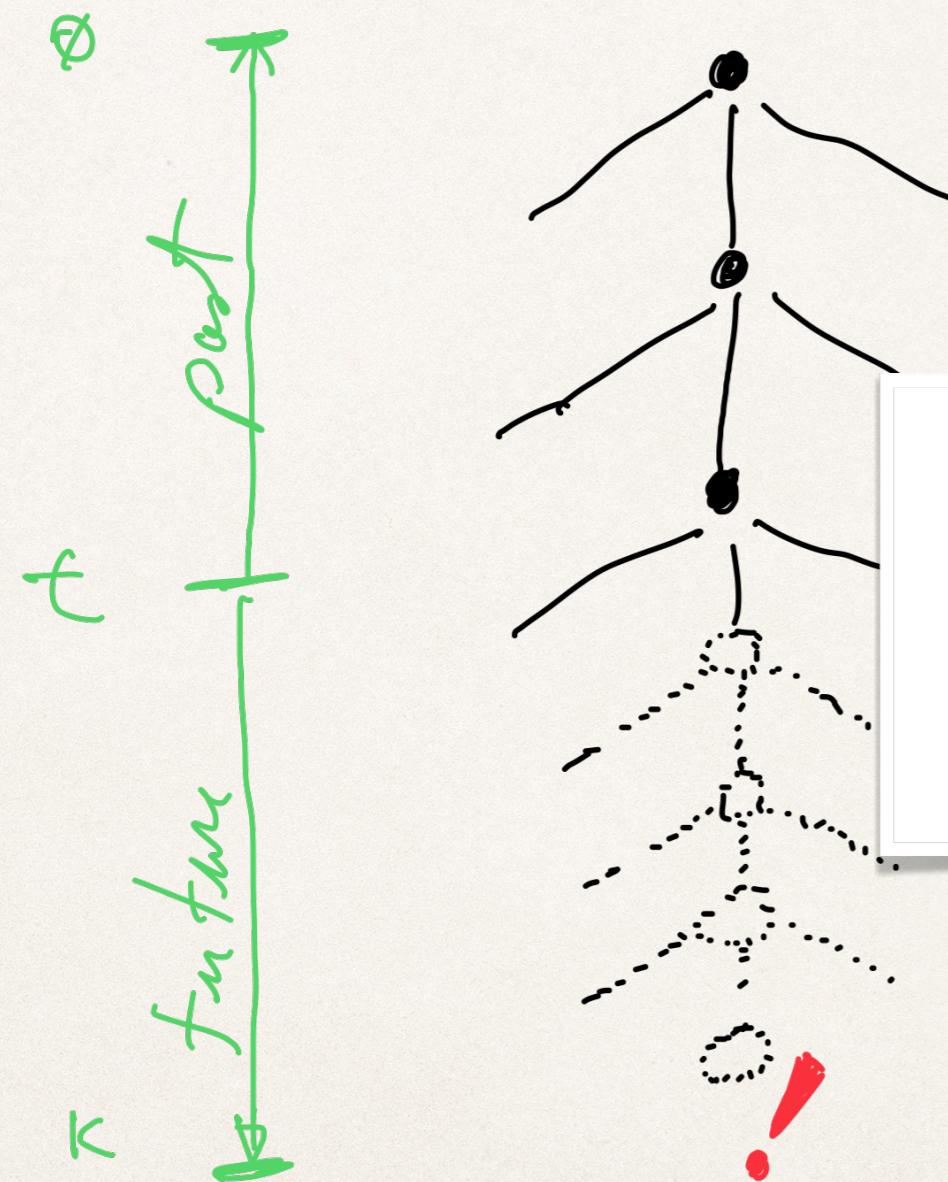
- internal:
 - no option, goal not achieved
 - norm / principle violation
 - ethical issues
- external:
 - undesired state
 - ethical issues
- ...

What To Do?



- stop
- reconsider options
 - now (t)
 - near the problem (k)
 - in the past ($0..t$)
(requires backtrack of actions)
- give up the intention

What To Do?



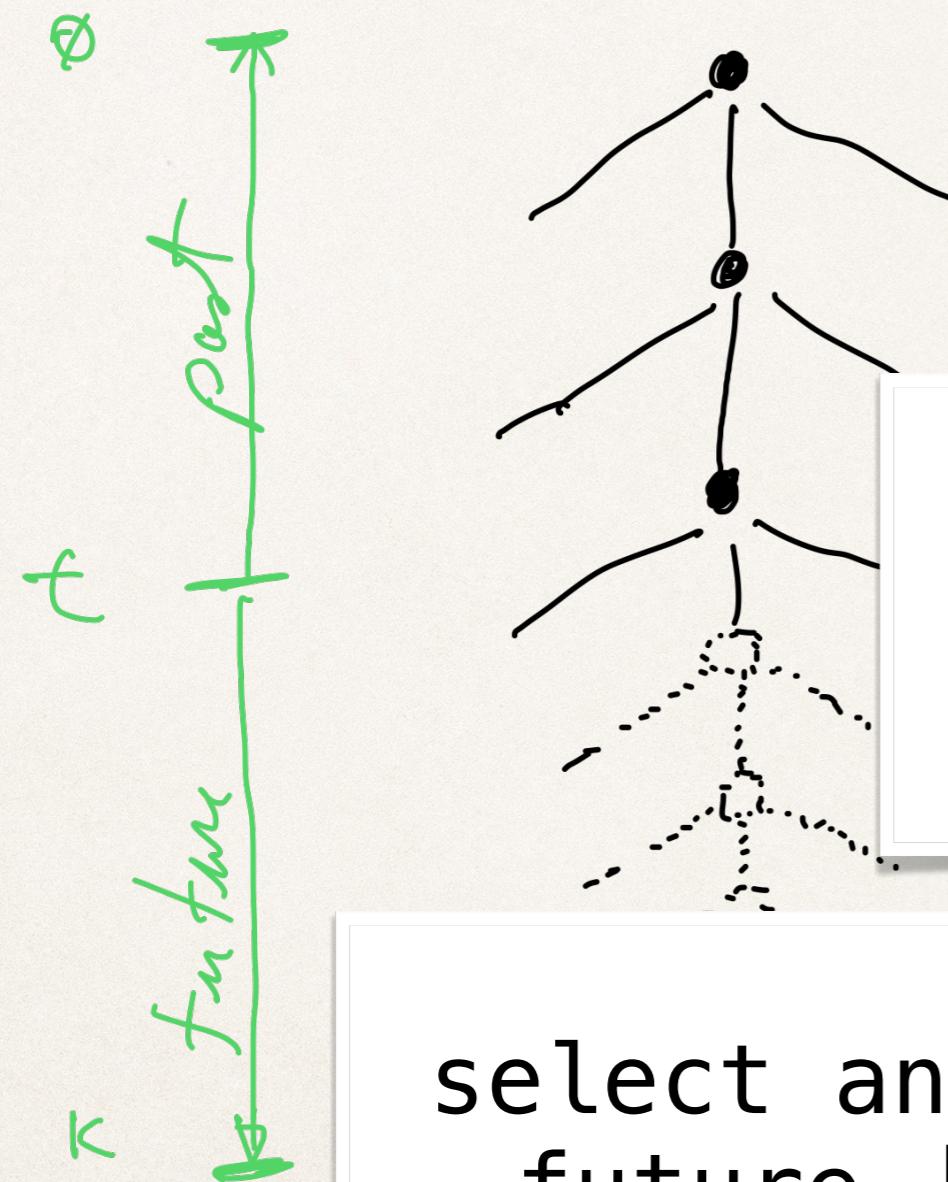
- stop
- reconsider options

what caused the problem?
[very difficult to answer]
[I will skip that]

actions)

- give up the intention

What To Do?

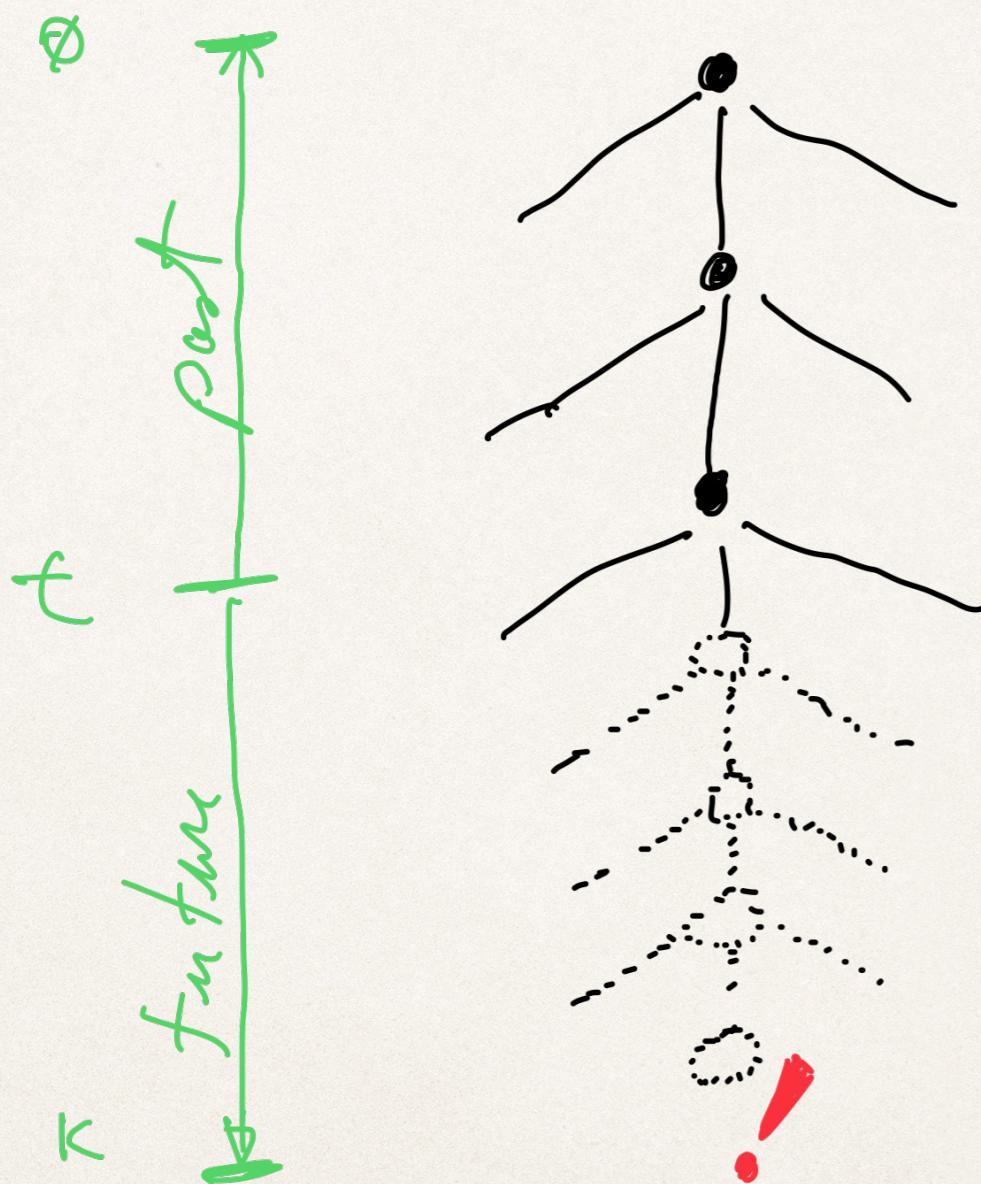


- stop
- reconsider options

what caused the problem?
[very difficult to answer]
[I will skip that]

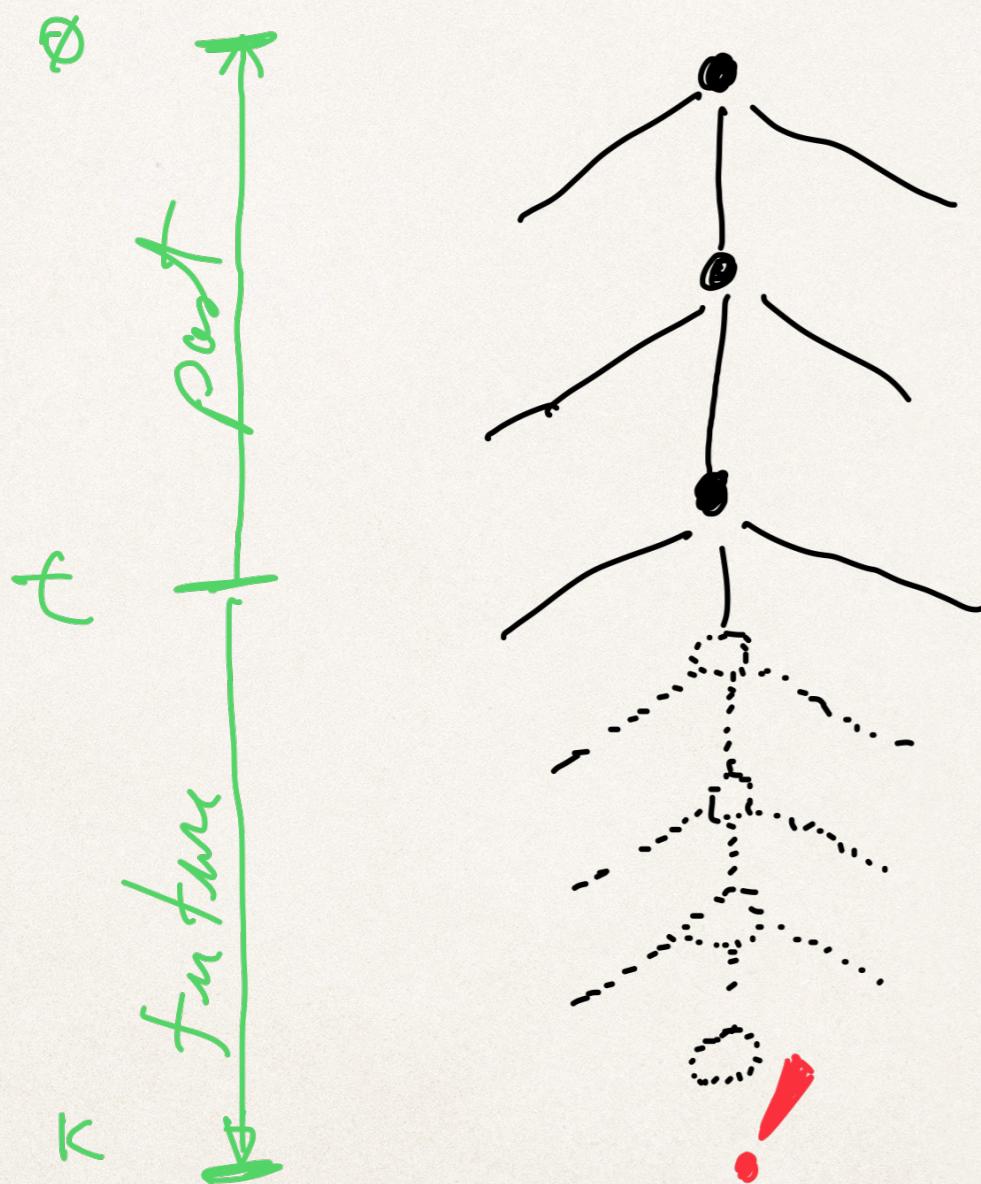
select an option with “nice”
future [without problems]

(Initial) Delimitations



- revise options from now on ($t..k$)
- what option?
[revision strategy]

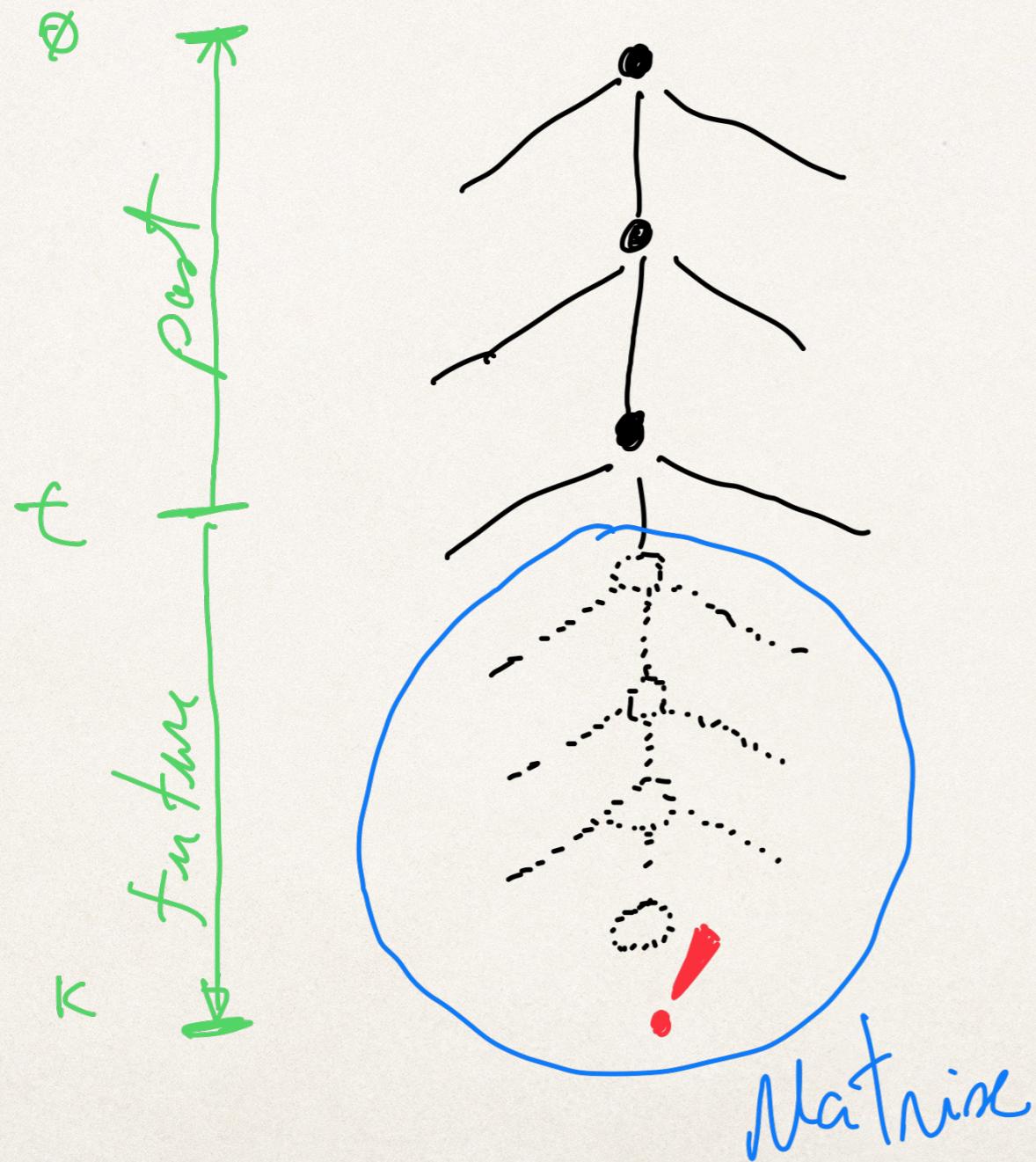
(Initial) Delimitations



- revise options from now on ($t..k$)
- what option?
[revision strategy]

move to experiments to help to answer

Jason(F)



execution modes:

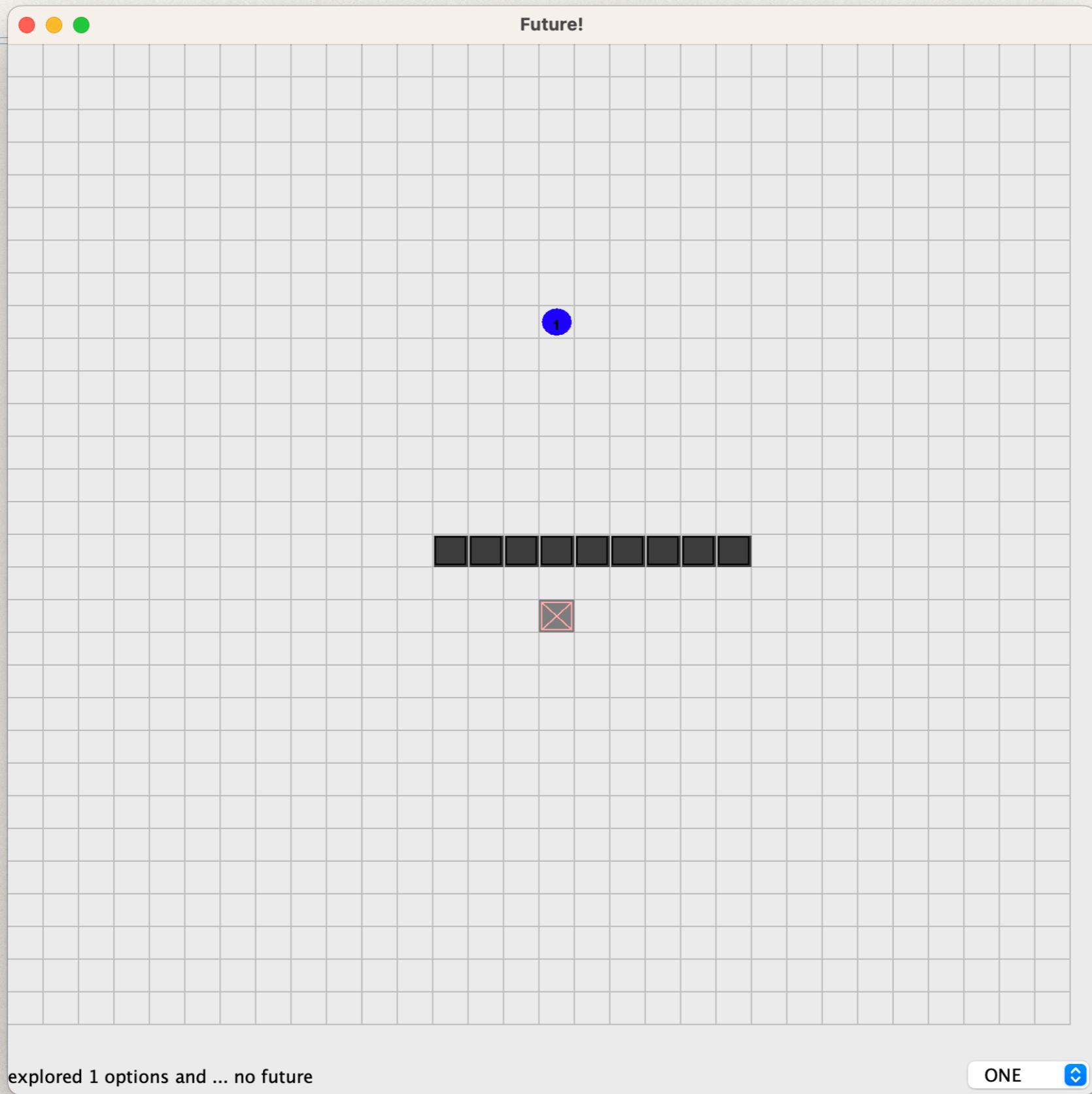
- normal
- **matrix mode**
(simulated environment)

at time t :

- clone itself into another agent
- run it in the matrix
- until success, failure, timeout

branching is given by plan options
[not actions]

Grid Scenario

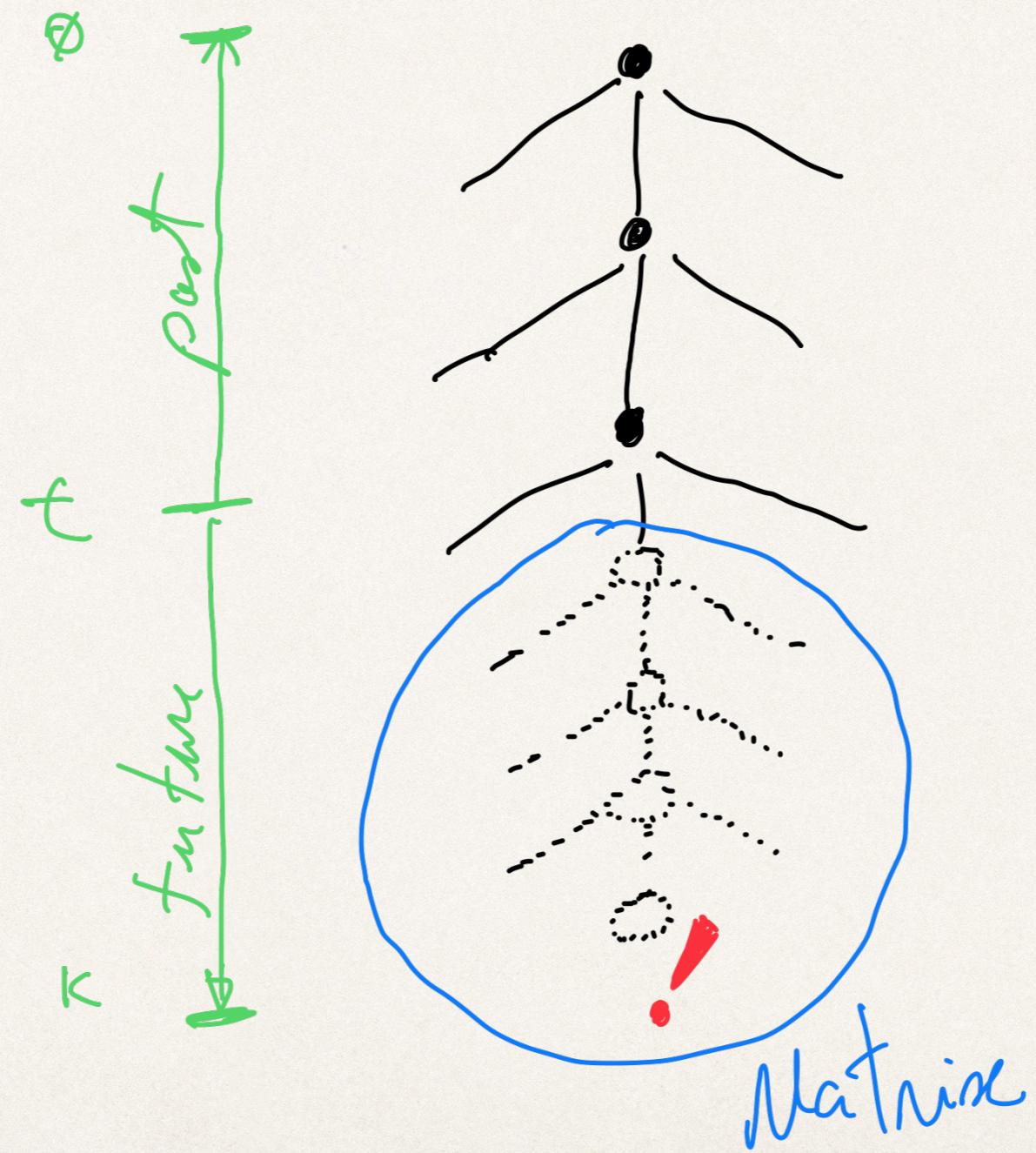


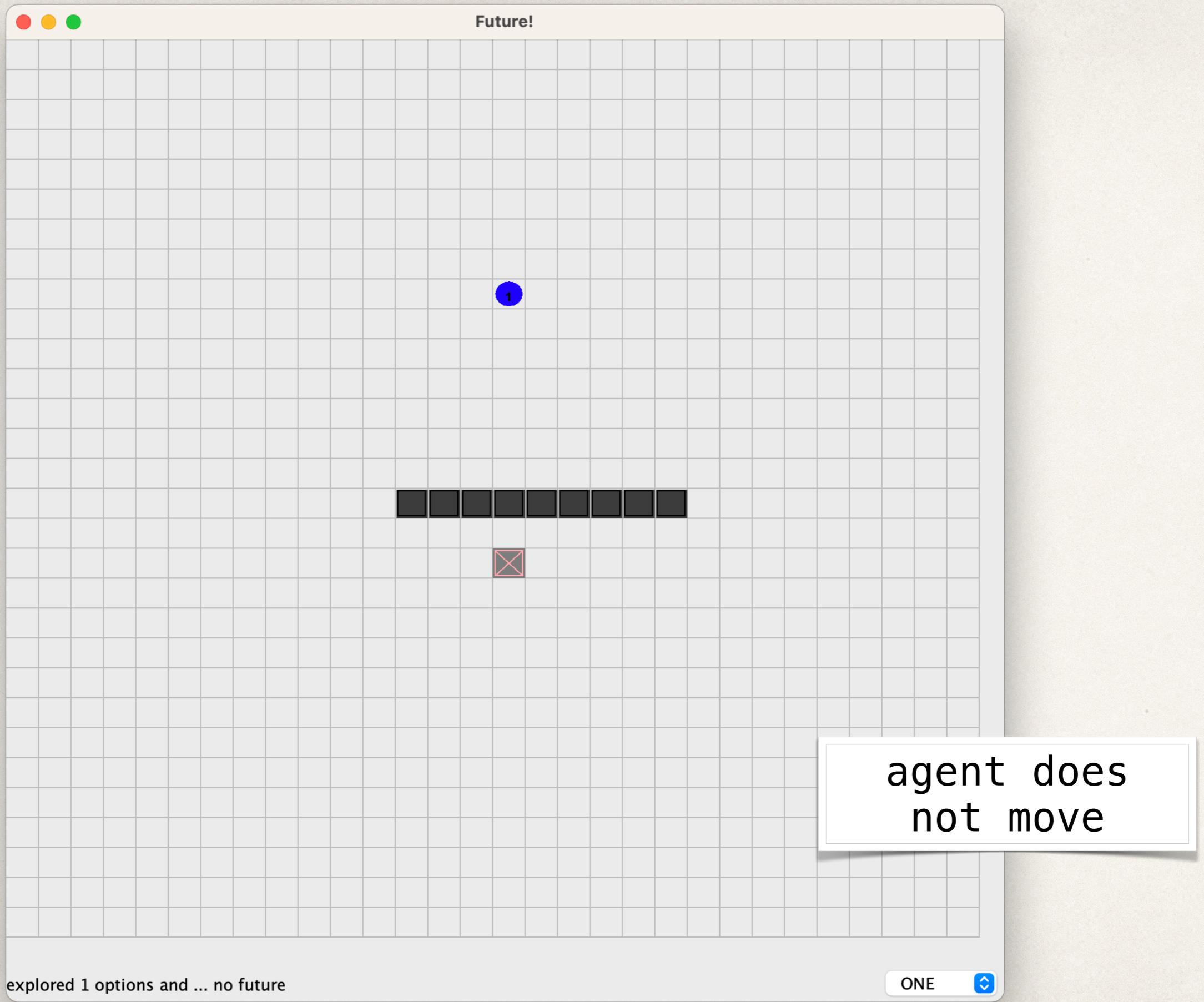
```

5 +destination(X,Y) :- !pos(X,Y). // create a goal when my destination is perceive
6 -destination(X,Y) :- .drop_all_desires. // drop everything if my destination is
7
8 @ [preference(0)] +!pos(X,Y) : pos(X,Y).
9 @s [preference(D)] +!pos(X,Y) : ok(s) & distance(s,D) <- s; !pos(X,Y).
10 @sw[preference(D)] +!pos(X,Y) : ok(sw)& distance(sw,D) <- sw; !pos(X,Y).
11 @se[preference(D)] +!pos(X,Y) : ok(se)& distance(se,D) <- se; !pos(X,Y).
12 @w [preference(D)] +!pos(X,Y) : ok(w) & distance(w,D) <- w; !pos(X,Y).
13 @e [preference(D)] +!pos(X,Y) : ok(e) & distance(e,D) <- e; !pos(X,Y).
14 @n [preference(D)] +!pos(X,Y) : ok(n) & distance(n,D) <- n; !pos(X,Y).
15 @nw[preference(D)] +!pos(X,Y) : ok(nw)& distance(nw,D) <- nw; !pos(X,Y).
16 @ne[preference(D)] +!pos(X,Y) : ok(ne)& distance(ne,D) <- ne; !pos(X,Y).
17
18 // checks if go to some direction is possible (free cell)
19 ok(D) :- next(D,X,Y) & free(X,Y).
20
21 next(s ,X ,Y+1) :- pos(X,Y). // my next location if doing south
22 next(sw,X-1,Y+1) :- pos(X,Y).
23 next(se,X+1,Y+1) :- pos(X,Y).
24 next(w ,X-1,Y ) :- pos(X,Y).
25 next(e ,X+1,Y ) :- pos(X,Y).
26 next(n ,X ,Y-1) :- pos(X,Y).
27 next(nw,X-1,Y-1) :- pos(X,Y).
28 next(ne,X+1,Y-1) :- pos(X,Y).
29
30 free(X,Y) :- X >= 0 & Y >= 0 & w_size(W,H) & X < W & Y < H & not obstacle(X,Y).
31 distance(Dir,Dist) :- next(Dir,X,Y) & destination(GX,GY) &
32 | | | | | Dist = math.sqrt( (X-GX)**2 + (Y-GY)**2 ) .

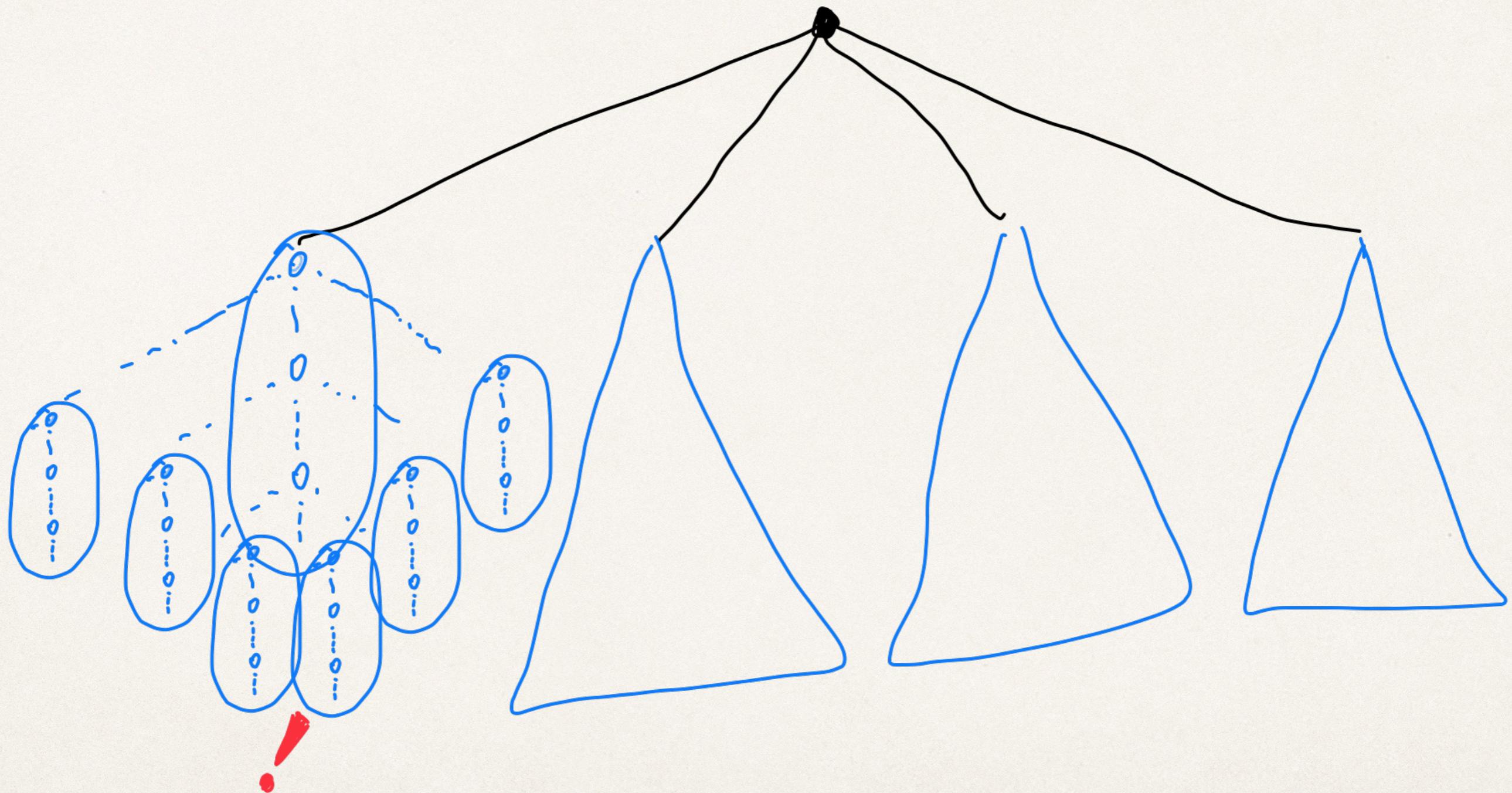
```

Strategy ONE

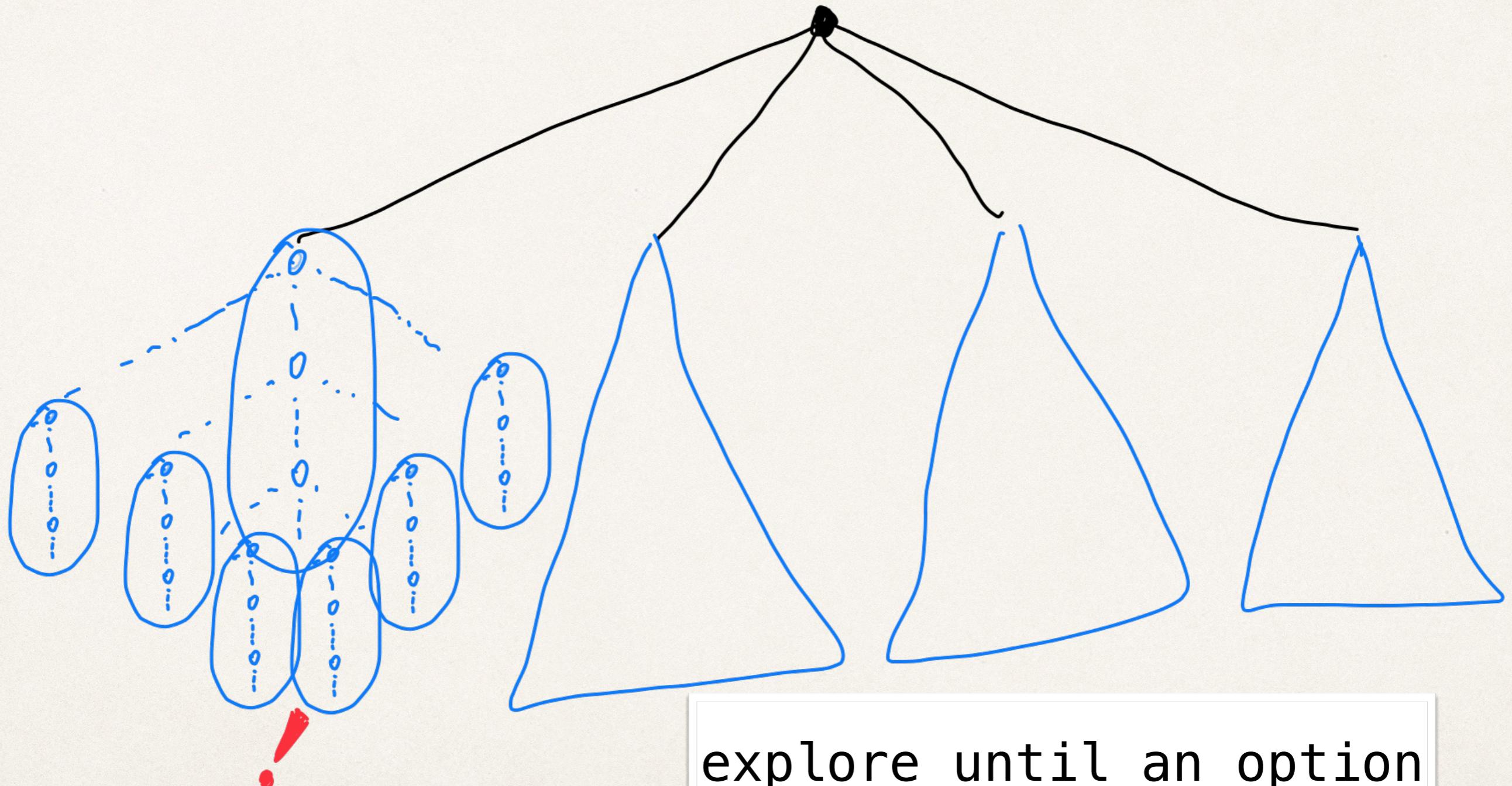




Strategy SOLVE_P – Search Tree

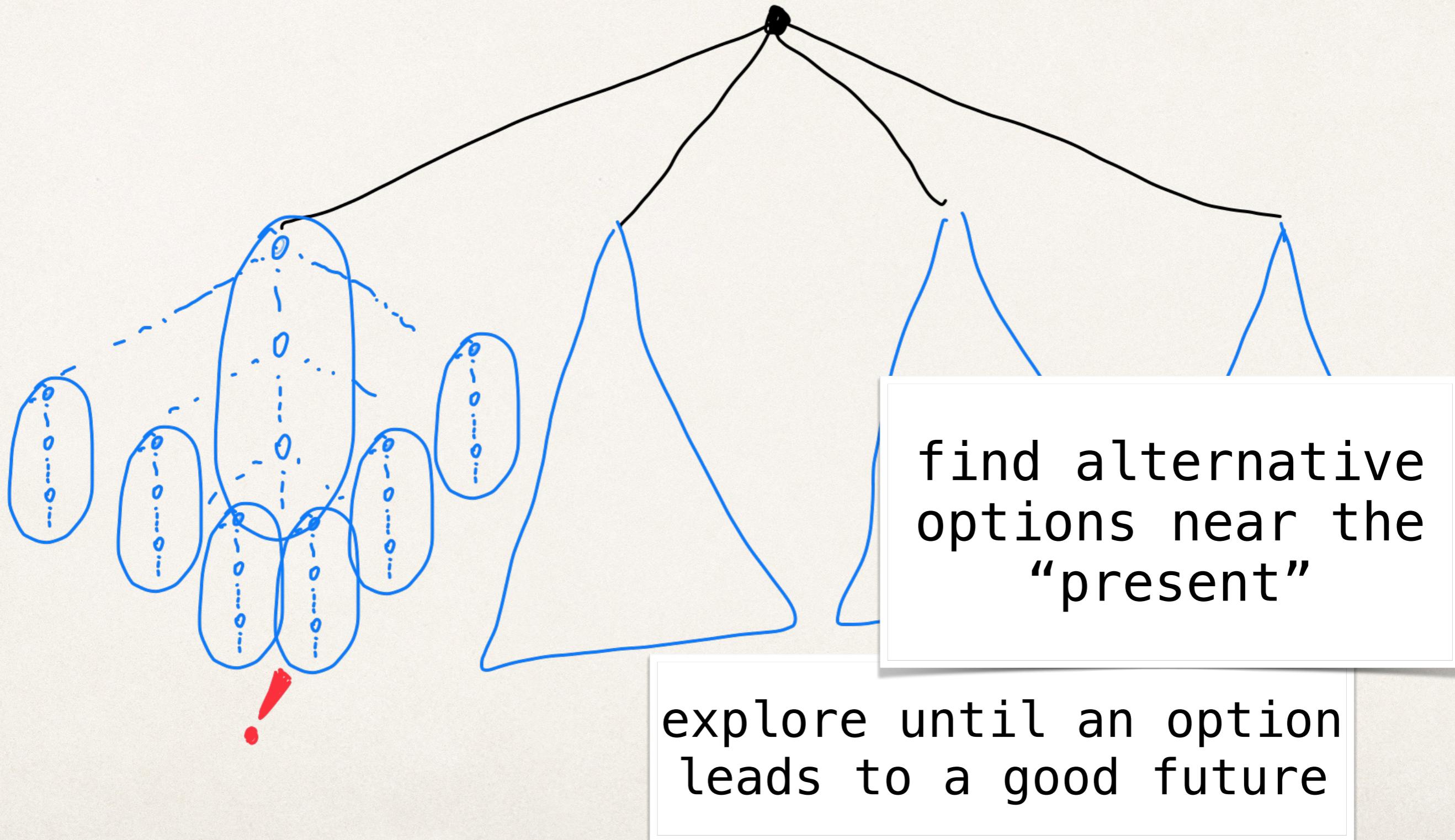


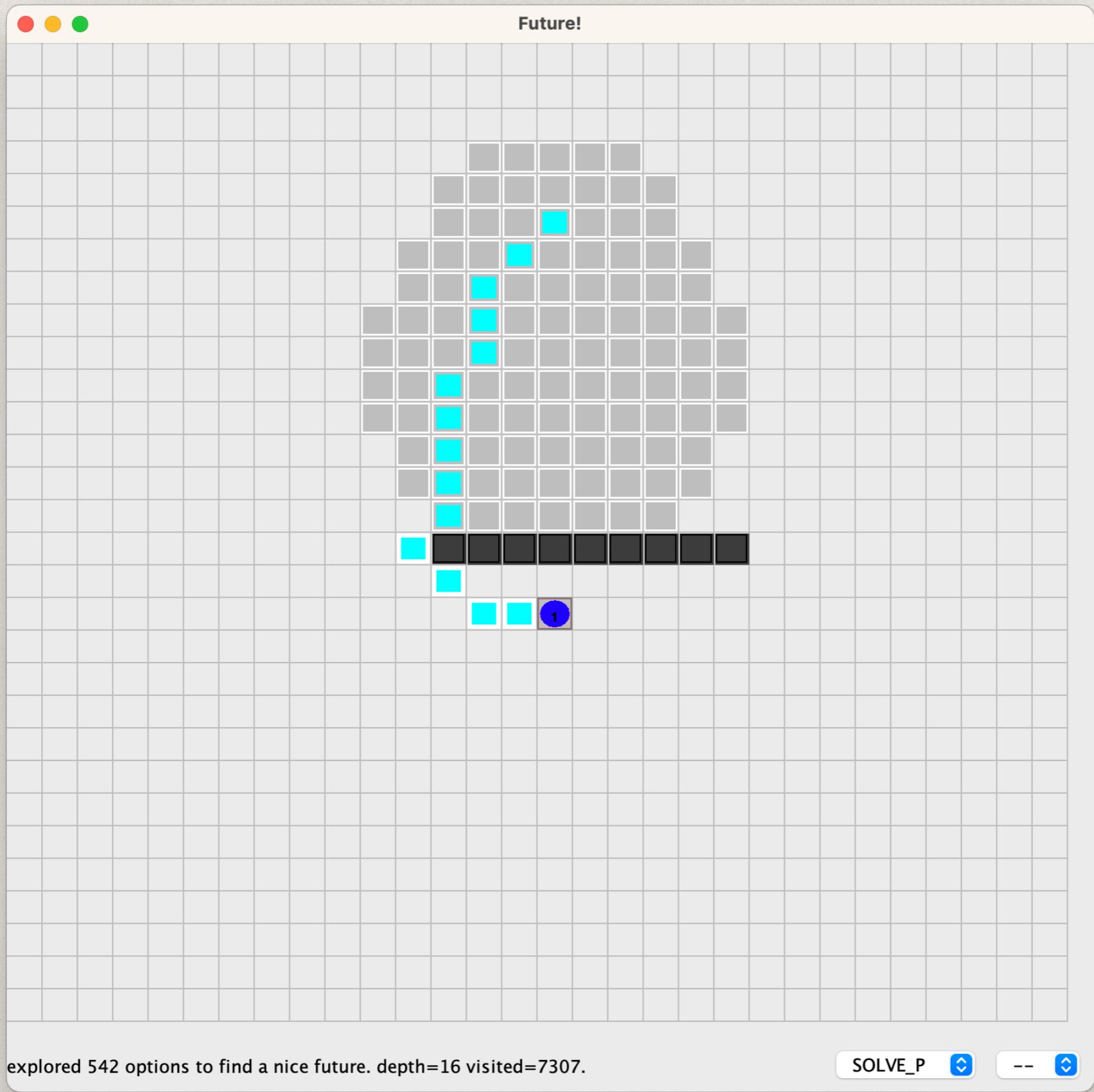
Strategy SOLVE_P – Search Tree

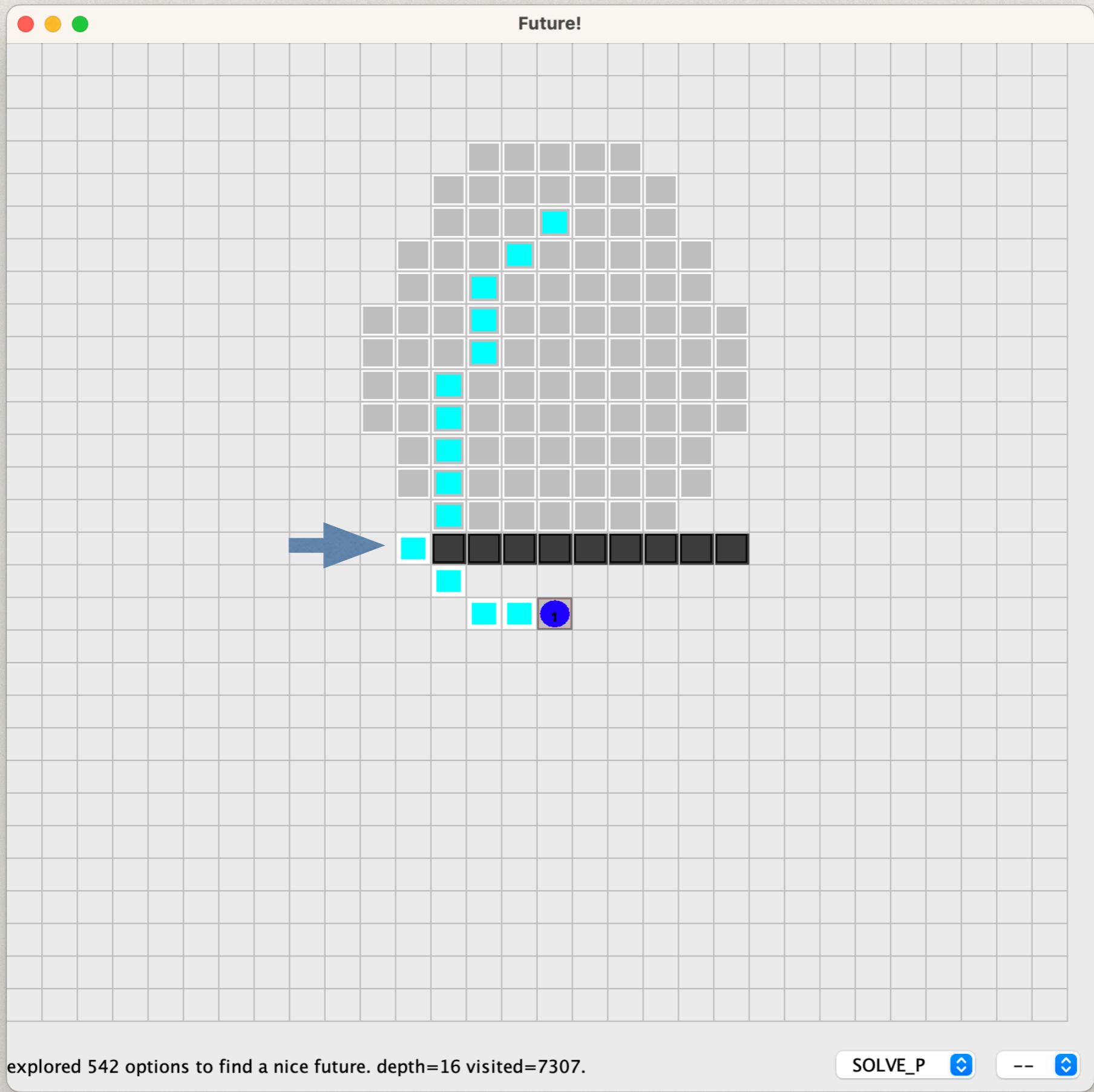


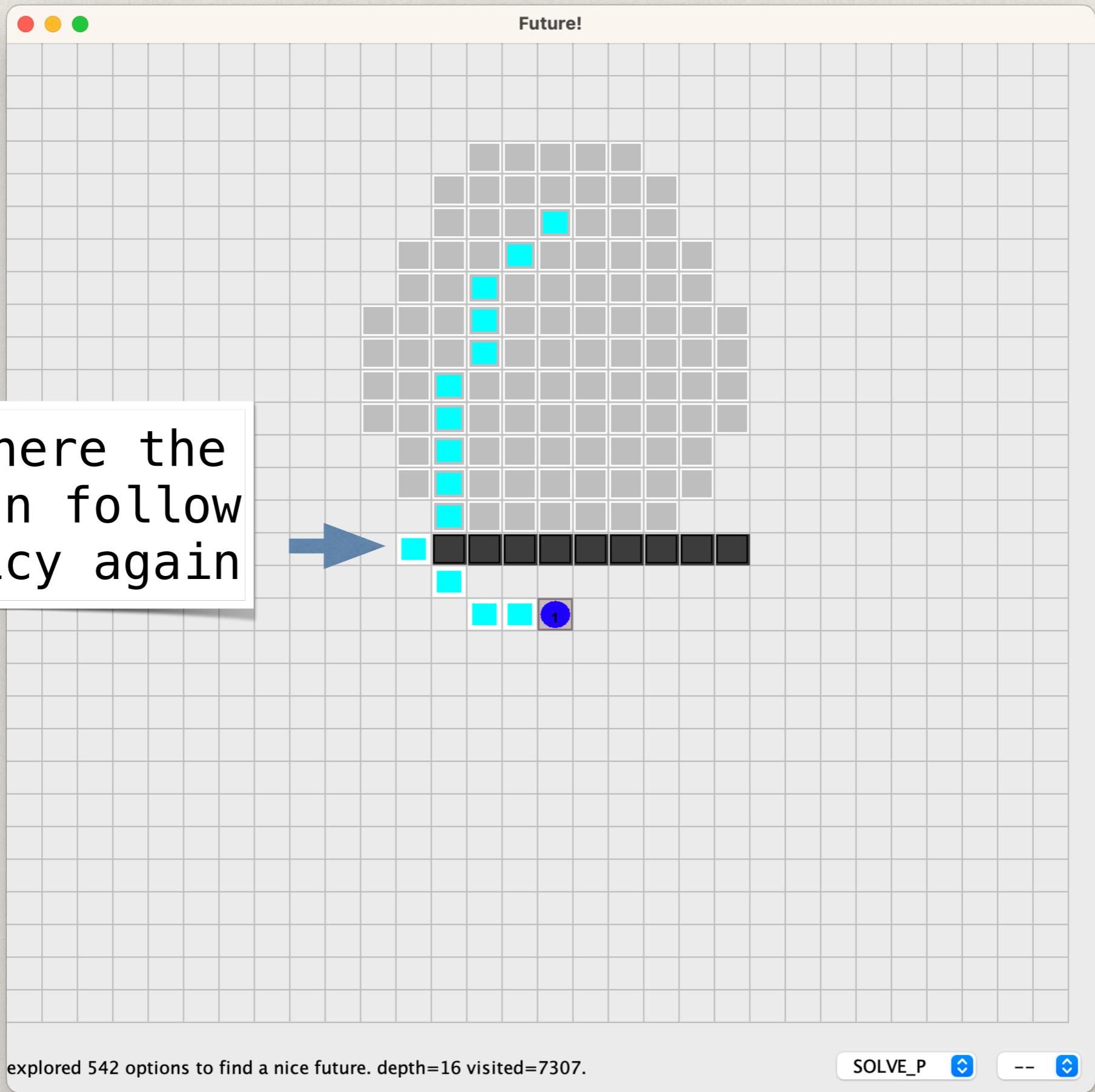
explore until an option
leads to a good future

Strategy SOLVE_P – Search Tree

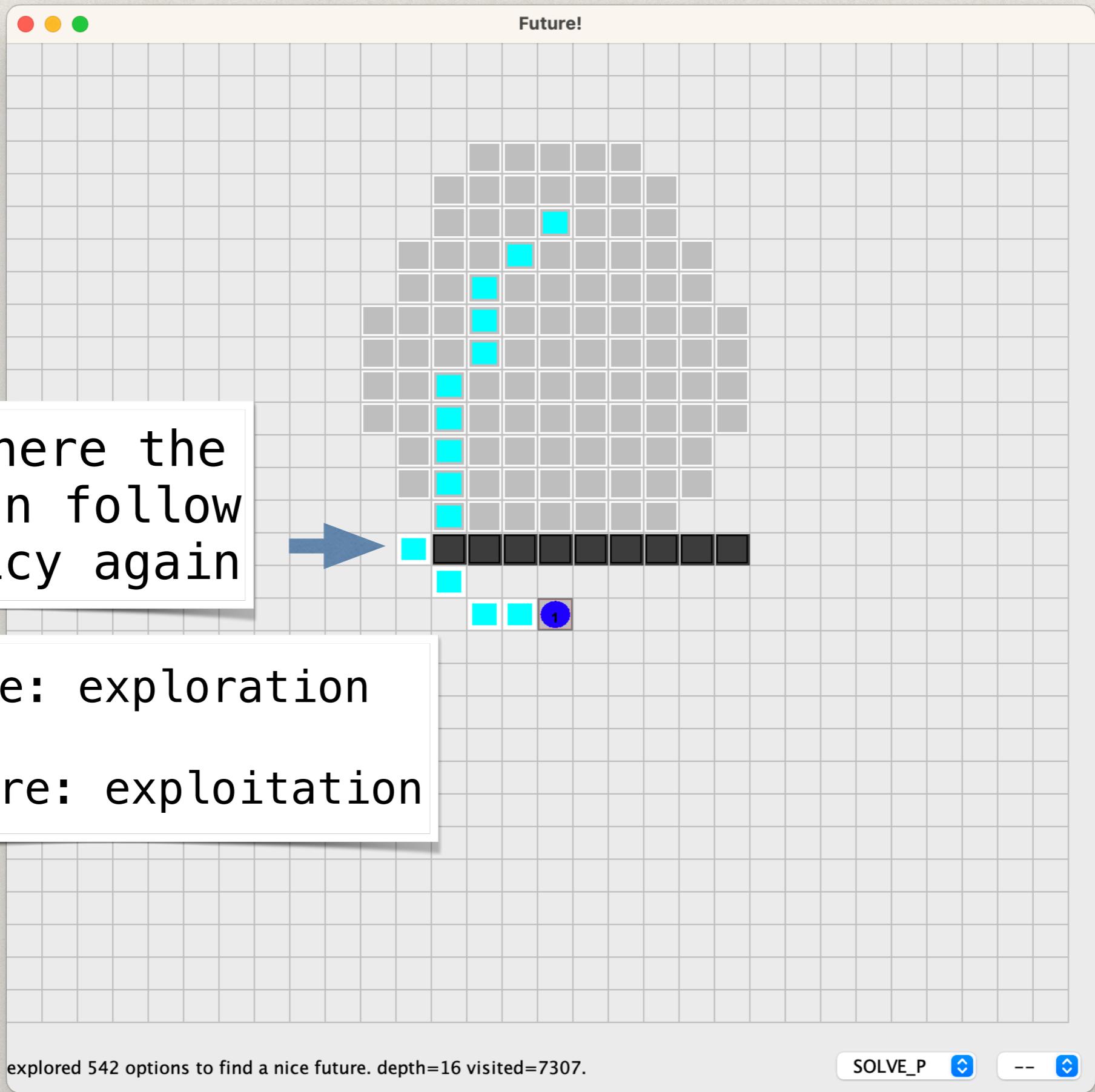


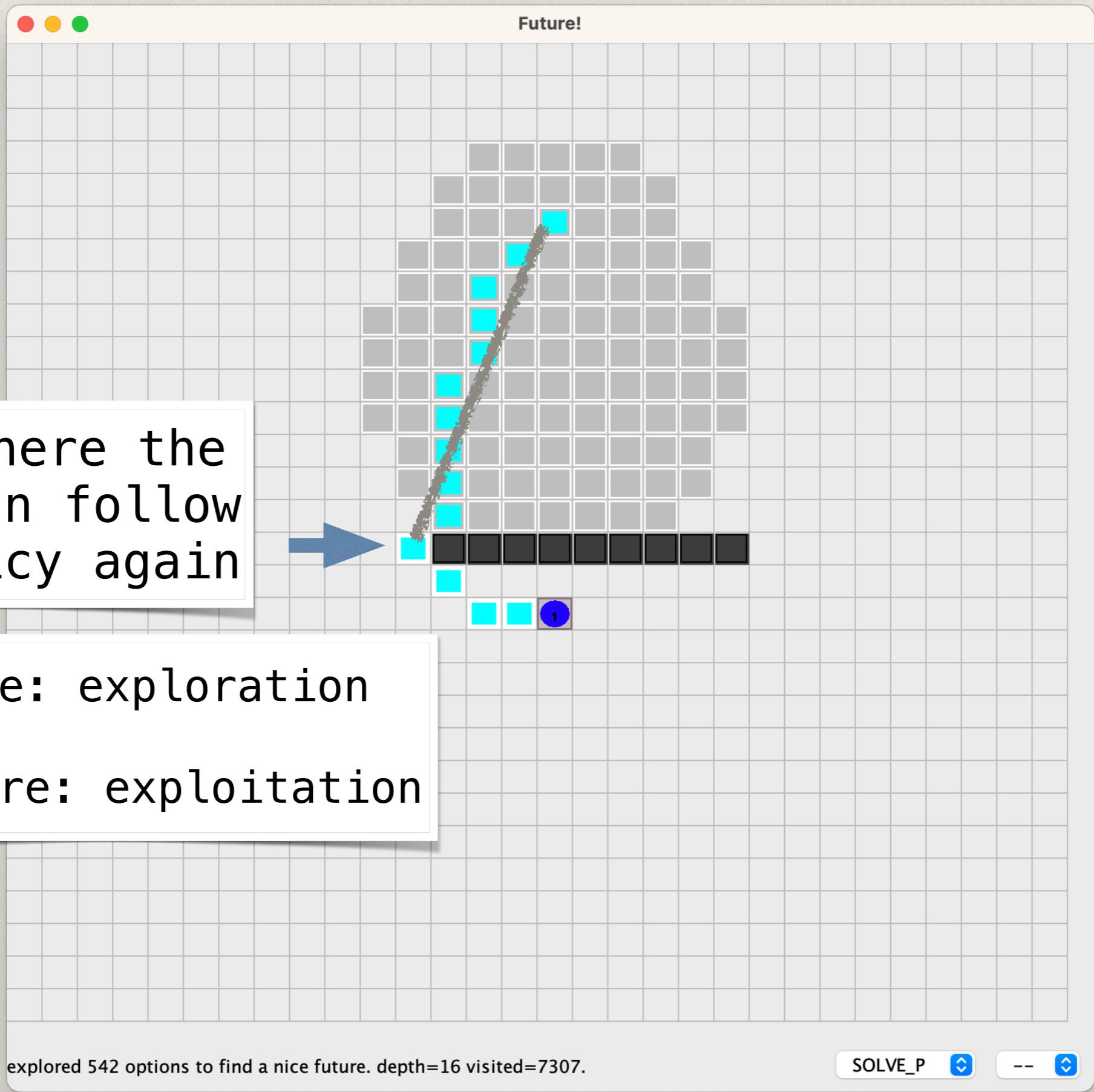


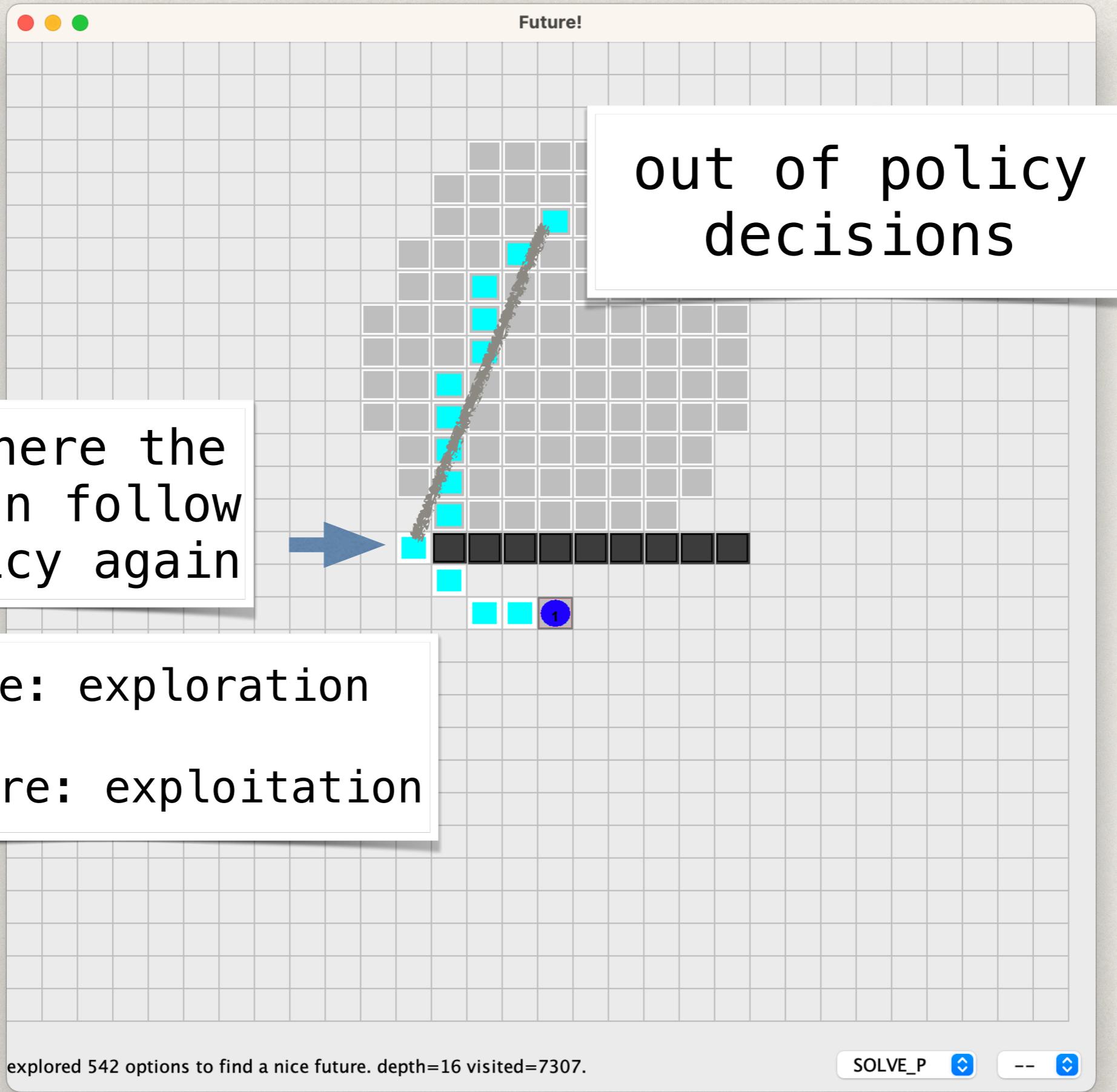




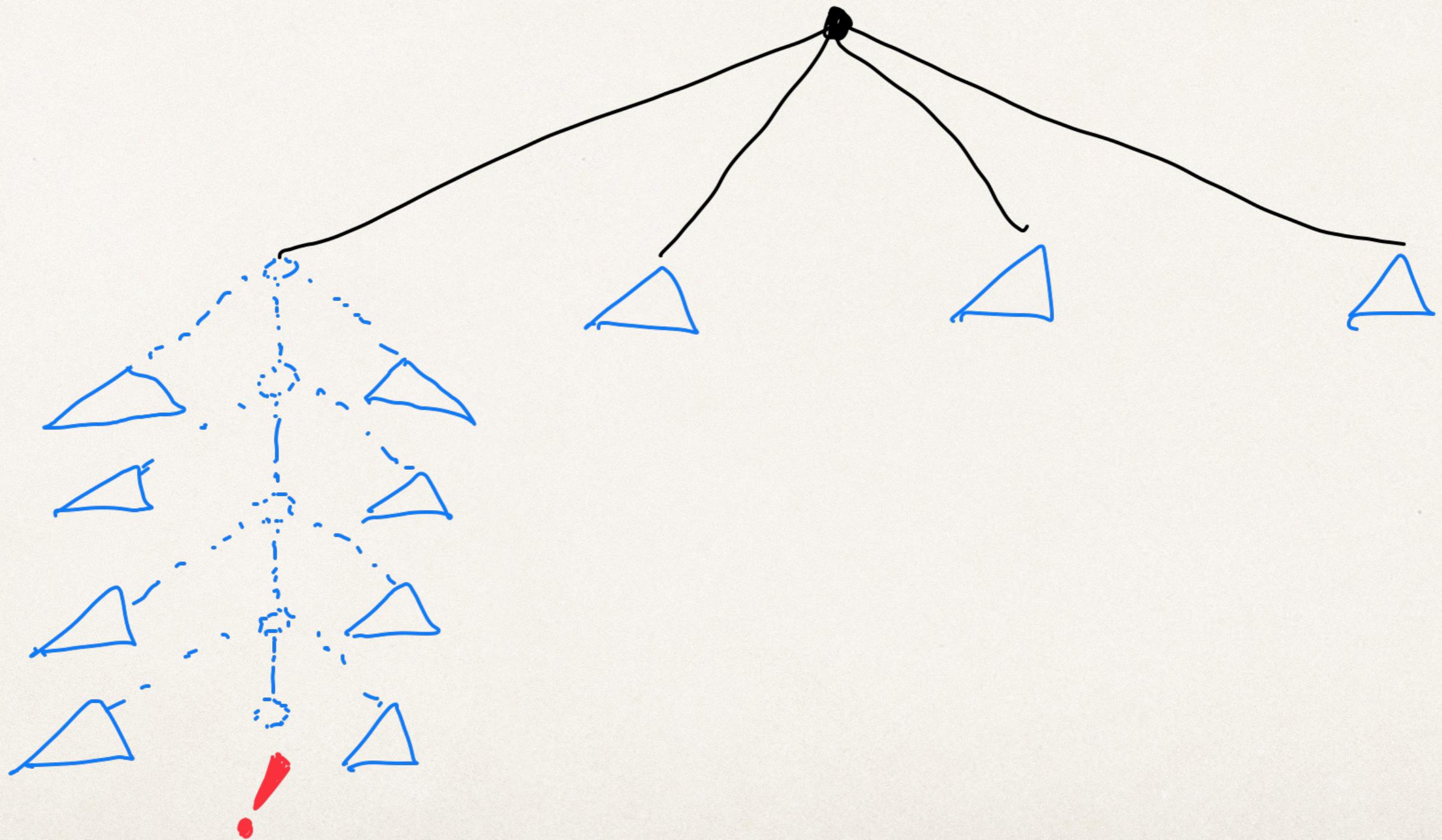
point where the
agent can follow
its policy again



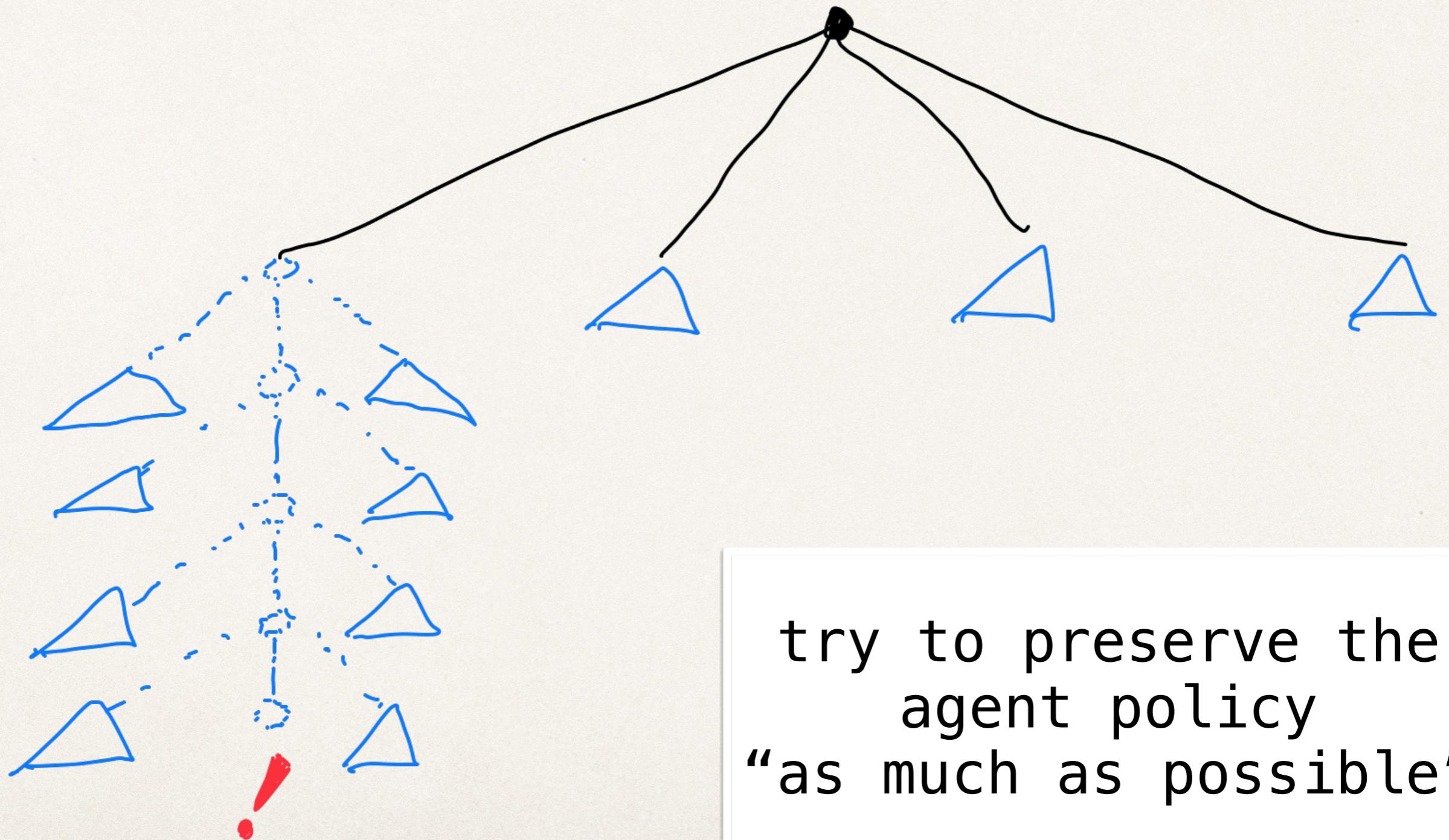


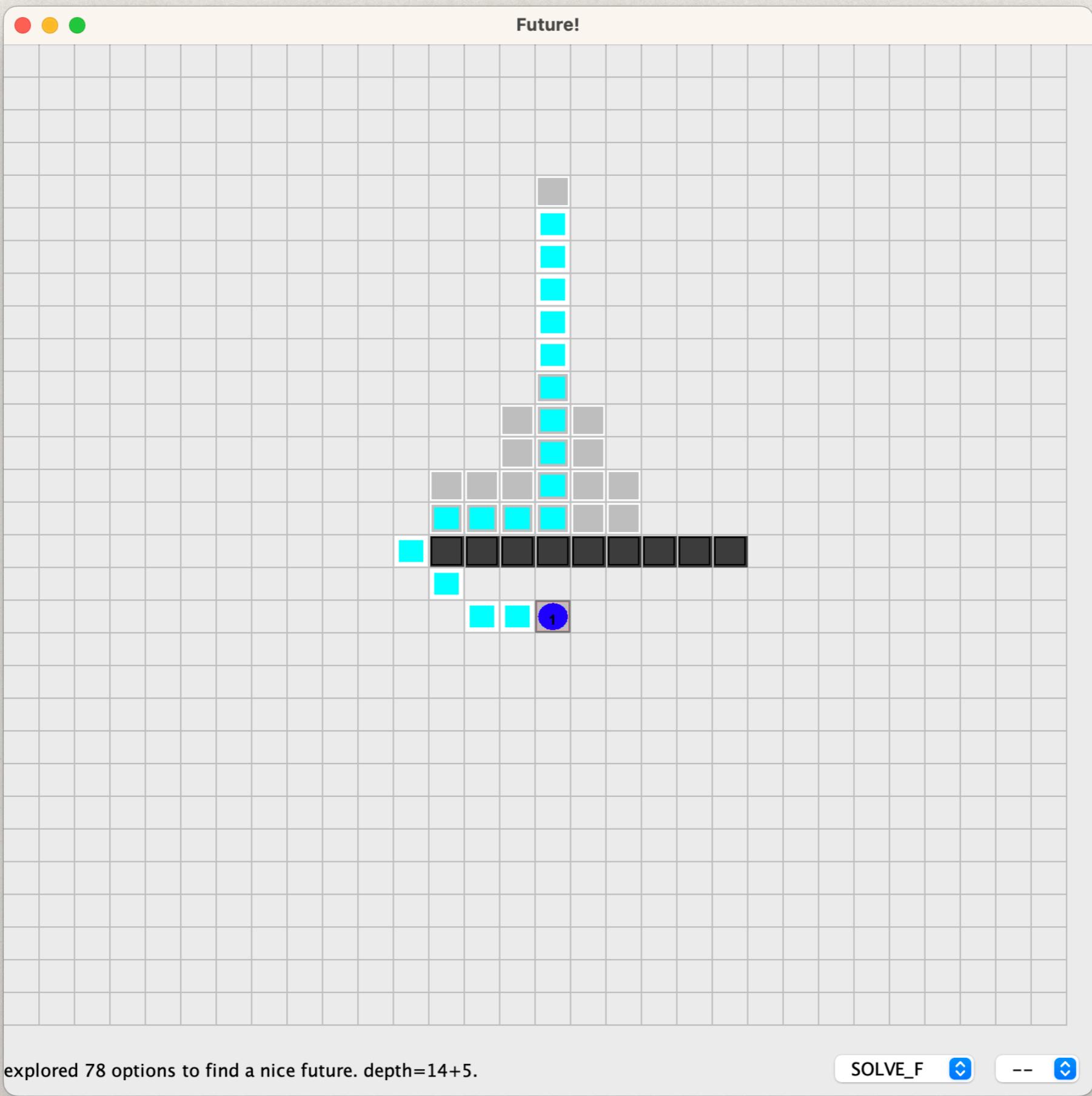


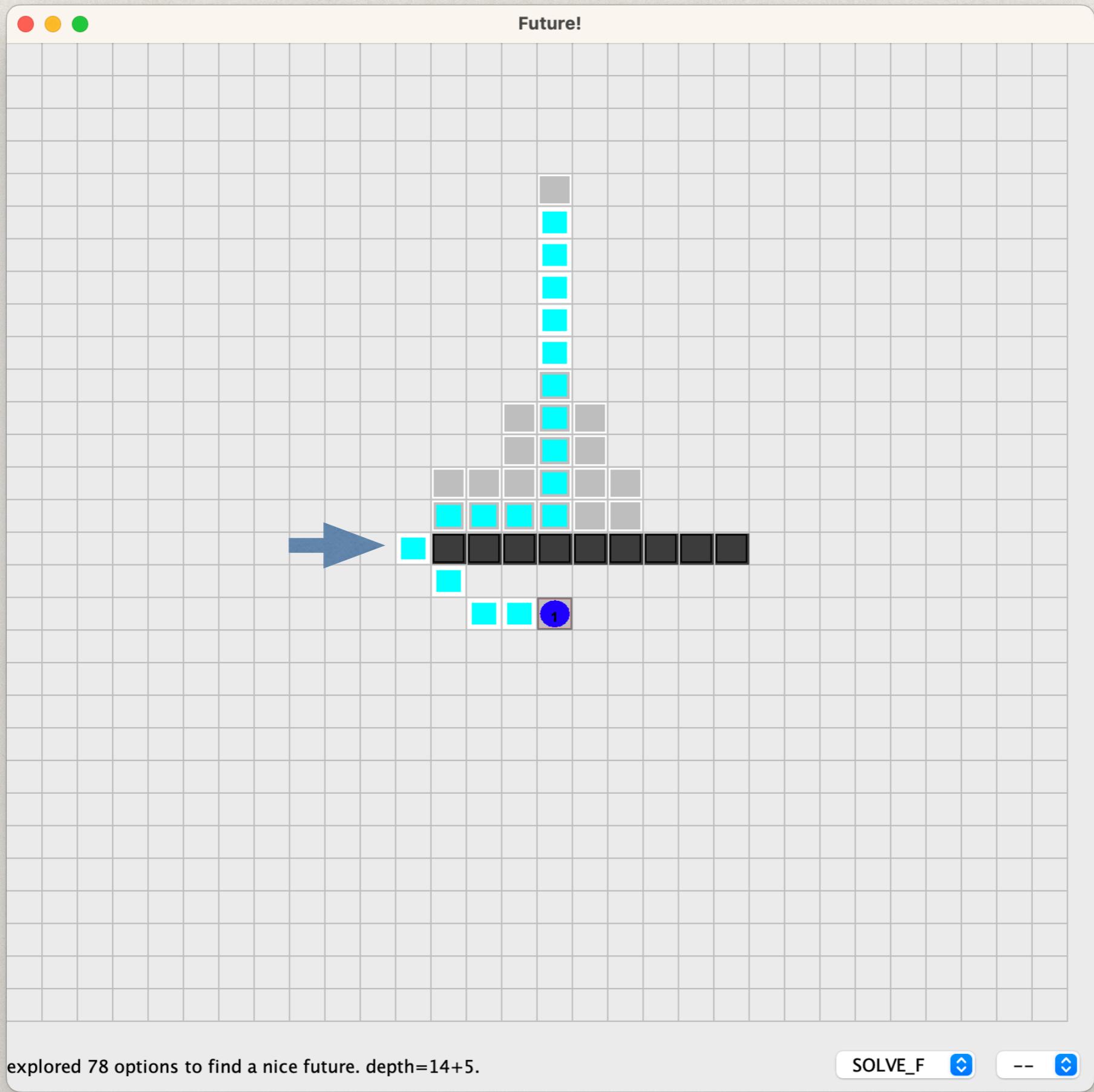
Strategy SOLVE_F

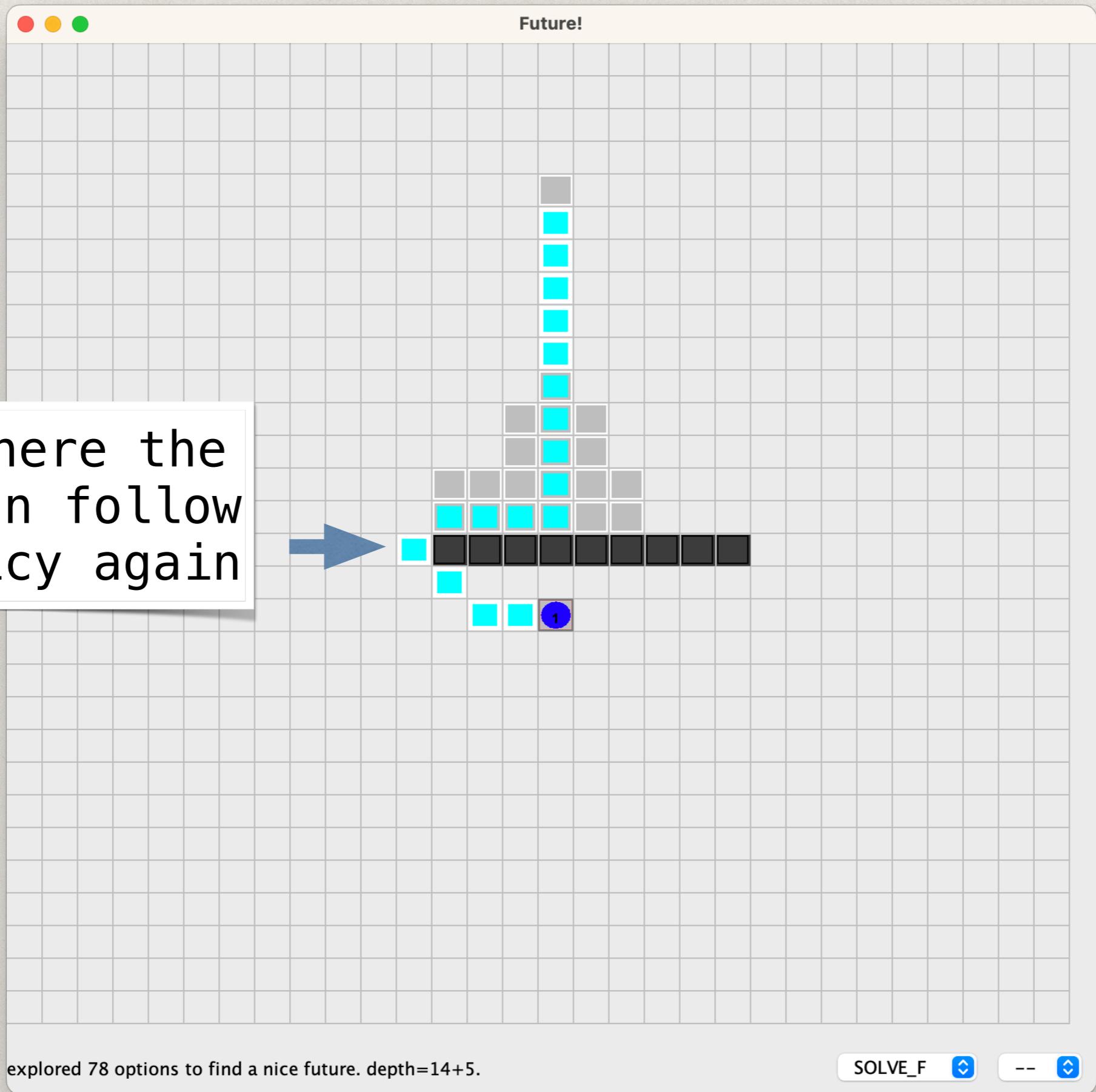


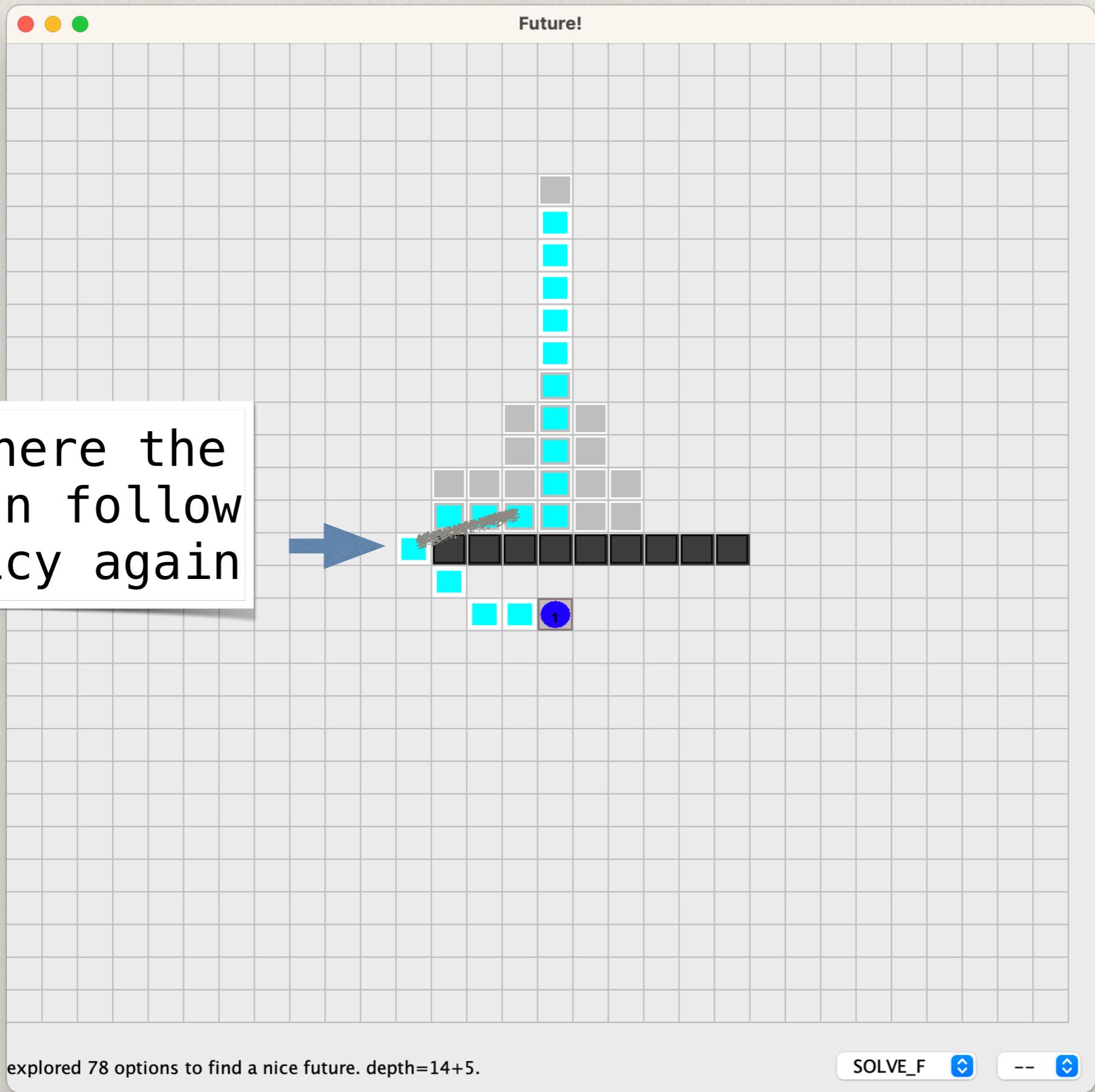
Strategy SOLVE_F

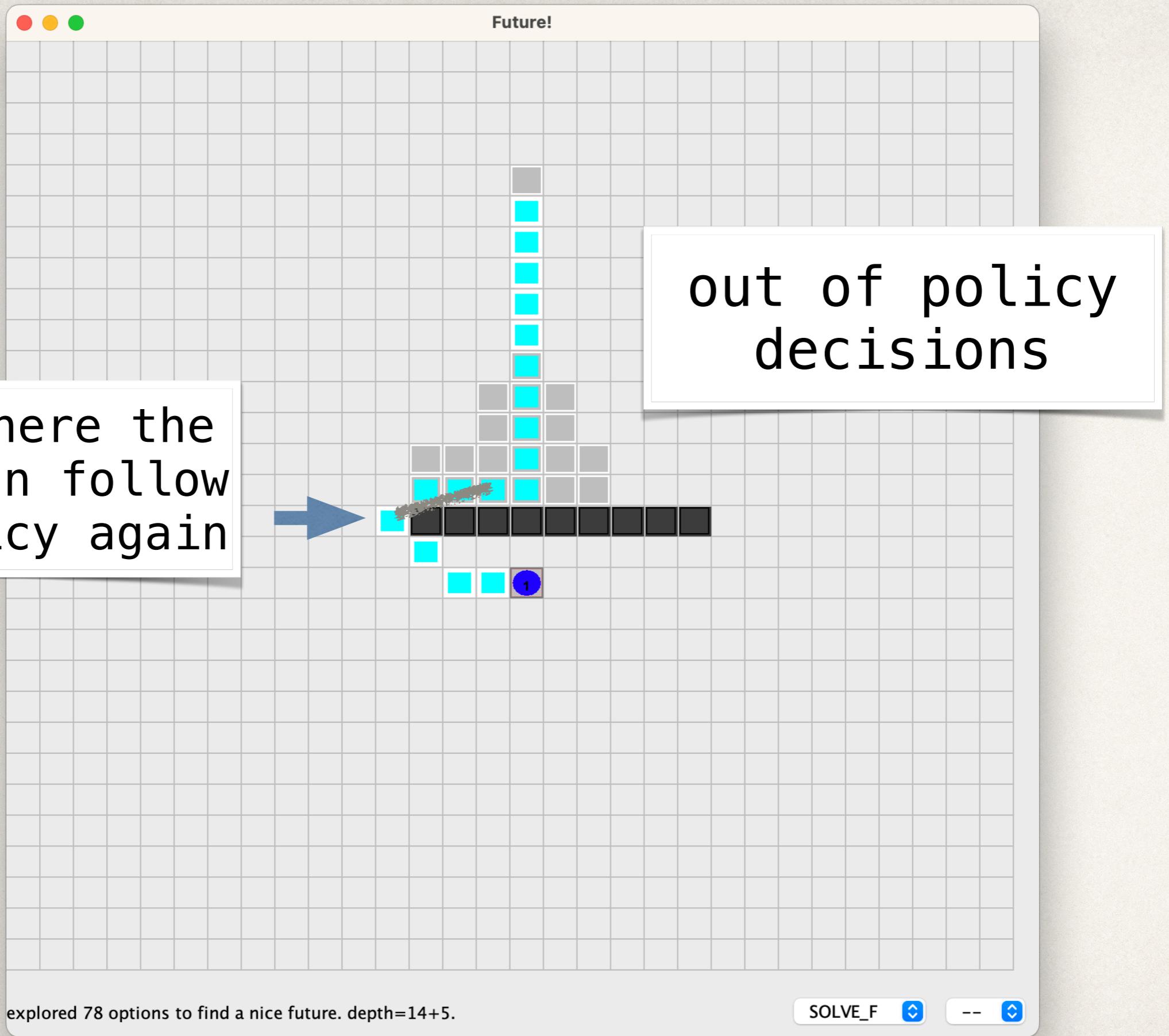


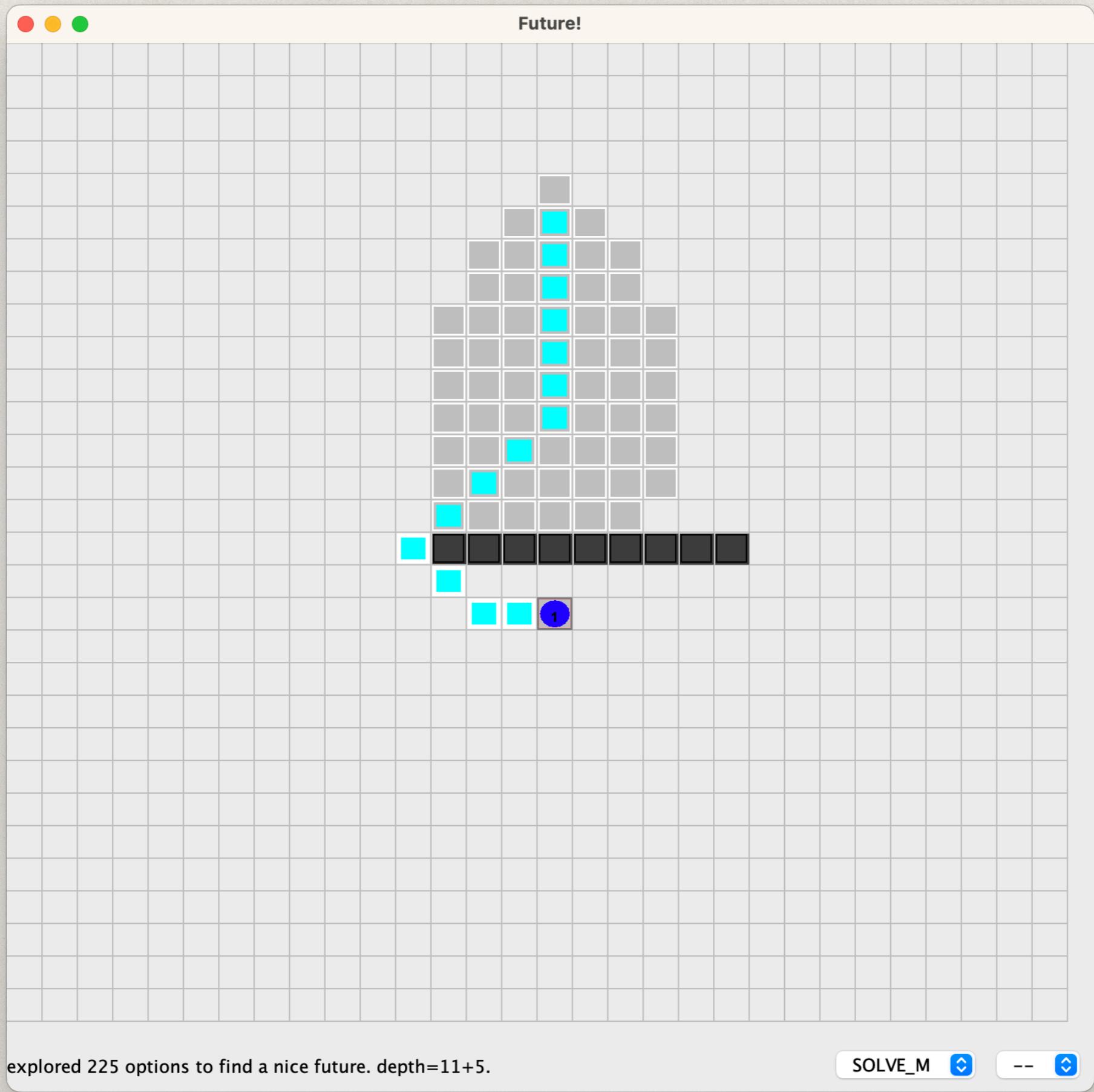


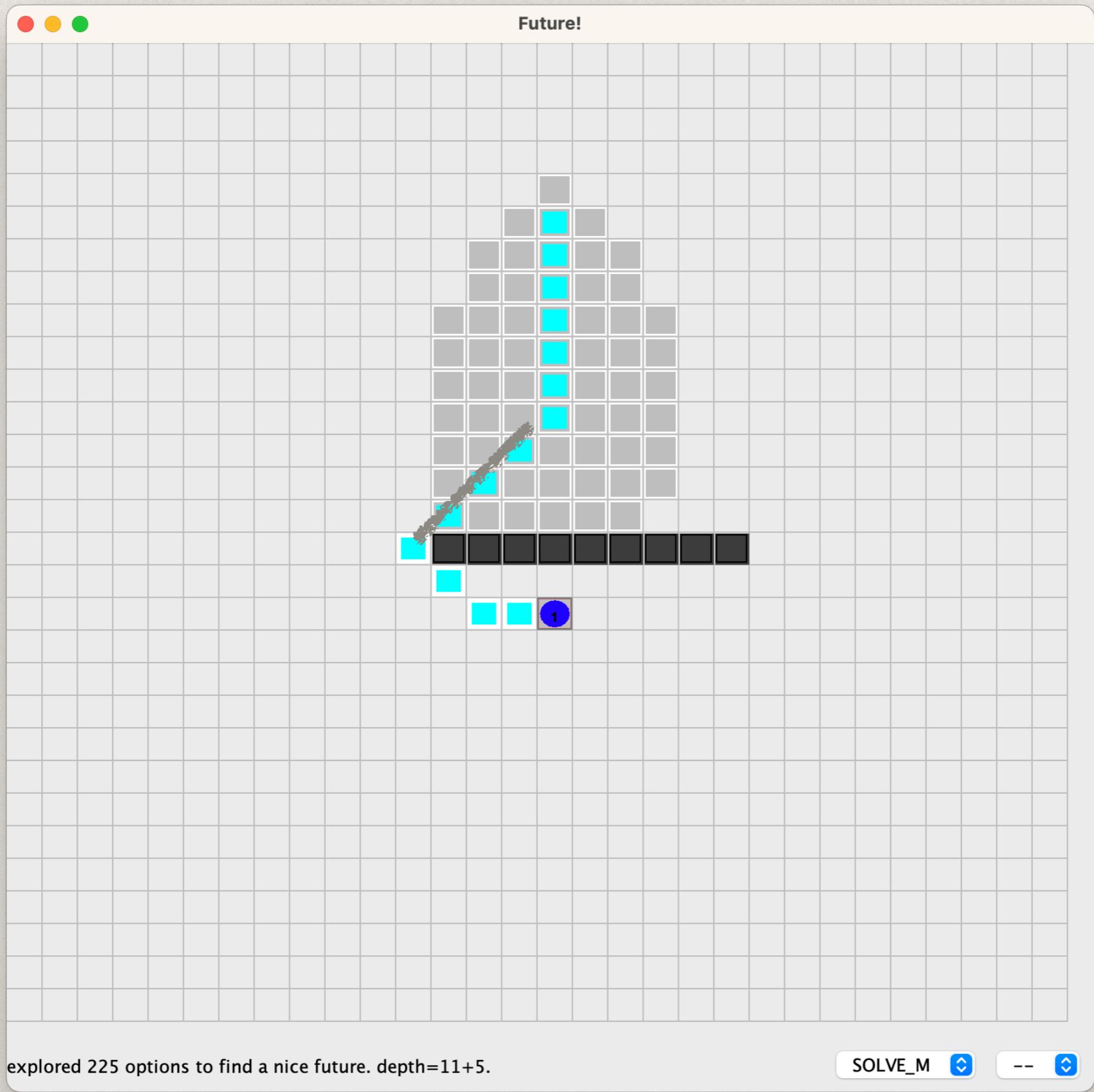


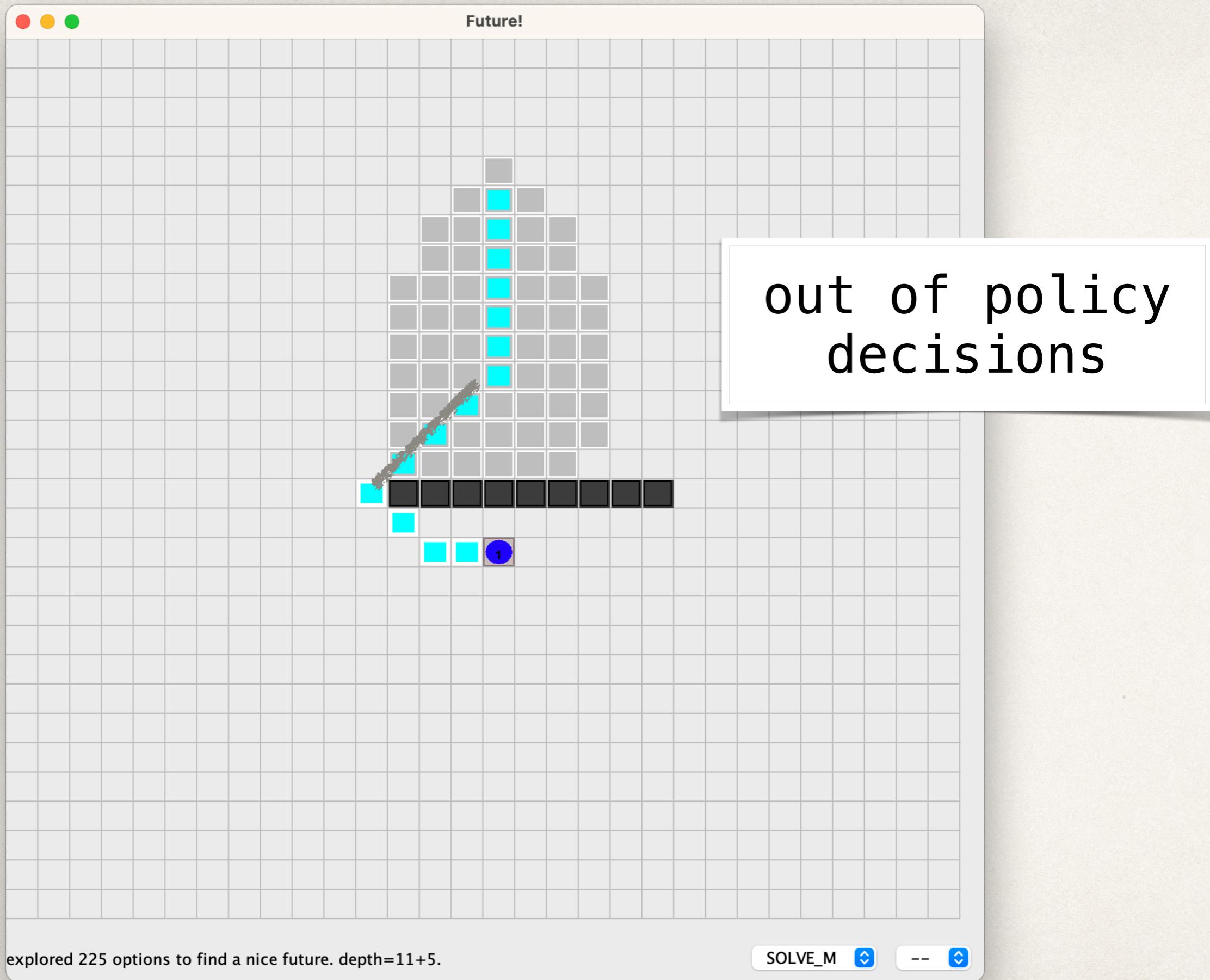


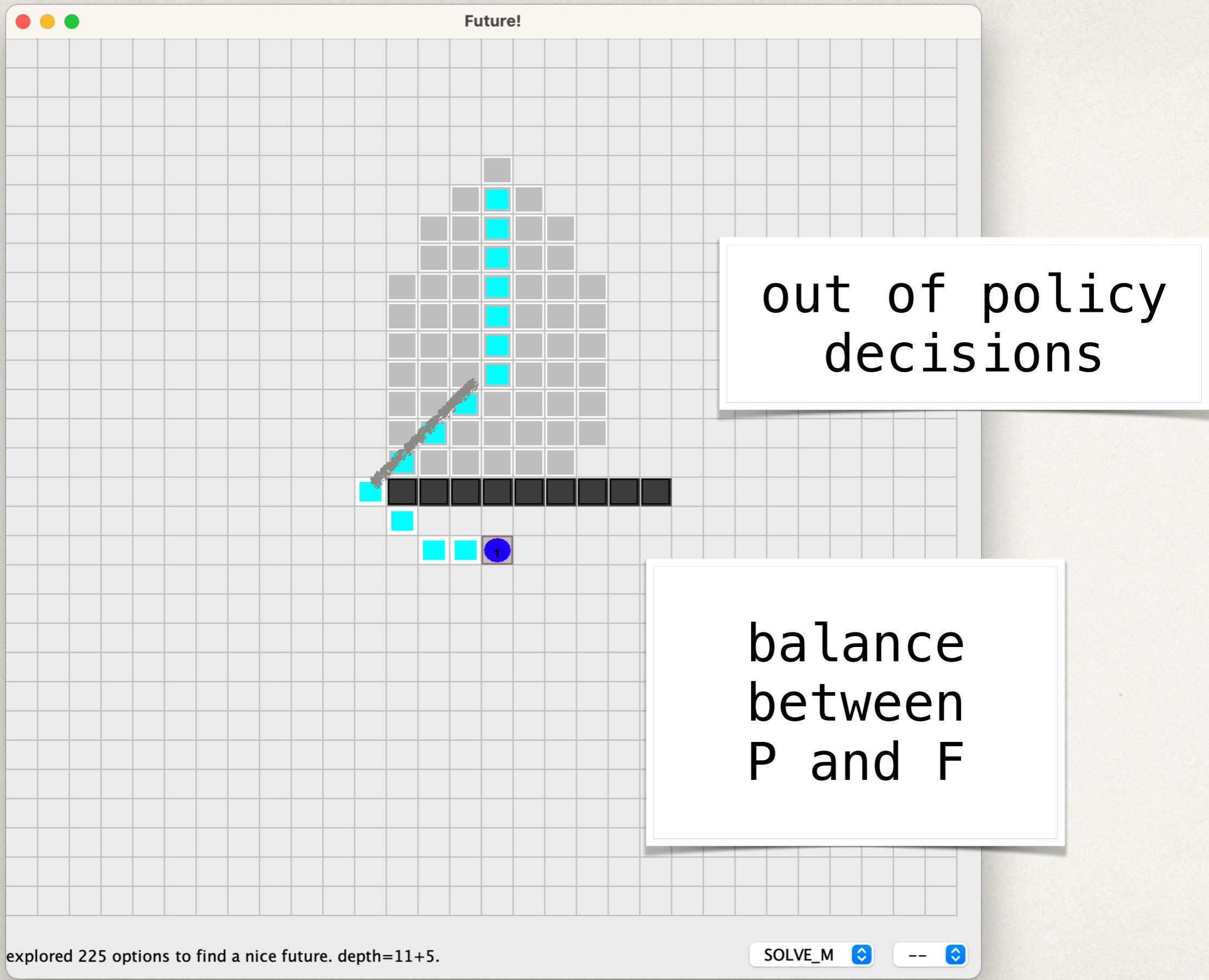












version 1.1

Scenario line

little "detour"

updated
HERE

Scenario U

good for the agent policy, need to anticipate that entering the U is not a good option

Scenario H

bad for the policy

scenario	strategy	visited	steps to solution	steps out of polity	steps in policy
line	SOLVE_P	419	15	9	6 (40%)
	SOLVE_M	217	15	4	11 (73%)
	SOLVE_F	78	18	4	14 (77%)
U	SOLVE_P	112	24	20	4 (16%)
	SOLVE_M	286	24	20	4 (16%)
	SOLVE_F	374	28	24	4 (14%)
H	SOLVE_P	2006	26	22	4 (15%)
	SOLVE_M	2028	26	22	4 (15%)
	SOLVE_F	2001	28	24	4 (14%)

Results

- ✿ move the agent out of its policy
(while exploiting its policy as much as possible)

- ✿ SOLVE_P: change option as **soon** as possible
 - + shorter plan
 - more exploration

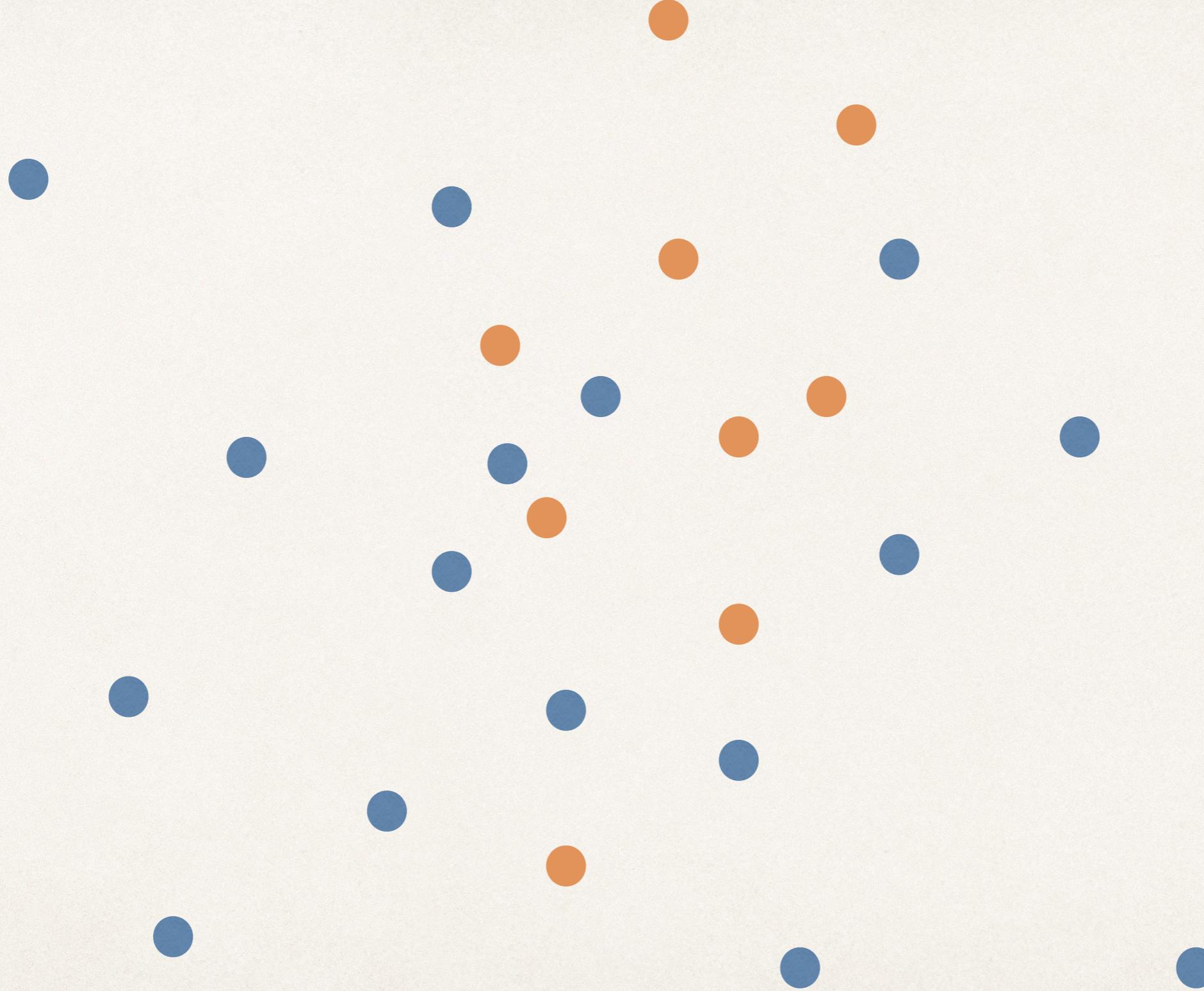
- ✿ SOLVE_F: change option as **latte** as possible
 - + less exploration
 - not so good plan

About the Agent Program

- ✿ the agent program (that defines its policy) is the **(how-to) knowledge** the programmer gives to the agent
- ✿ without it, we (may) have tradicional search
(to consider this **K** distinguishes Jason(S) from search)
- ✿ if **K** is very very bad designed, we (may) have tradicional search [if, at least, K gives options]
- ✿ if **K** very very well designed, Jason(F) does nothing
(the future of the policy is always good)

possible behaviors (ok | not ok)

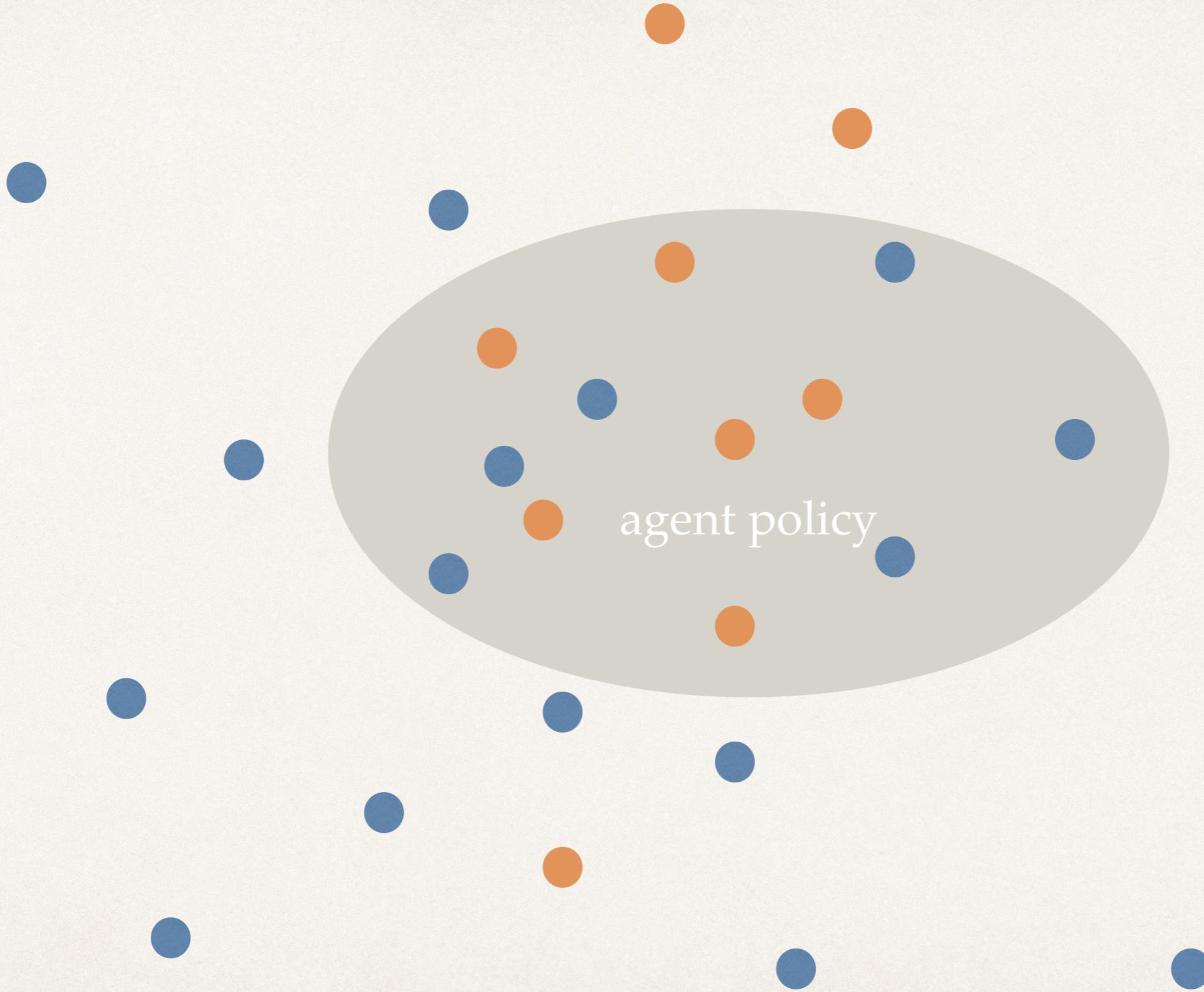
required "energy"



possible behaviors (ok | not ok)

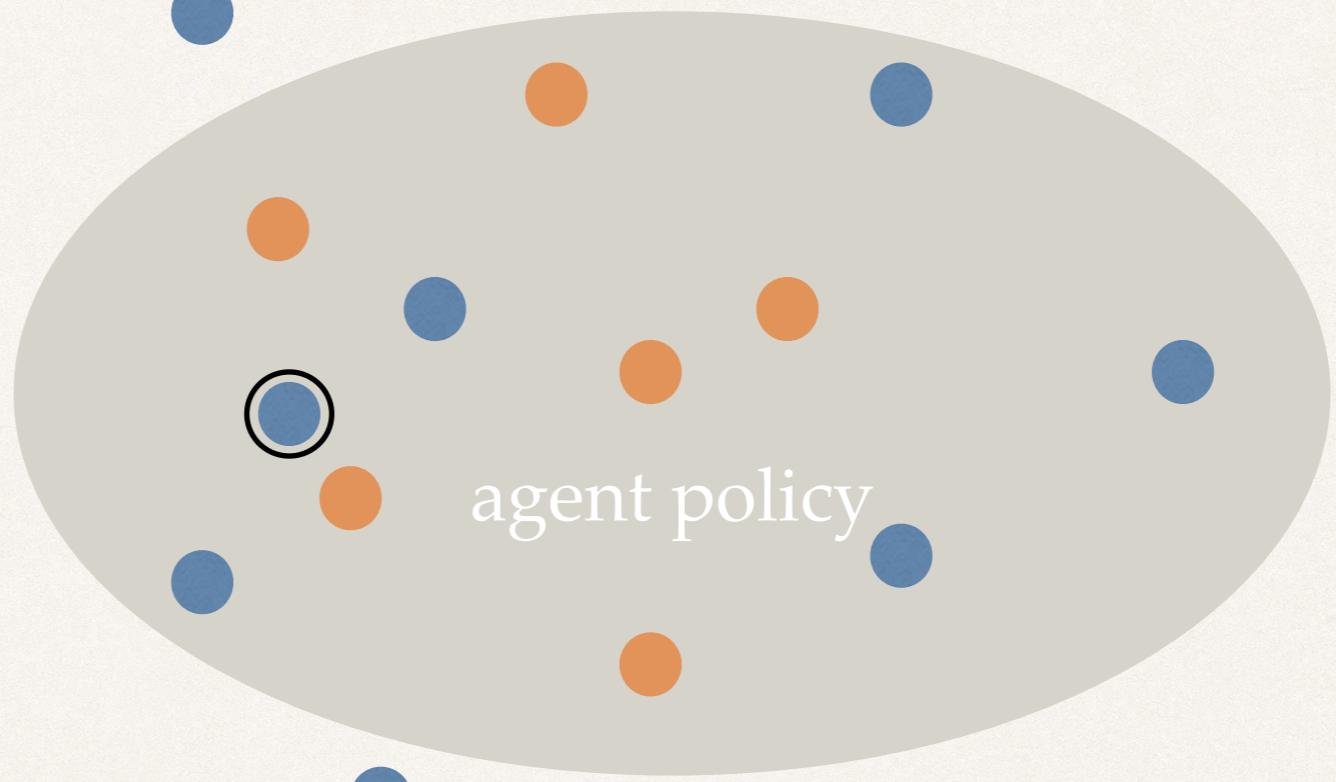
required "energy"

agent policy



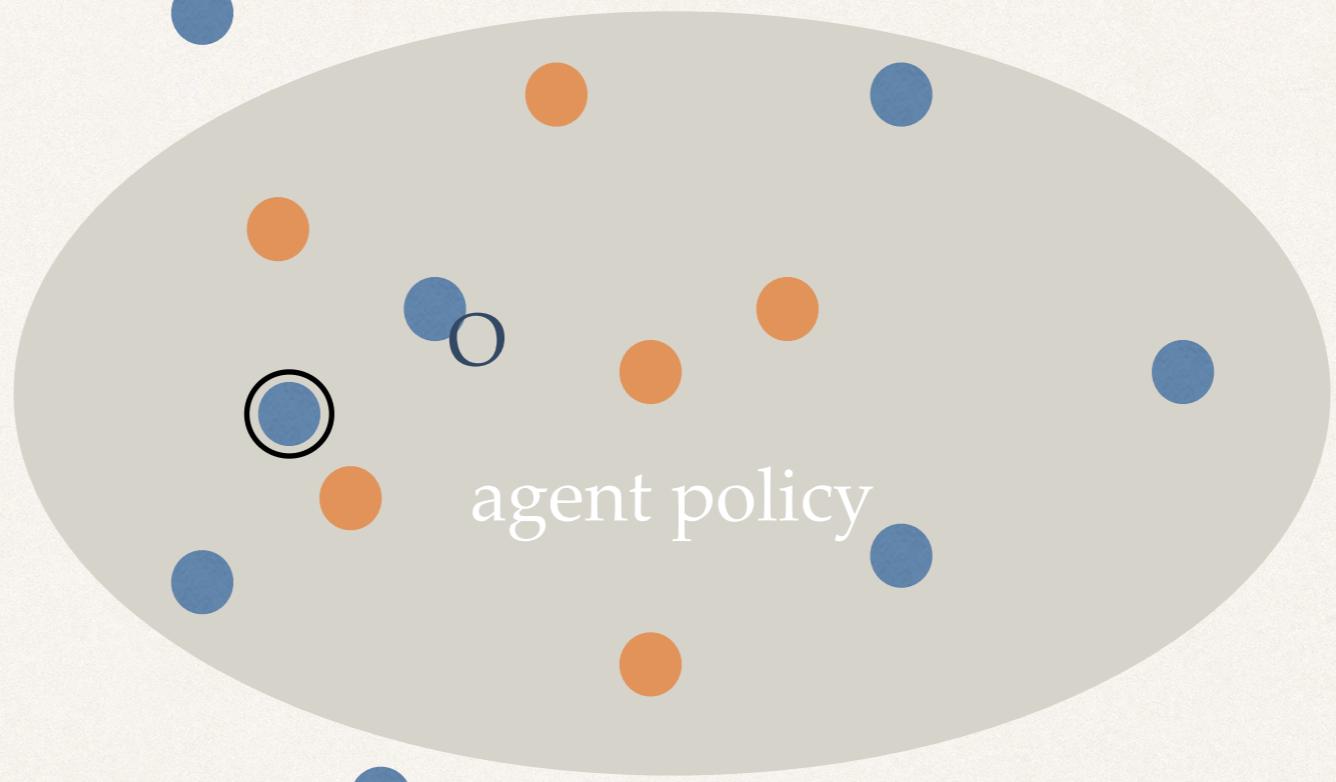
possible behaviors (ok | not ok)

required "energy"



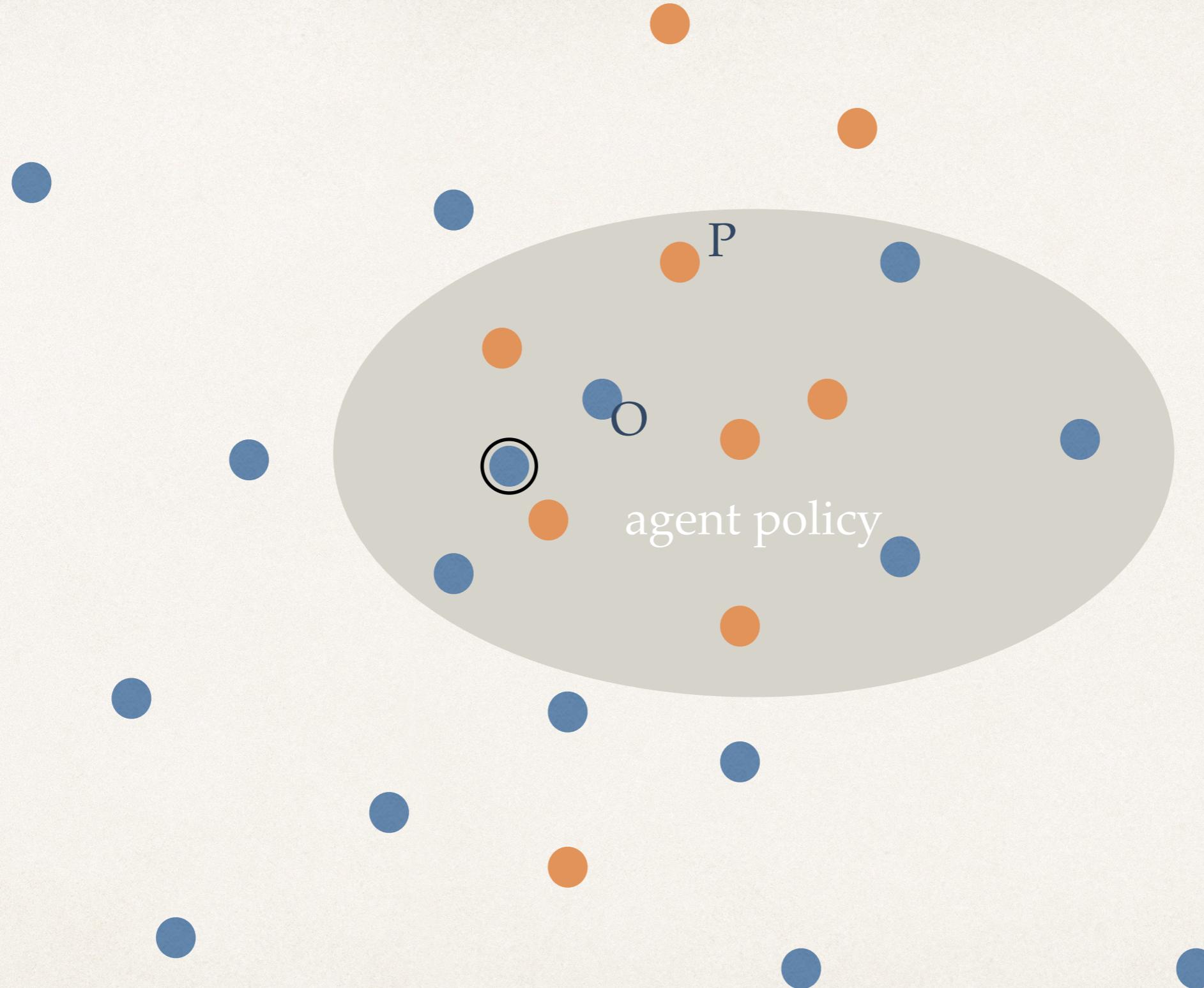
possible behaviors (ok | not ok)

required "energy"



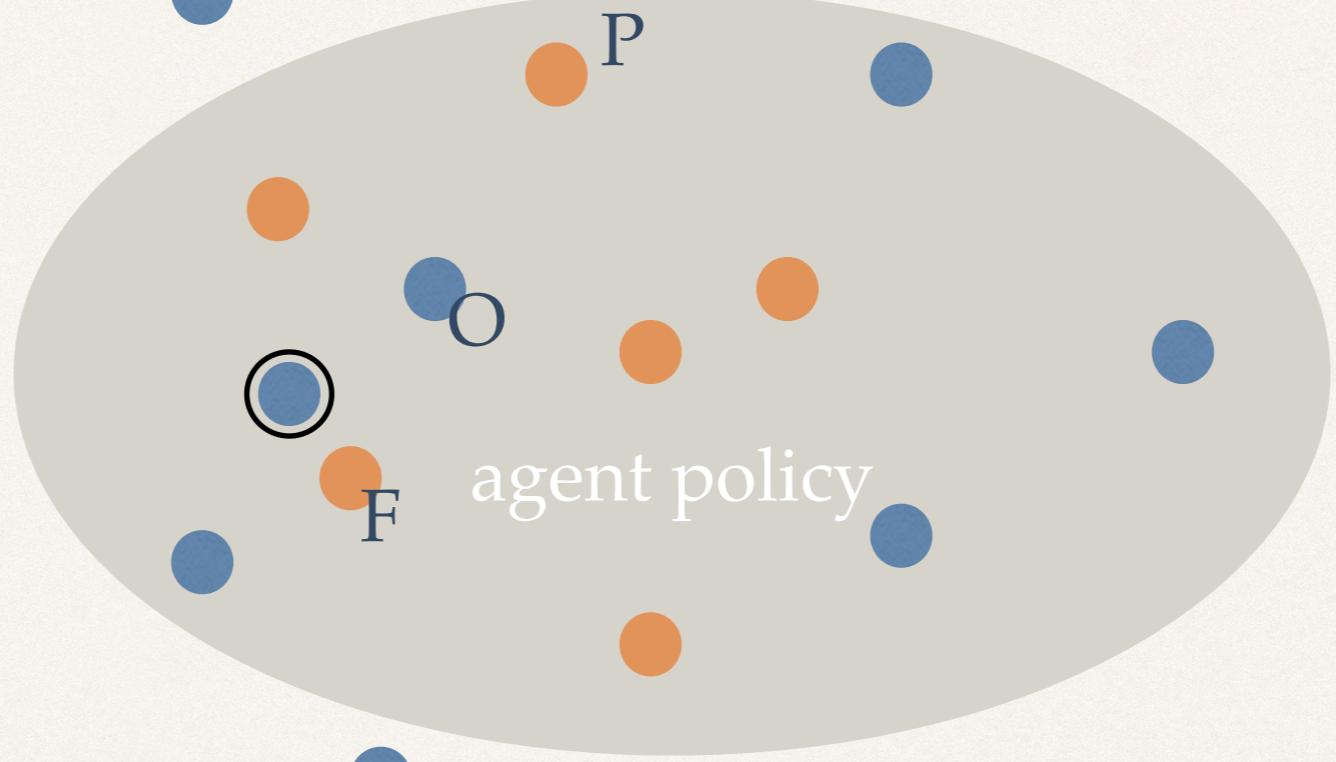
possible behaviors (ok | not ok)

required "energy"



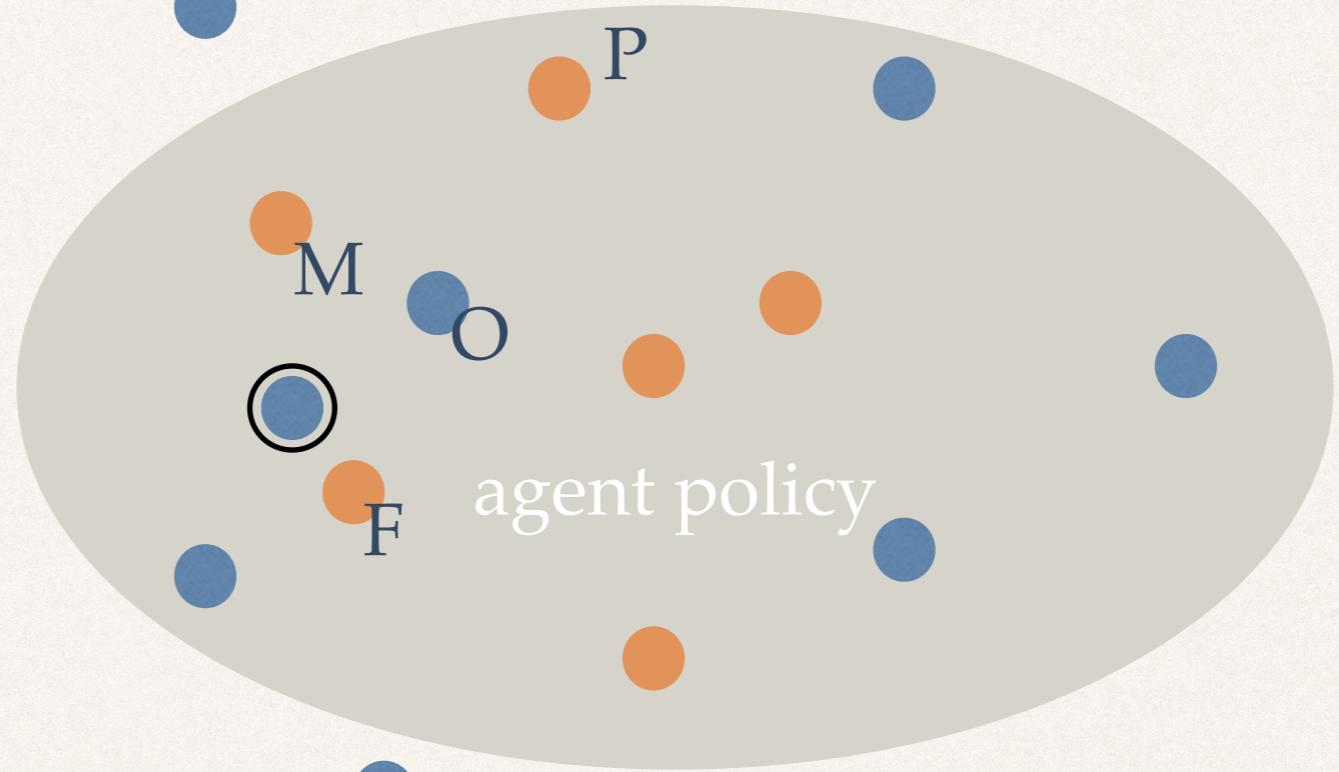
possible behaviors (ok | not ok)

required "energy"



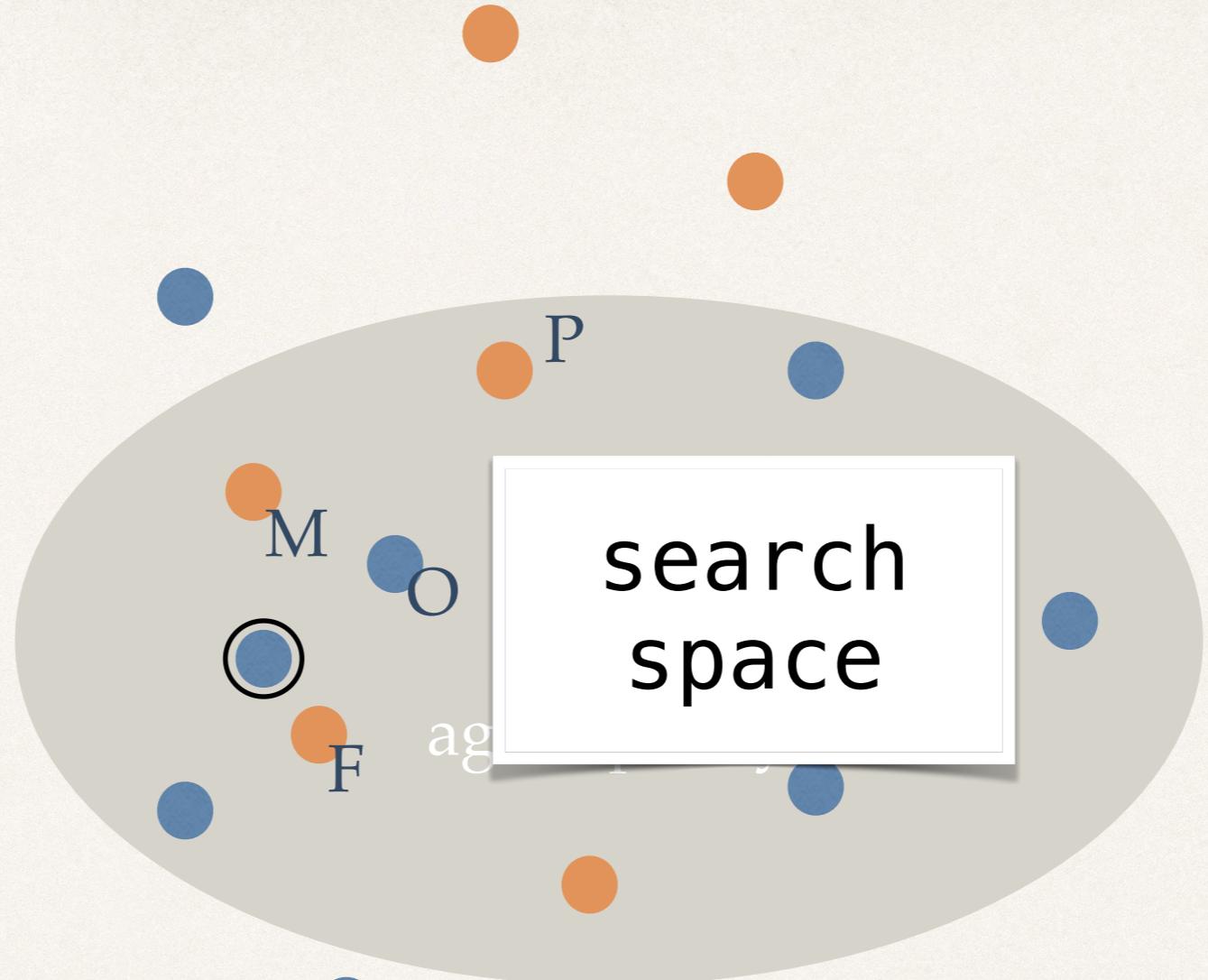
possible behaviors (ok | not ok)

required "energy"



possible behaviors (ok | not ok)

required "energy"



Questions

- ✿ is it just search? planning? monte carlo?
[it is inspired on all these, but...]
[we have the agent policy]
[no adversarial]

- ✿ does agent policy (options + preference) play as heuristic? [i guess so — preference part]
[Jason(F) scapes from preference when it isn't ok]

- ✿ is it optimal?
[no] [maybe if preference + cost are considered]

Questions

- ✿ does it work for any kind of agent program?
[it works if the program produce *enough* options]
[just one option: nothing to do; several options (with no preference): usual search]
- ✿ does it work without preference?
[yes, but less efficient]
- ✿ how much do we depend on preferences? [for efficiency]
can we survive without? [yes]

Jason(F) 1.1

- ❖ initial scenarios
- ❖ handles internal problem (goal not achieved)
- ❖ strategies: one, solve_(p|m|f)
- ❖ generic for any Jason program
[+ environment model]

Multi-Agent

- ✿ Requires model of others
 - ✿ ask them for their model
 - ✿ they are as me
 - ✿ developer provides
- ✿ cooperation implies that changes in “path” may be more critical

Multi-Agent

- ✿ Requires model of others
 - ✿ ask them for their model
 - ✿ they are as me
 - ✿ developer provides
- ✿ cooperation implies that changes in “path” may be more critical

environment transitions

$$e : S \times A^n \rightarrow S$$

agent i policy (as ordered options)

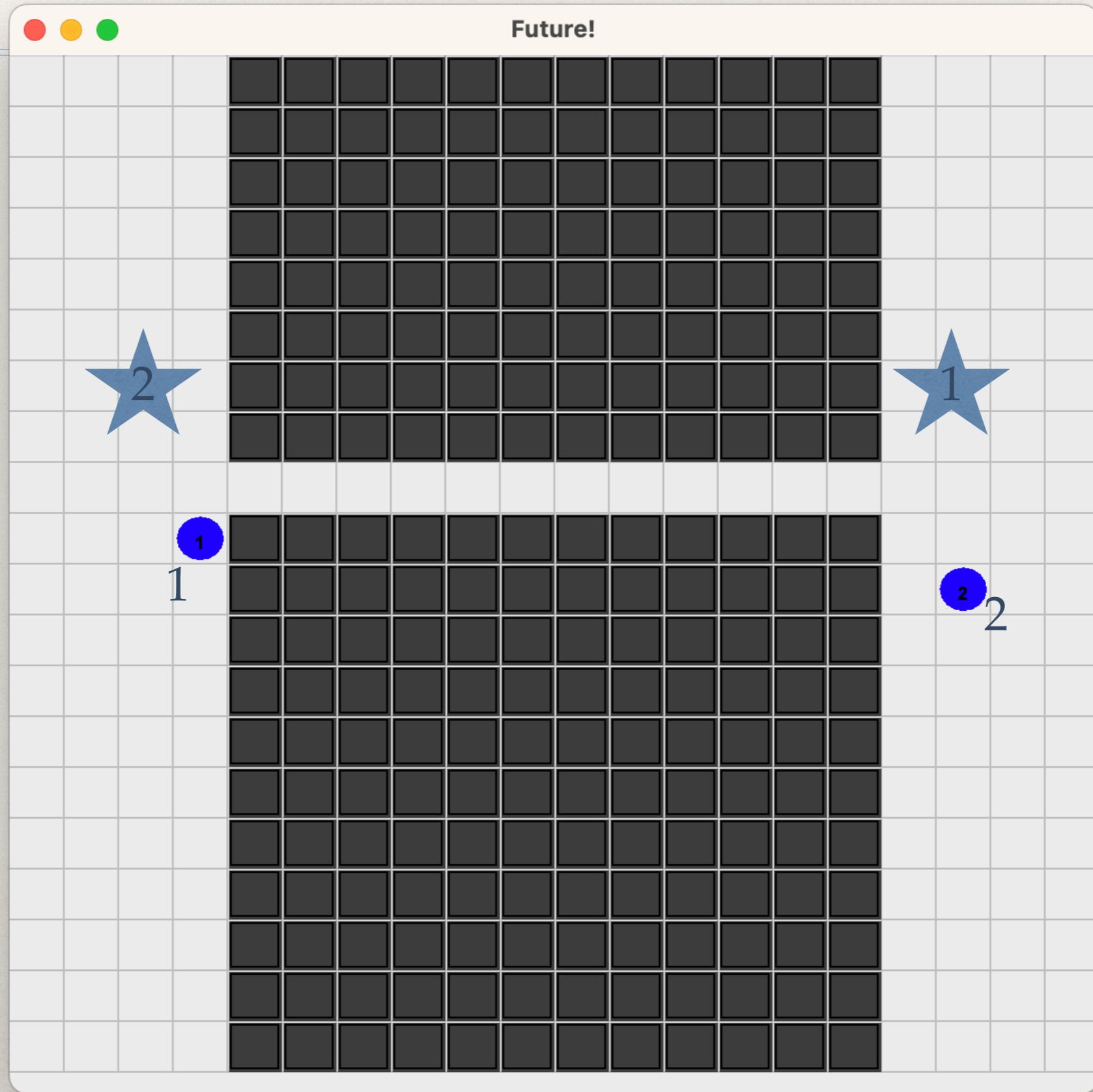
$$\pi_i : S \rightarrow A^n$$

future state at k

$$f : S \times \mathbb{N} \times \mathbb{N} \rightarrow S$$

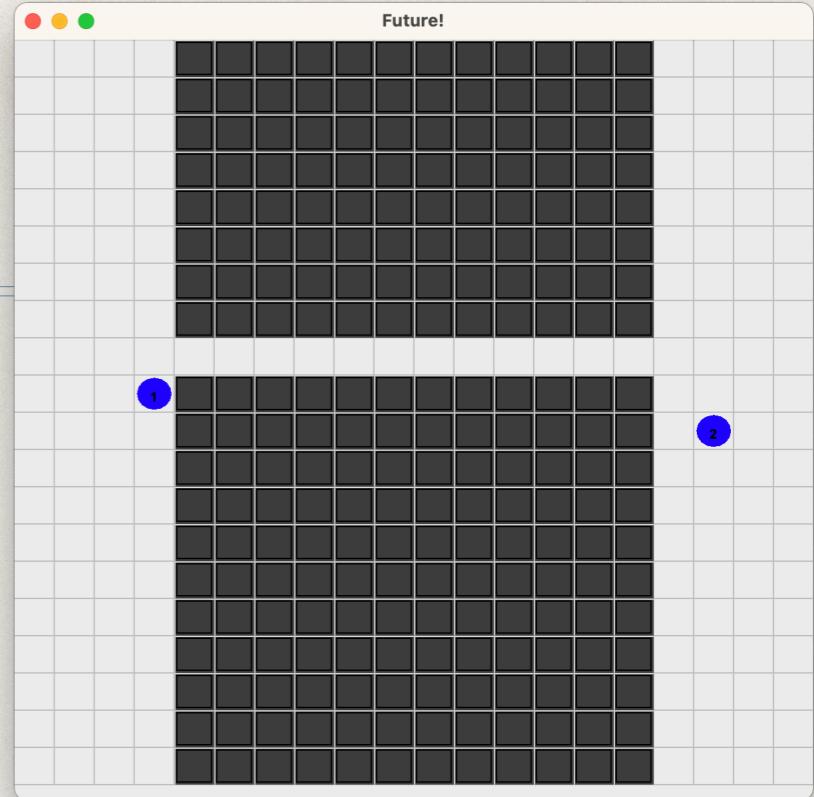
$$f(s, t, k) = \begin{cases} s & \text{if } t = k \\ f(e(s, \pi_1(s)_1), \pi_2(s)_1), \dots, t + 1, k) & \text{if } t < k \end{cases}$$

Bridge Scenario



Strategies

- ✿ none: both agents are blocked in the middle of the bridge
- ✿ left agent with **one**: right agent crosses, left agent gives up
- ✿ left agent with **solve_p**: right agent crosses, left waits and then crosses



Results

strategy	solve	matrices	visited	steps	steps in policy
NONE	no	0	∞	∞	∞ (100%)
ONE	no	1	25	—	0 (0%)
SOLVE_P	yes	942	8333	27	21 (77%)

`solve_p` is slower to find options
(higher cost of building matrixes)

Jason(F) 1.3

- ❖ matrix with multi-agents
[no communication considered]
- ❖ others are simulated as regular (non-Jason(F)) agents
- ❖ (still) internal problem (goal not achieved)
- ❖ strategies: one, solve_(p | m | f)
- ❖ generic for any Jason program
[+ environment model]
[model of others is trivial in Jason, just get their state]

Remarks for Multi-agent case

- ✿ Nothing new or special for the multi-agent case (!)
- ✿ From the Jason(F) agent perspective, others are part of the environment
 - ✿ only their actuation in the environment is indeed perceived
- ✿ if both agents are Jason(F), both will wait 5 steps and then try to cross at the same time!
 - ✿ some coordination strategy should (must?) be put in place (e.g., a leader that decides who cross)

Next Steps

- ✿ Relax assumptions (deterministic environment, ...)
- ✿ More scenarios (more complex and realistic)
- ✿ Running in background
- ✿ Opportunistic options
oracle: “your policy is ok, but you could do better”
- ✿ Consider backtrack (options in the past)
- ✿ Other types of problem (internal state, norm violation)
- ✿ Related work

What to Measure?

- ❖ time & memory
- ❖ reactivity
- ❖ efficiency & efficacy