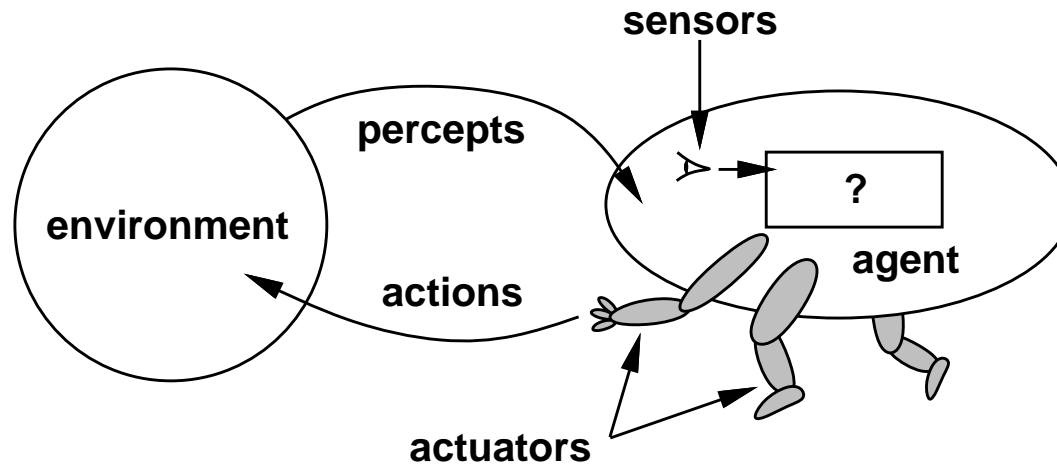


INTELLIGENT AGENTS

CHAPTER 2

Agents and environments



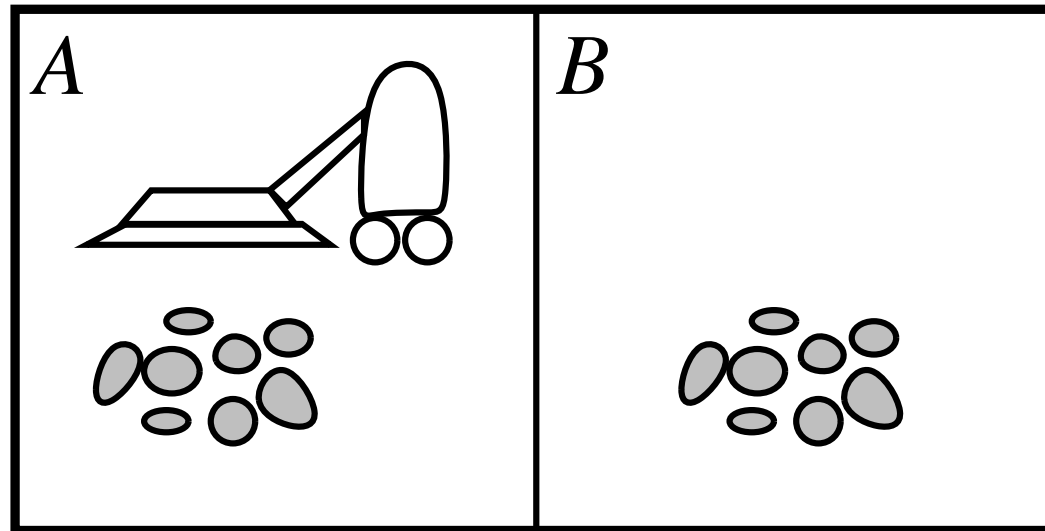
Agents include humans, robots, softbots, thermostats, etc.

The agent function maps from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

The agent program runs on the physical architecture to produce f

Vacuum-cleaner world



Percepts: location and contents, e.g., $[A, \textit{Dirty}]$

Actions: *Left*, *Right*, *Suck*, ***NoOp***

A vacuum-cleaner agent

Percept sequence	Action
$[A, \textit{Clean}]$	<i>Right</i>
$[A, \textit{Dirty}]$	<i>Suck</i>
$[B, \textit{Clean}]$	<i>Left</i>
$[B, \textit{Dirty}]$	<i>Suck</i>
$[A, \textit{Clean}], [A, \textit{Clean}]$	<i>Right</i>
$[A, \textit{Clean}], [A, \textit{Dirty}]$	<i>Suck</i>
\vdots	\vdots

function REFLEX-VACUUM-AGENT($[location, status]$) **returns** an action

if $status = \textit{Dirty}$ **then return** *Suck*
else if $location = A$ **then return** *Right*
else if $location = B$ **then return** *Left*

What is the **right** function?

Can it be implemented in a small agent program?

Rationality

Fixed **performance measure** evaluates the **environment sequence**

- one point per square cleaned up in time T ?
- one point per clean square per time step, minus one per move?
- penalize for $> k$ dirty squares?

A **rational agent** chooses whichever action maximizes the **expected** value of the performance measure **given the percept sequence to date**

Rational \neq omniscient

- percepts may not supply all relevant information

Rational \neq clairvoyant

- action outcomes may not be as expected

Hence, rational \neq successful

Rational \Rightarrow exploration, learning, autonomy

PEAS

To design a rational agent, we must specify the **task environment**

Consider, e.g., the task of designing an automated taxi:

Performance measure??

Environment??

Actuators??

Sensors??

PEAS

To design a rational agent, we must specify the **task environment**

Consider, e.g., the task of designing an automated taxi:

Performance measure?? safety, destination, profits, legality, comfort, ...

Environment?? US streets/freeways, traffic, pedestrians, weather, ...

Actuators?? steering, accelerator, brake, horn, speaker/display, ...

Sensors?? video, accelerometers, gauges, engine sensors, keyboard, GPS, ...

Internet shopping agent

Performance measure??

Environment??

Actuators??

Sensors??

Internet shopping agent

Performance measure?? price, quality, appropriateness, efficiency

Environment?? current and future WWW sites, vendors, shippers

Actuators?? display to user, follow URL, fill in form

Sensors?? HTML pages (text, graphics, scripts)

Environment types

	Solitaire	Backgammon	Internet shopping	Taxi
<u>Observable??</u> <u>Deterministic??</u> <u>Episodic??</u> <u>Static??</u> <u>Discrete??</u> <u>Single-agent??</u>				

Environment types

	Solitaire	Backgammon	Internet shopping	Taxi
<u>Observable??</u>	Yes	Yes	No	No
<u>Deterministic??</u>				
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Environment types

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Environment types

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<u>Episodic??</u>	No	No	No	No
<u>Static??</u>	Yes	Semi	Semi	No
<u>Discrete??</u>	Yes	Yes	Yes	No
<u>Single-agent??</u>	Yes	No	Yes (except auctions)	No

The environment type largely determines the agent design

The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

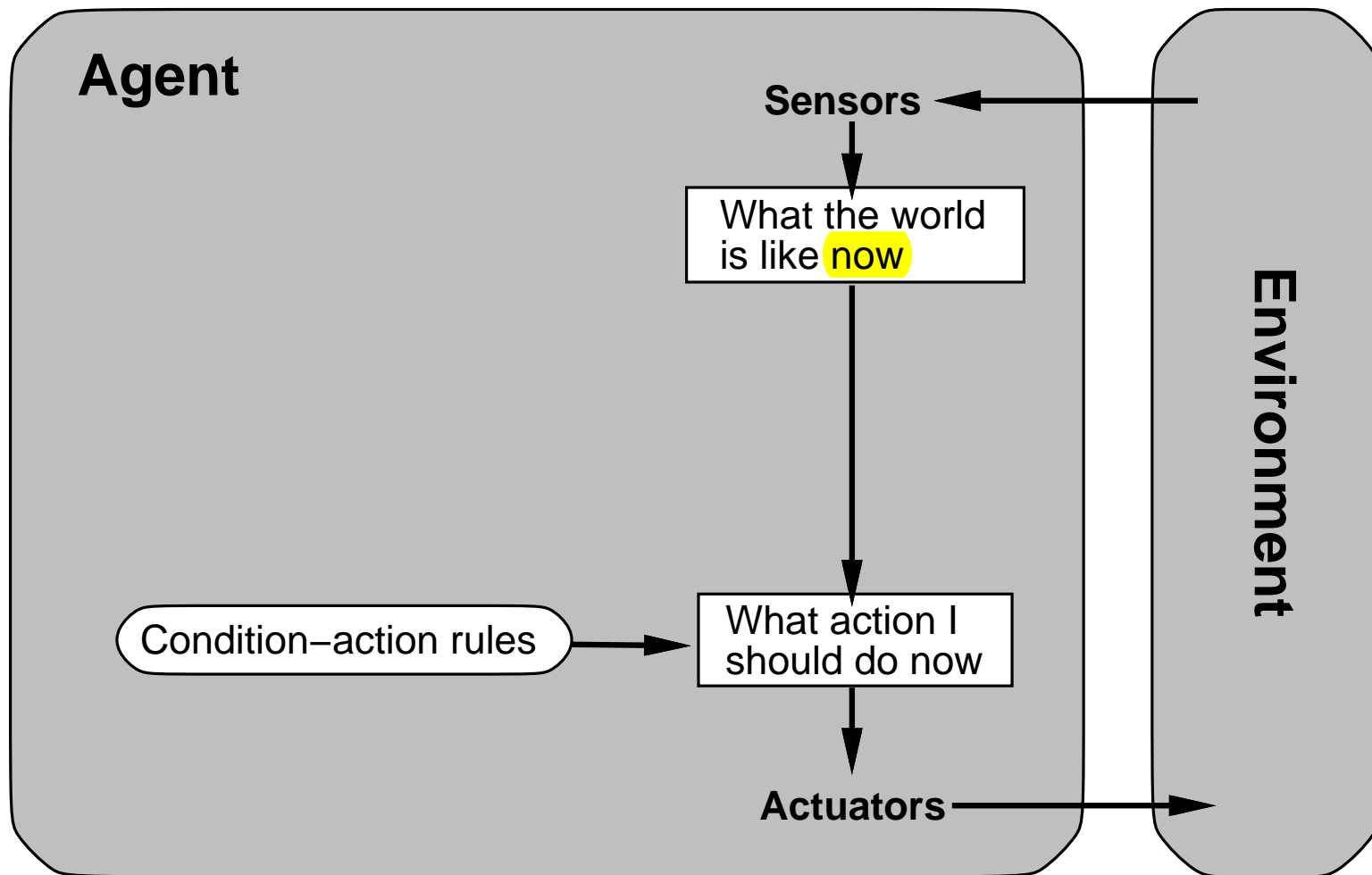
Agent types

Four basic types in order of increasing generality:

- simple reflex agents
- reflex agents with state
- goal-based agents
- utility-based agents

All these can be turned into learning agents

Simple reflex agents



Example

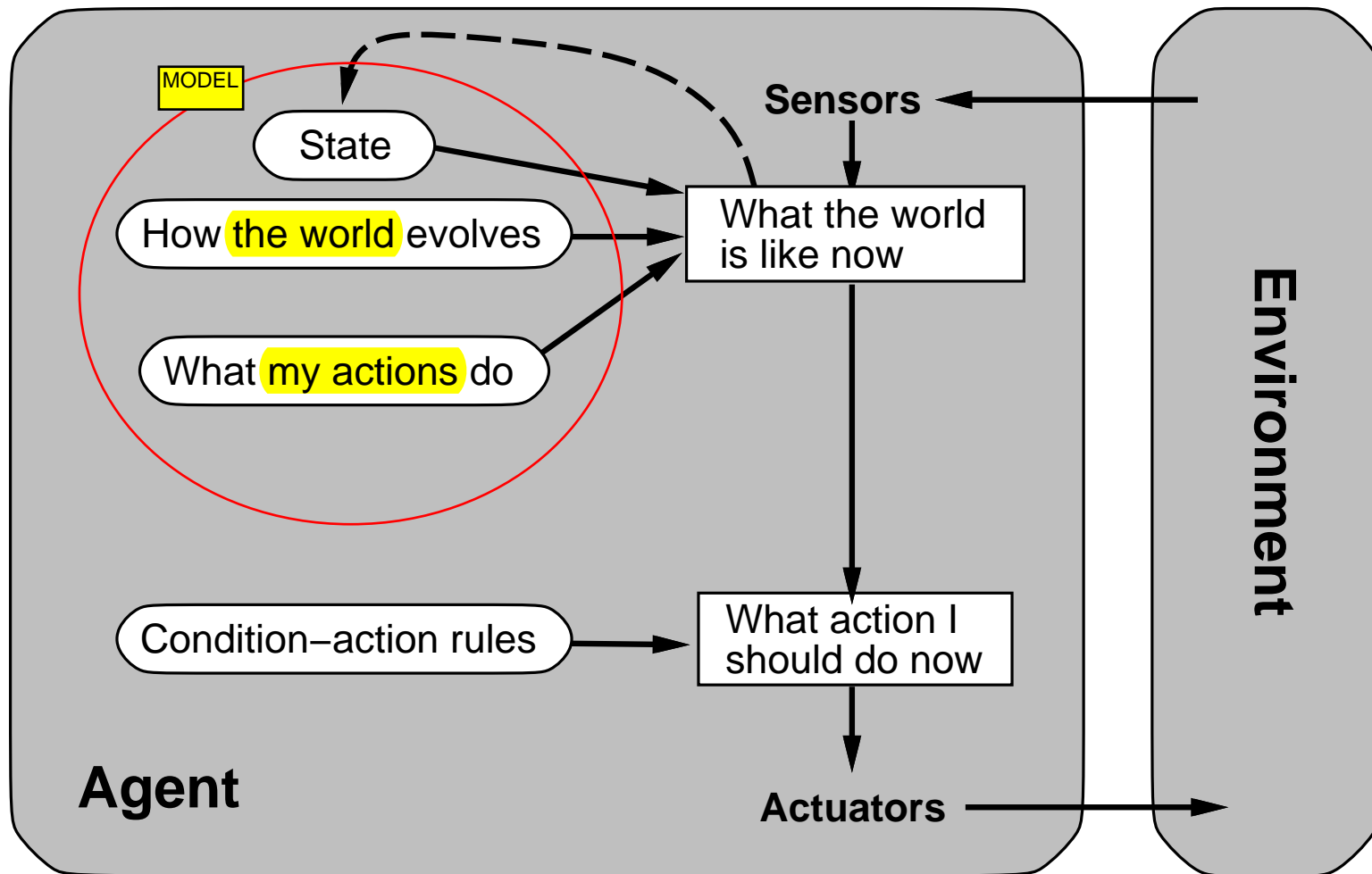
function REFLEX-VACUUM-AGENT([*location,status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = *B* **then return** *Left*

```
(setq joe (make-agent :name 'joe :body (make-agent-body)
                      :program (make-reflex-vacuum-agent-program)))
```

```
(defun make-reflex-vacuum-agent-program ()
  #'(lambda (percept)
      (let ((location (first percept)) (status (second percept)))
        (cond ((eq status 'dirty) 'Suck)
              ((eq location 'A) 'Right)
              ((eq location 'B) 'Left))))))
```

Reflex agents with state

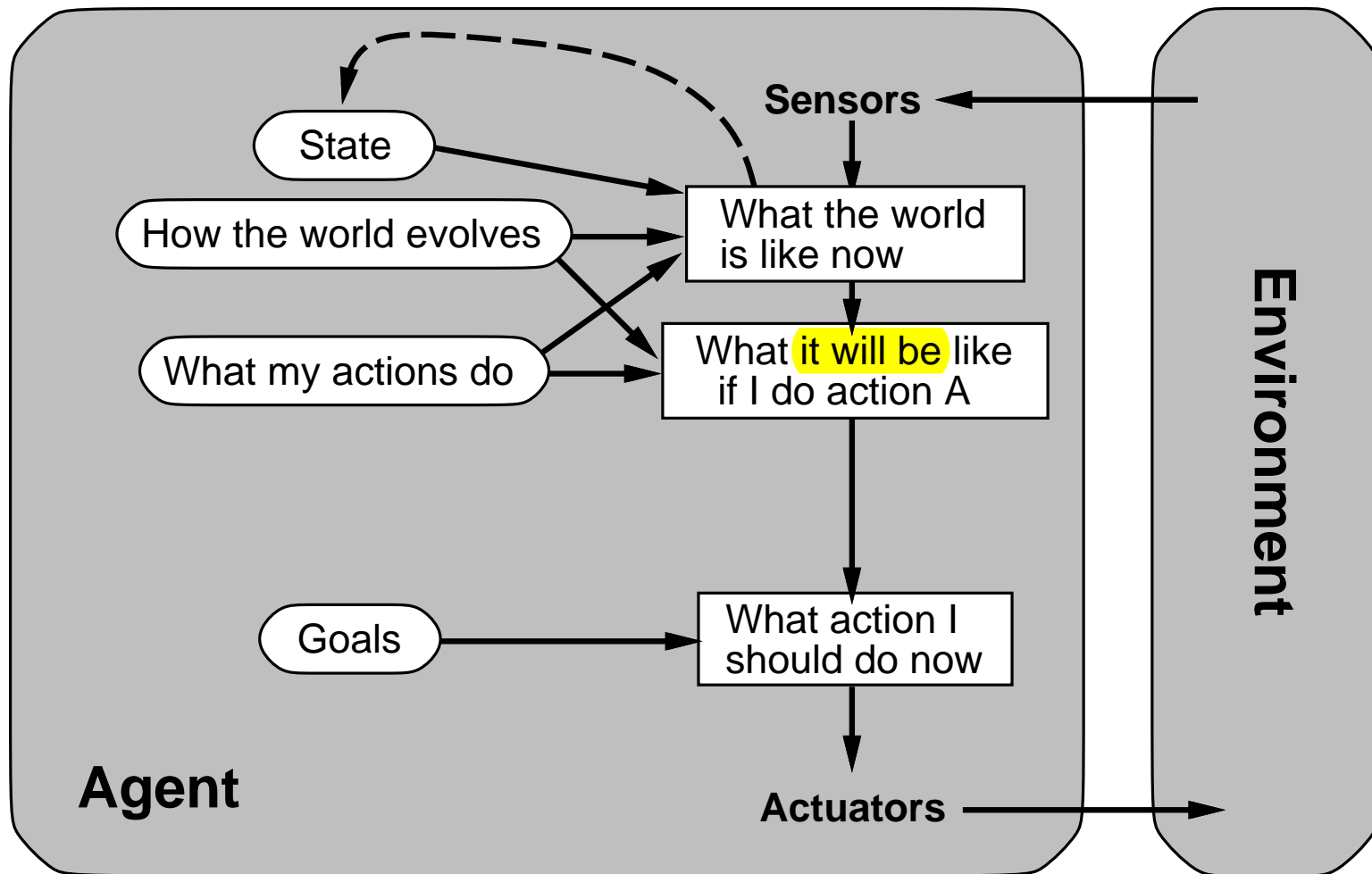


Example

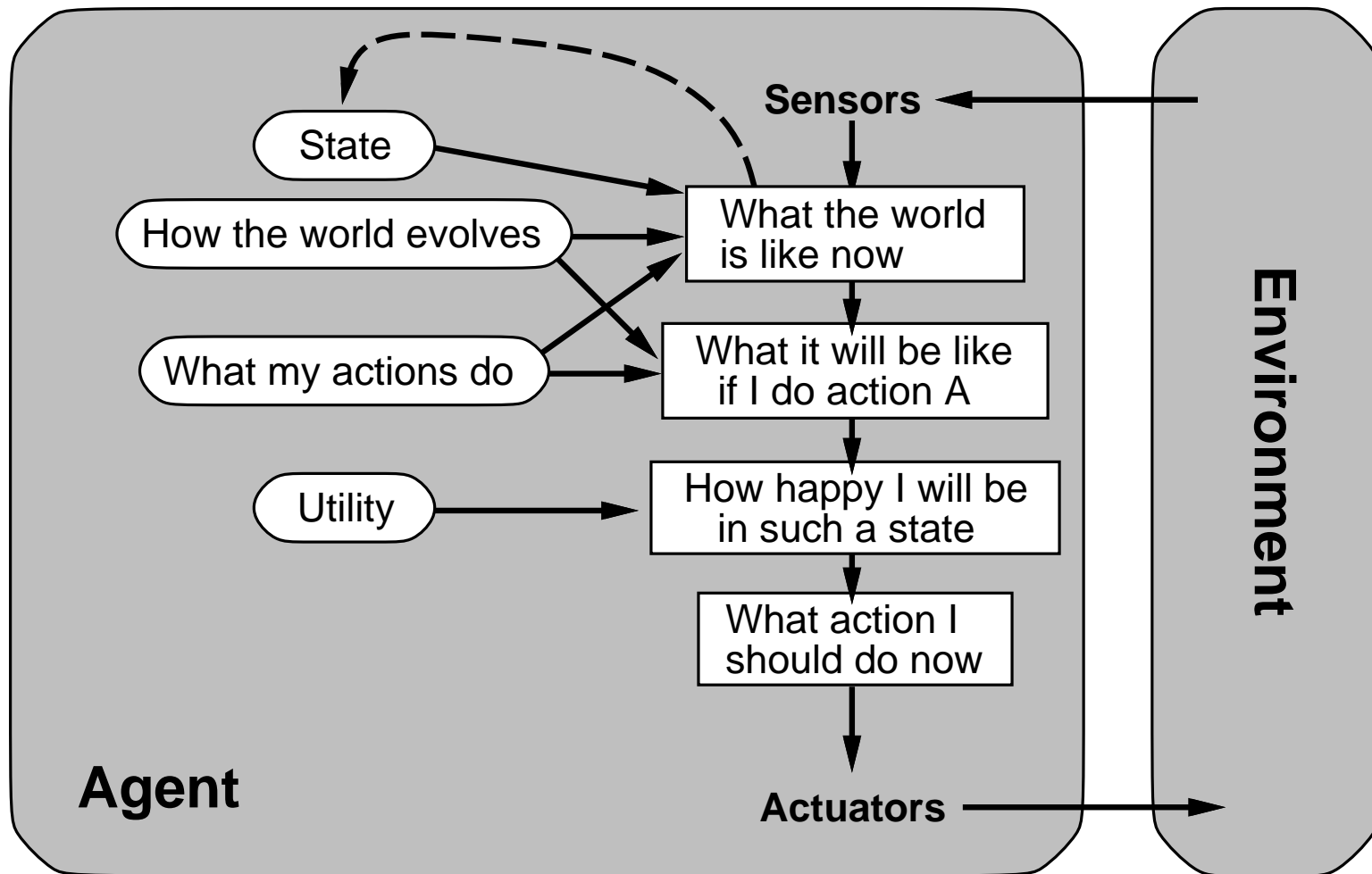
function REFLEX-VACUUM-AGENT(*[location,status]*) **returns** an action
static: *last_A, last_B*, numbers, initially ∞
if *status = Dirty* **then** ...

```
(defun make-reflex-vacuum-agent-with-state-program ()
  (let ((last-A infinity) (last-B infinity))
    #'(lambda (percept)
      (let ((location (first percept)) (status (second percept)))
        (incf last-A) (incf last-B)
        (cond
         ((eq status 'dirty)
          (if (eq location 'A) (setq last-A 0) (setq last-B 0))
          'Suck)
         ((eq location 'A) (if (> last-B 3) 'Right 'NoOp))
         ((eq location 'B) (if (> last-A 3) 'Left 'NoOp)))))))
```

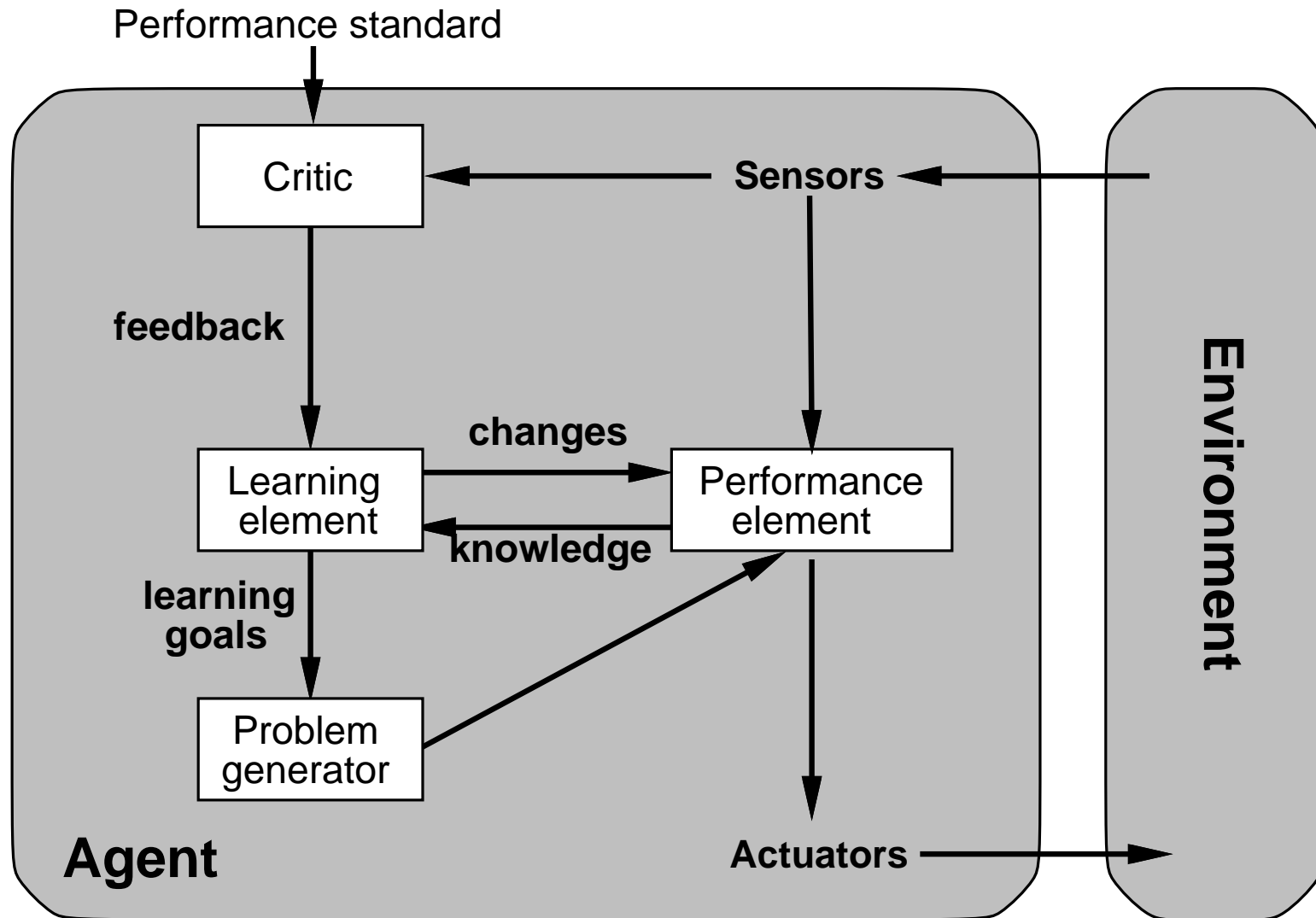
Goal-based agents



Utility-based agents



Learning agents



Summary

Agents interact with environments through actuators and sensors

The agent function describes what the agent does in all circumstances

The performance measure evaluates the environment sequence

A perfectly rational agent maximizes expected performance

Agent programs implement (some) agent functions

PEAS descriptions define task environments

Environments are categorized along several dimensions:

observable? deterministic? episodic? static? discrete? single-agent?

Several basic agent architectures exist:

reflex, reflex with state, goal-based, utility-based