CMSC 170

Introduction to Artificial Intelligence

2nd Semester AY 2014-2015

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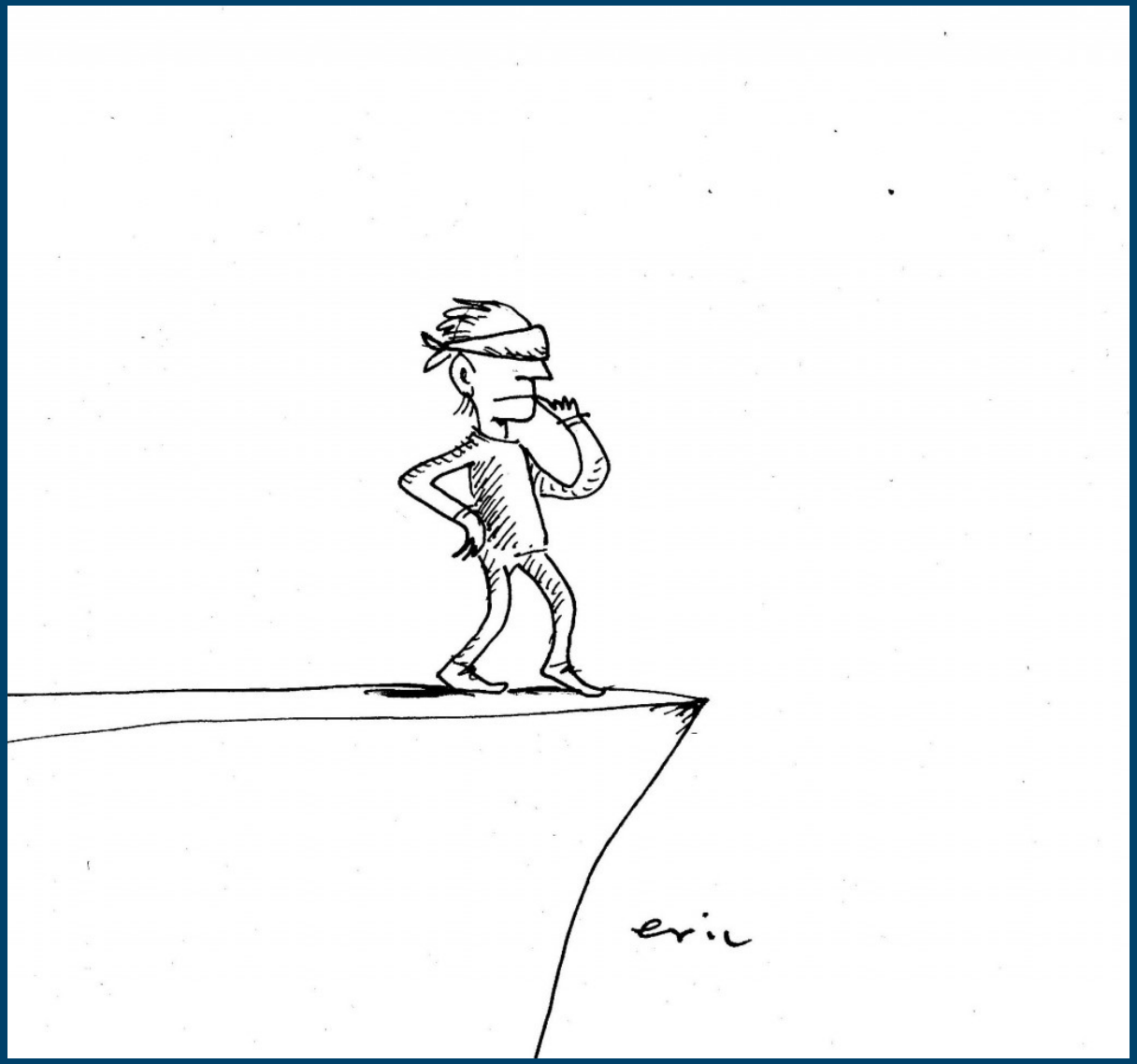
PREVIOUSLY...

We used problem solving techniques (like A*-search) to find solutions to problems, but these methods only work when environments are fully-observable and deterministic.

WHY?

The agent thinks up a plan/solution, then executes it blindly, without sensing the environment.

CAN WE DO THAT IN REAL LIFE?



WE CAN'T

We thus need to interleave planning and executing to handle difficult environments like...

1.

Stochastic environments

If the result of an action is not solely dependent on agent actions, we must handle all possible results after an action is performed.

2.

Multi-agent environments

Agents must be able to react to the actions of other agents that may affect the environment.

3.

Partial Observability

We might not be aware of the situation in a further section of the plan; some actions might need to be modified if certain conditions are met.

EXAMPLE

Given a plan to go campus via Raymundo Gate:

F. O. Santos → Ruby St. → Raymundo Gate → CEM

The success of the solution will be dependent on whether Raymundo Gate is open, something that we can't observe when we start at F. O. Santos.

There may also be other factors like...

1.

Lack of/Faulty Knowledge

The agent may be equipped with faulty sensors, or may have been given an incomplete map.

2.

Hierarchical Plans

Plans may specify what an agent should do, but not how to do it.

REMEMBER...

EXAMPLE

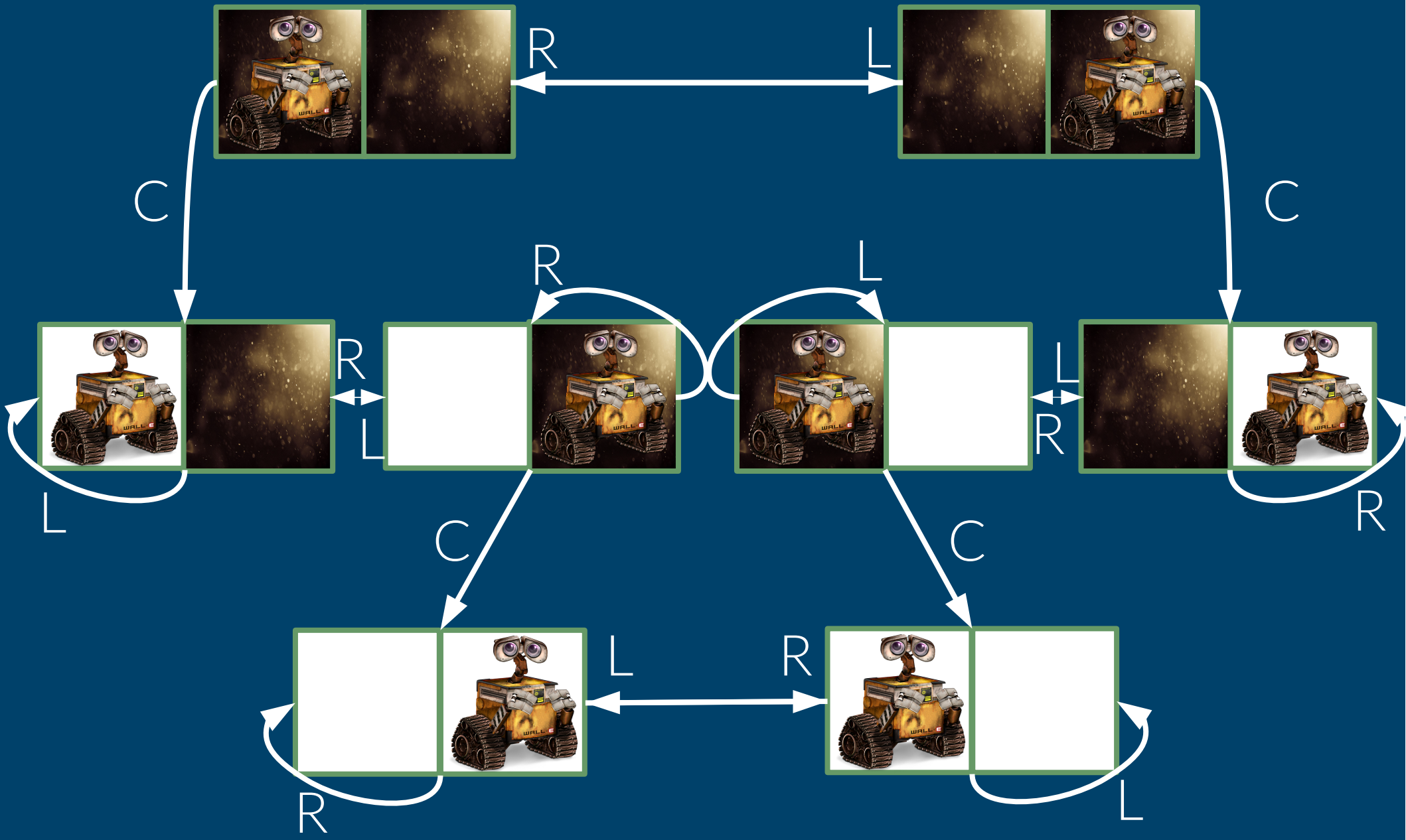
The robot can be in one of two positions, L or R.

EXAMPLE

Each position can either have dust or not.

EXAMPLE

The robot can clean the position it is in to remove the dust.


R
L
C
C
R
L
R
L
R
L
L
R
C
C
L
R
R
L

We are looking at world states, where each state describes exactly one, atomic state.

BUT WHAT IF...

The sensor breaks down?

The agent can't sense its location.

The agent can't sense if the location is dirty or not.

Instead of looking at actual world states, we look at

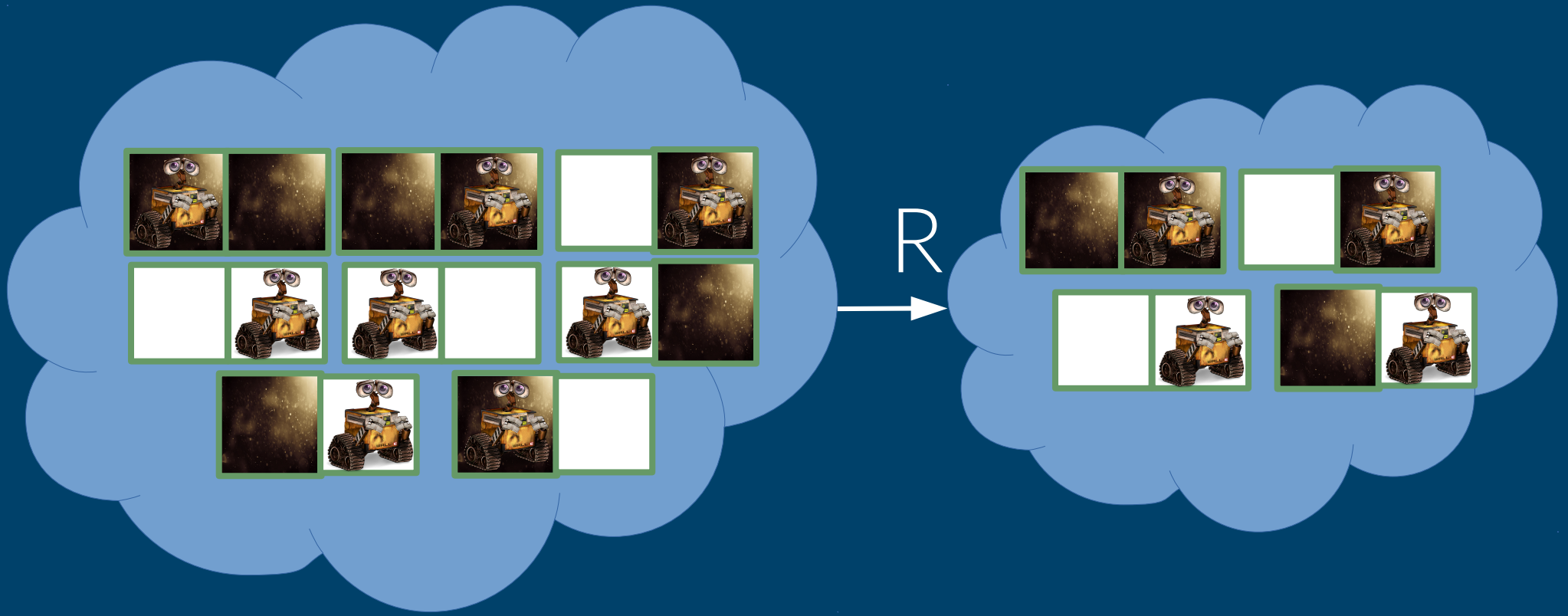
belief states.

Belief States

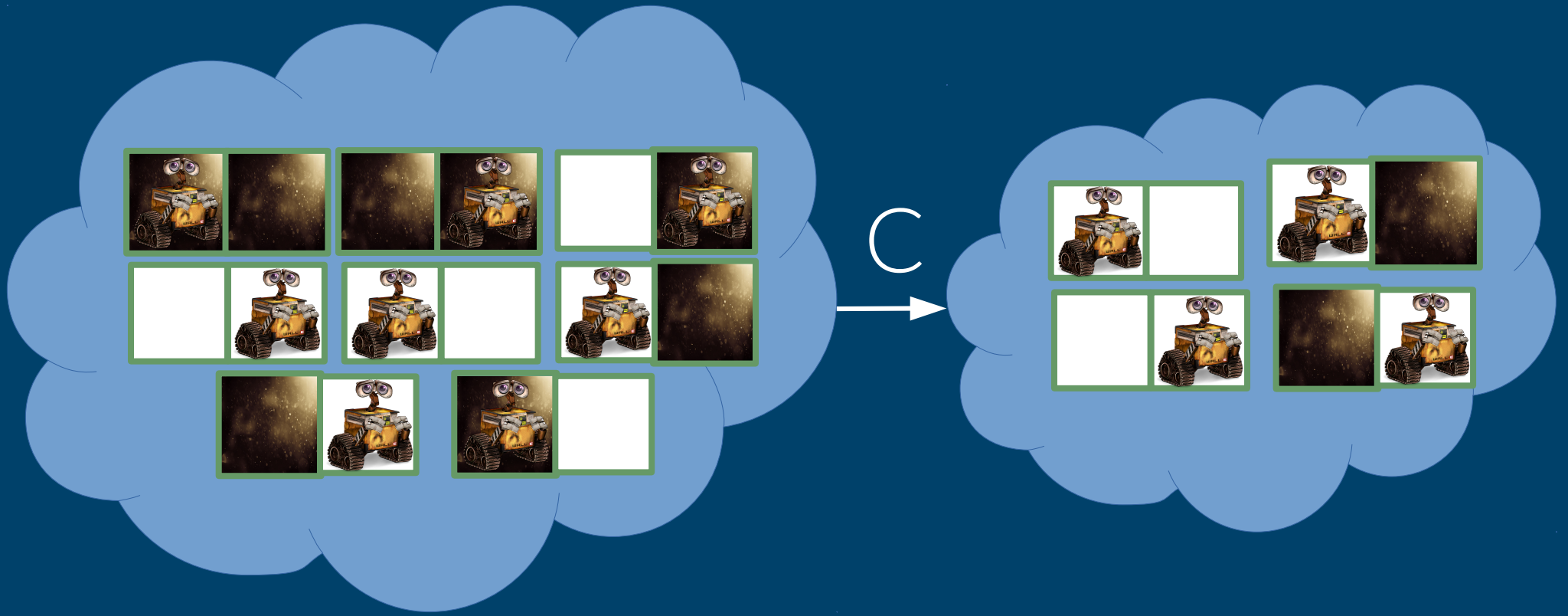
May contain one or more world states; the agent **believes** that it is in one of them.

In the beginning, we know nothing, except that we are in one of the eight states.

We then conduct actions to reduce the number of states in the belief state.



We then conduct actions to reduce the number of states in the belief state.



QUIZ (1/4)

Give a series of actions that will allow you to arrive at a belief state containing only states where both rooms are clean?

Possible actions:

R – Move to the right

L – Move to the left

C – Clean current position

ANSWER

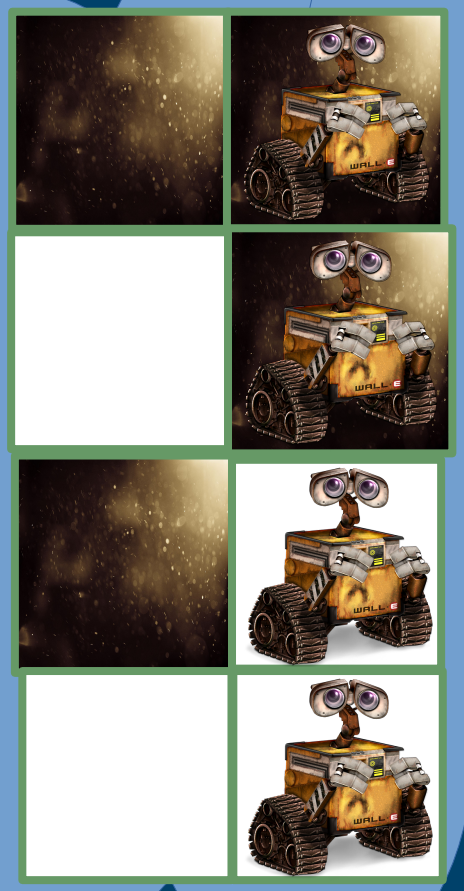
$$L \rightarrow C \rightarrow R \rightarrow C \,/\, [L, C, R, C]$$

or

$$R \rightarrow C \rightarrow L \rightarrow C \,/\, [R, C, L, C]$$

As much as possible, actions should result in a belief state with equal or less actual world states.

If an agent is capable of sensing local location and cleanliness, it can also **observe**, which should split the belief state into possibly several pieces.



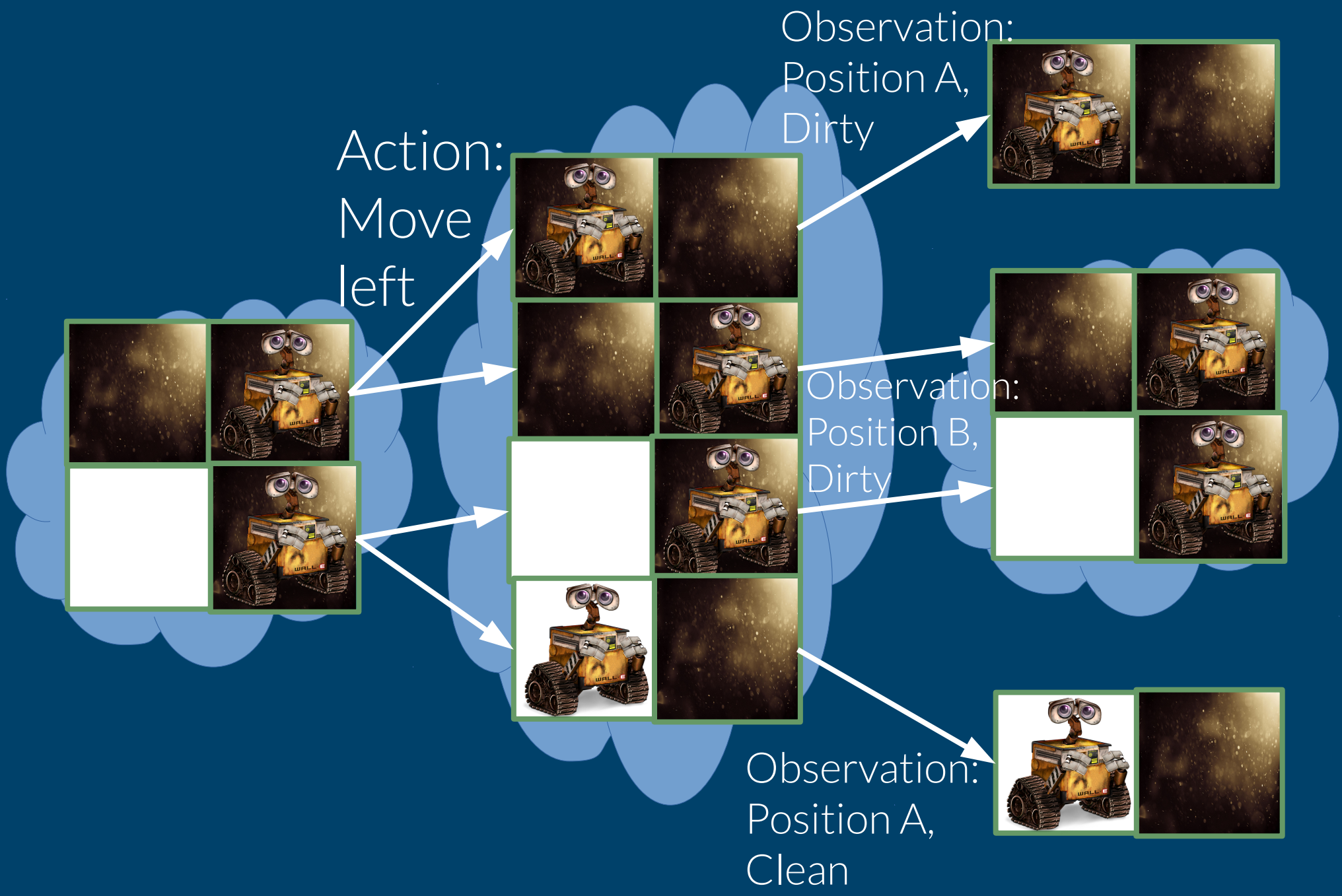
Observation:
Position B,
Dirty

Observation:
Position B,
Clean

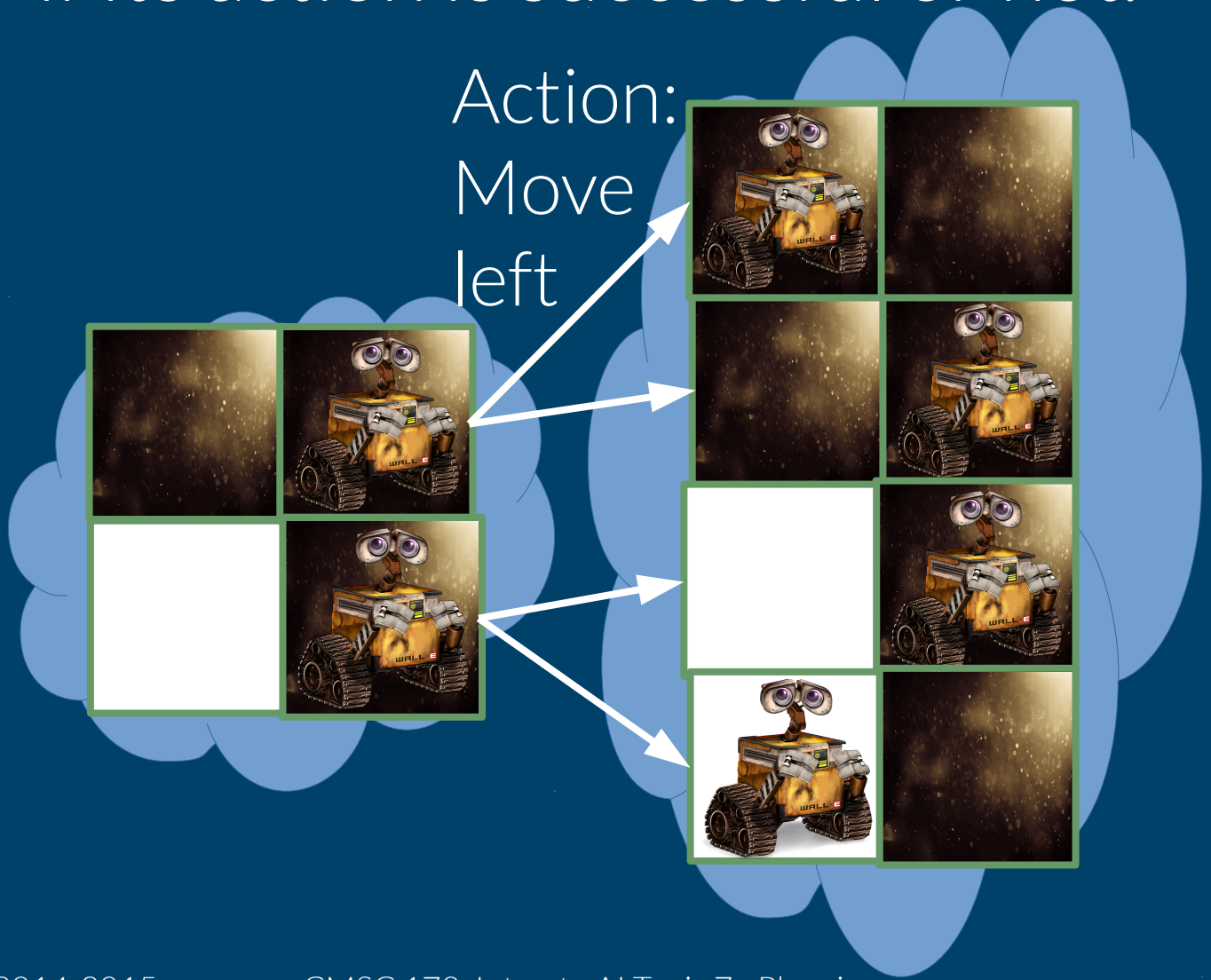
What if the environment is stochastic?

EXAMPLE

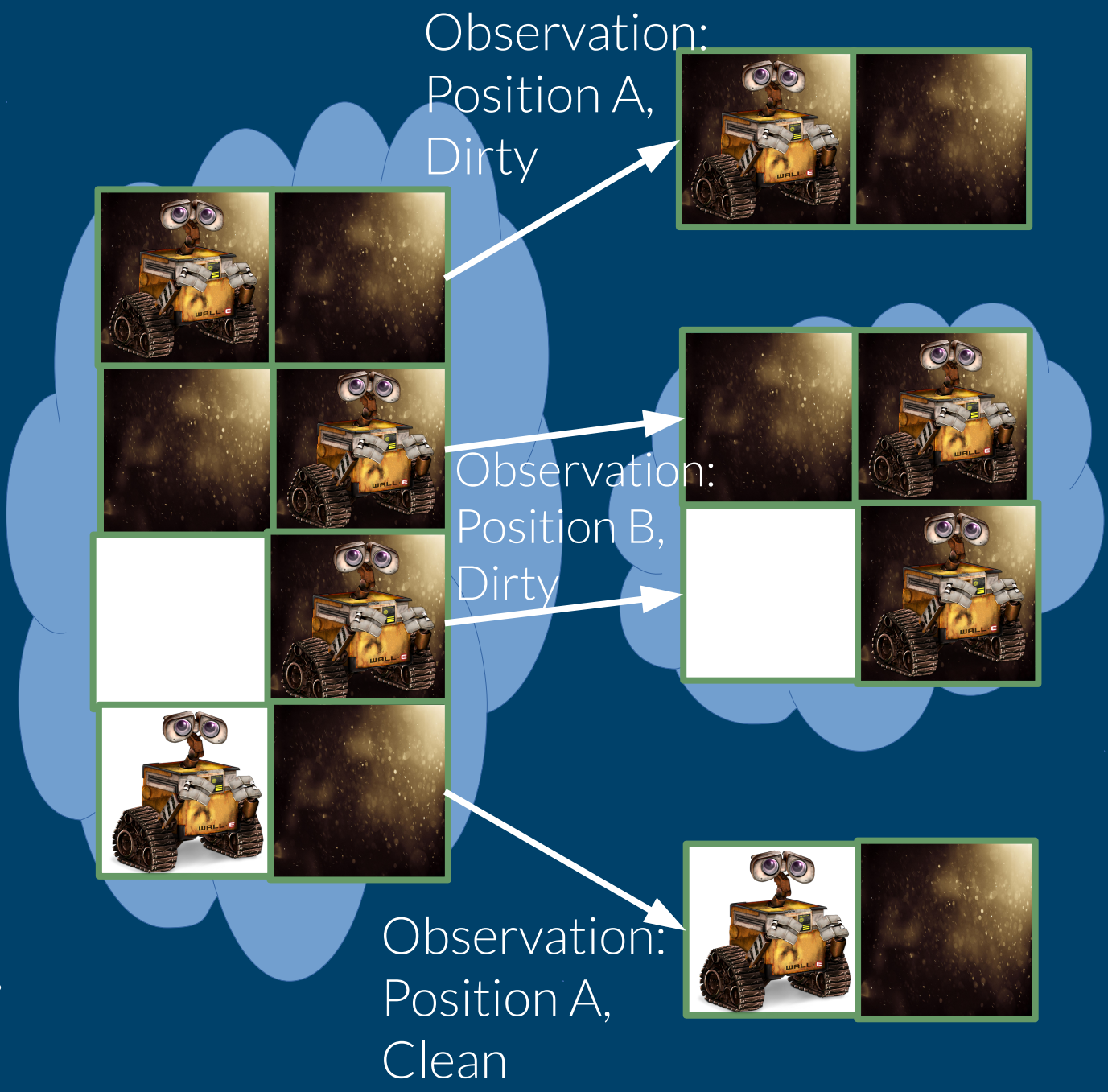
The robot has a good local sensor and vacuum, but its wheels are slippery which sometimes causes its attempts to move left or right to fail.


Action:
Move
left
Observation:
Position A,
Dirty
Observation:
Position B,
Dirty
Observation:
Position A,
Clean

In these cases, actions increase the size of the belief state because the agent does not know if its action is successful or not.

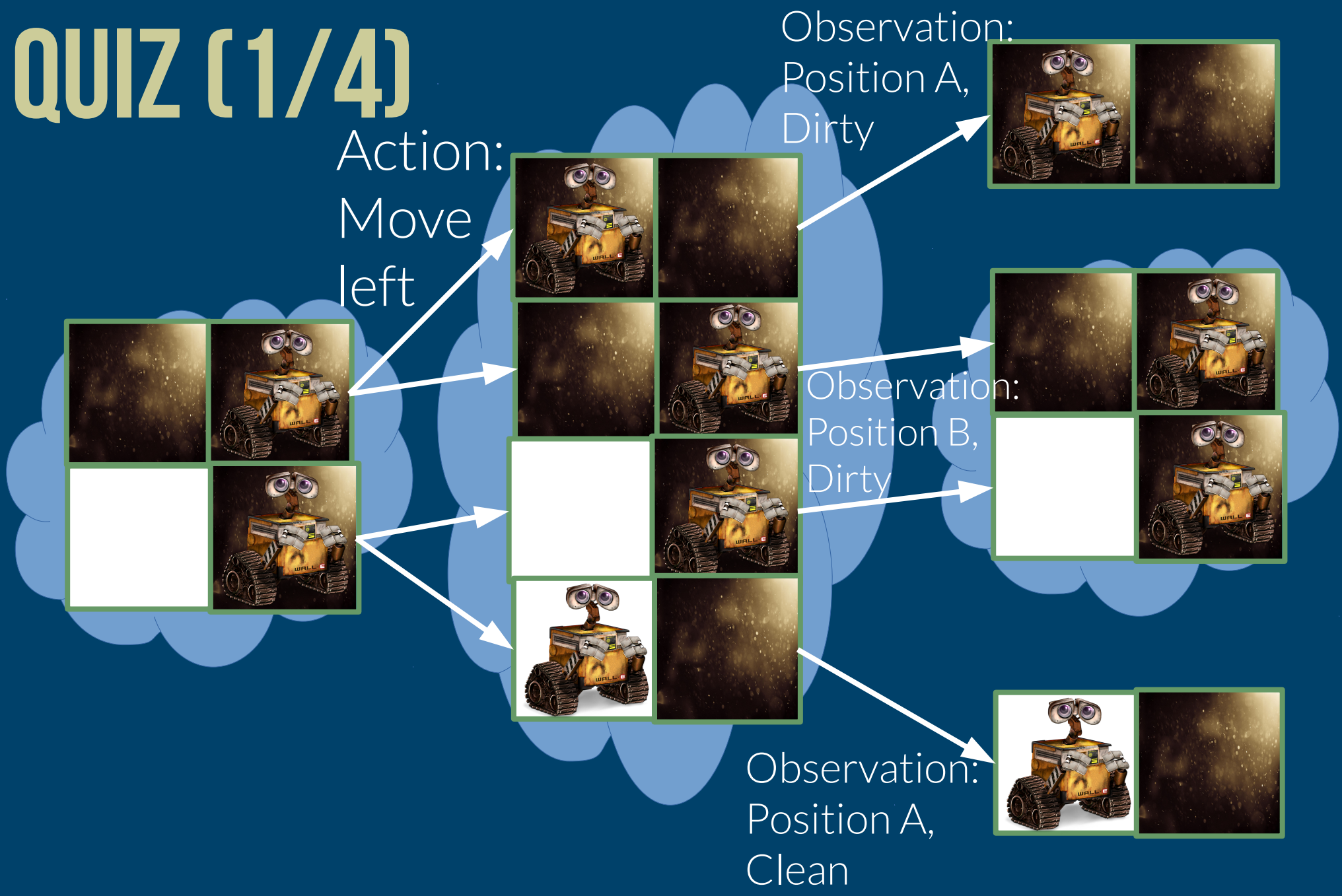


Observations then **partition** these increased belief states into possibly several belief states to check if its action was successful.



In stochastic environments, actions increase uncertainty, while observations bring uncertainty back down.

QUIZ (1/4)


Action:
Move
left
Observation:
Position A,
Dirty
Observation:
Position B,
Dirty
Observation:
Position A,
Clean

QUIZ (1/4)

Will each of the following plans always result in two clean rooms (the agent has a good local sensor and vacuum, but slippery wheels)? Answer yes or no only.

1. [C, R, C]
2. [R, C, L, C]
3. [C, R, R, C]
4. [C, R, C, R, C]

Possible actions:
C – Clean
R – Move right
L – Move left

ANSWERS

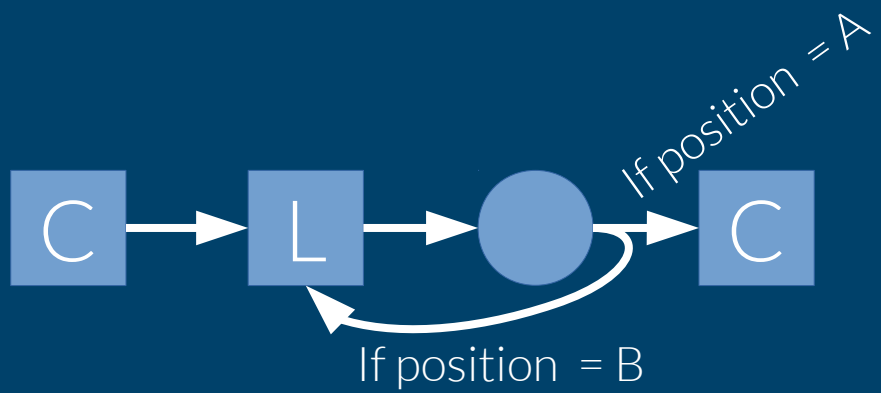
1. No
2. No
3. No
4. No

Given a stochastic environment, plans with finite steps are not guaranteed to find the goal belief/world state; we must allow notation for infinite steps.

EXAMPLE

Finite Sequence:
[C, R, C]

Infinite Sequence:



[S, while position B: L, C]

In stochastic environments, there is no way to infer the finite number of steps required to eventually reach the goal.