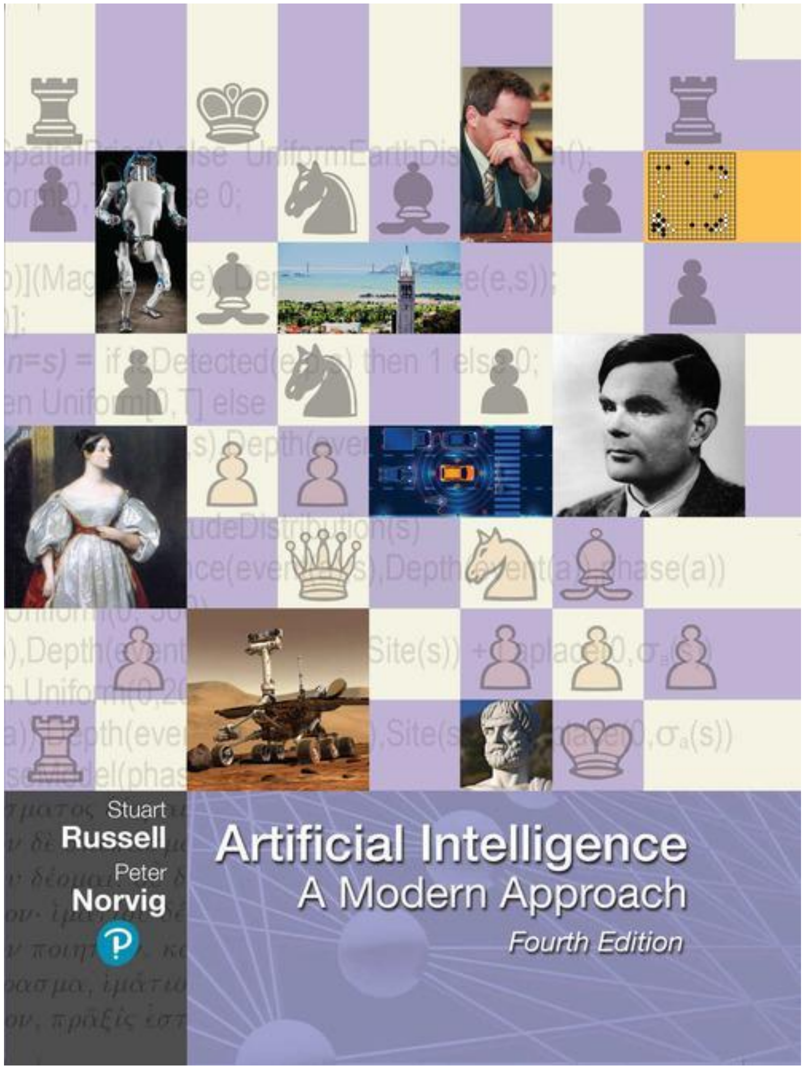
Artificial Intelligence: A Modern Approach

Fourth Edition



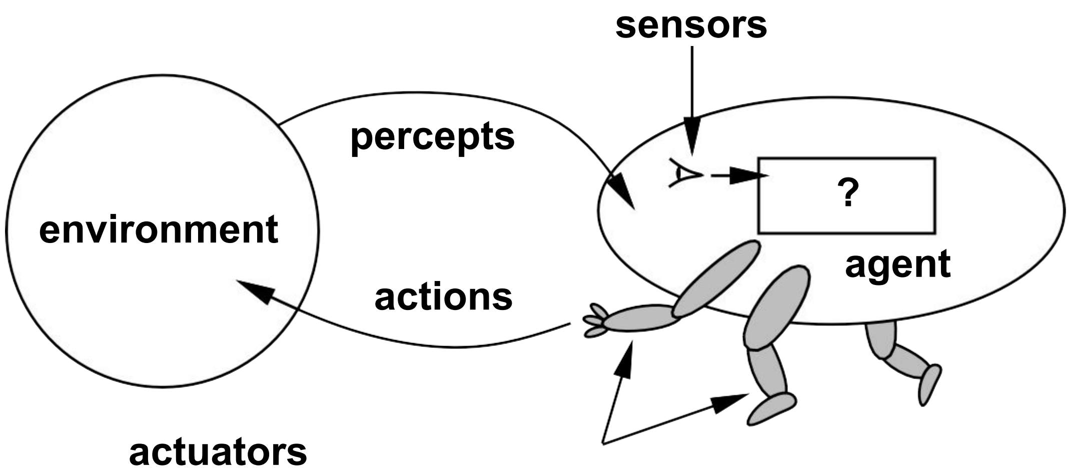
Chapter 2

Intelligent Agents

Outline

- Agents and environments
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

Agents and environments



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

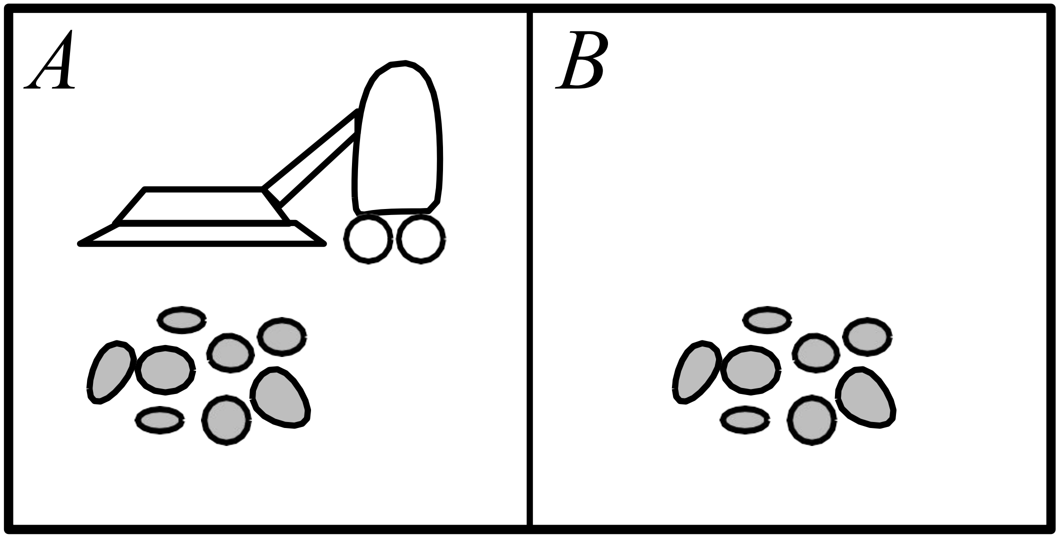
An agent can be anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

The agent function maps from percept histories to actions:

$$f : P^* \rightarrow A$$

The agent program runs on the physical architecture to produce f

Vacuum-cleaner world



Percepts: location and contents, e.g., [*A*, *Dirty*]

Actions: *Left*, *Right*, *Suck*, *N oOp*

A vacuum-cleaner agent

Percept sequence	Action
[*A*, *Clean*]	*Right*
[*A*, *Dirty*]	*Suck*
[*B*, *Clean*]	*Left*
[*B*, *Dirty*]	*Suck*
[*A*, *Clean*], [*A*, *Clean*]	*Right*
[*A*, *Clean*], [*A*, *Dirty*]	*Suck*
.	.

```
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
```

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 /= omniscient

– percepts may not supply all relevant information

Rational /= clairvoyant

– action outcomes may not be as expected

Hence, rational /= 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??

- Environm

  ent??

- 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
Observable?? Deterministic?? Episodic?? Static?? Discrete?? Single-agent??	

Environment types

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	Yes	Yes	No	No
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

Environment types

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	Yes	Yes	No	No
Deterministic??	Yes	No	Partly	No
Episodic??				
Static??				
Discrete??				
Single-agent??				

Environment types

	Solitaire Backgammon Internet shopping Taxi
Observable??	Yes Yes No No
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Episodic??	No No No No
Static??	
Discrete??	
Single-agent??	

Environment types

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Deterministic??	Yes	No	Partly	No
Episodic??	No	No	No	No
Static??	Yes	Semi	Semi	No
Discrete??				
Single-agent??				

Environment types

	Solitaire	Backgammon	Internet shopping	Taxi
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Discrete??	Yes	Yes	Yes	No
Single-agent??				

Environment types

	Solitaire Backgammon Internet shopping Taxi
Observable??	Yes Yes No No
Deterministic?	Yes No Partly No
? Episodic??	No No No No
Static??	Yes Semi Semi No
Discrete??	Yes Yes Yes No Yes No Yes (except
Single-agent?	auctions)No
?	

The environment type largely determines the agent design

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

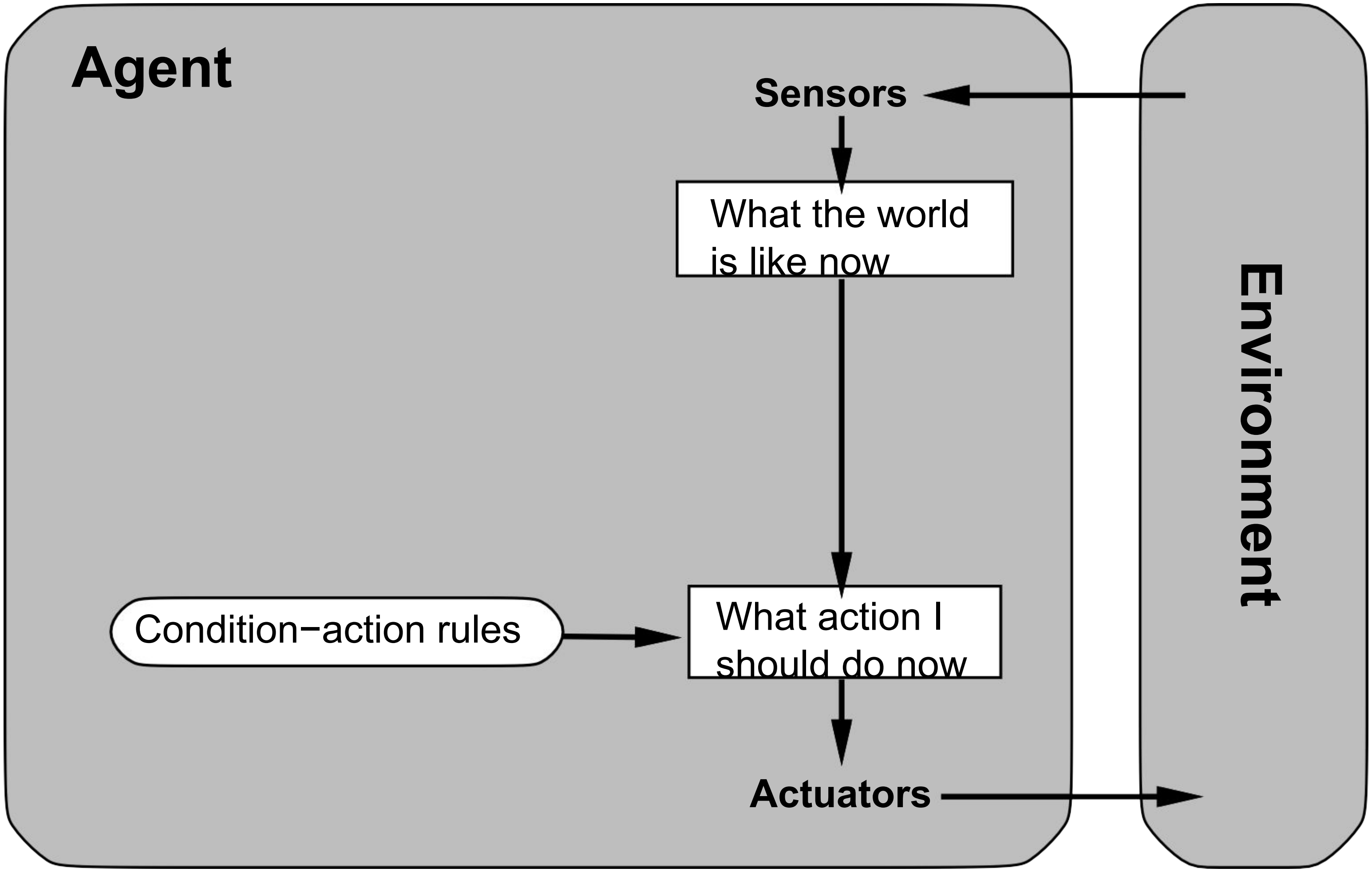
Agent types

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



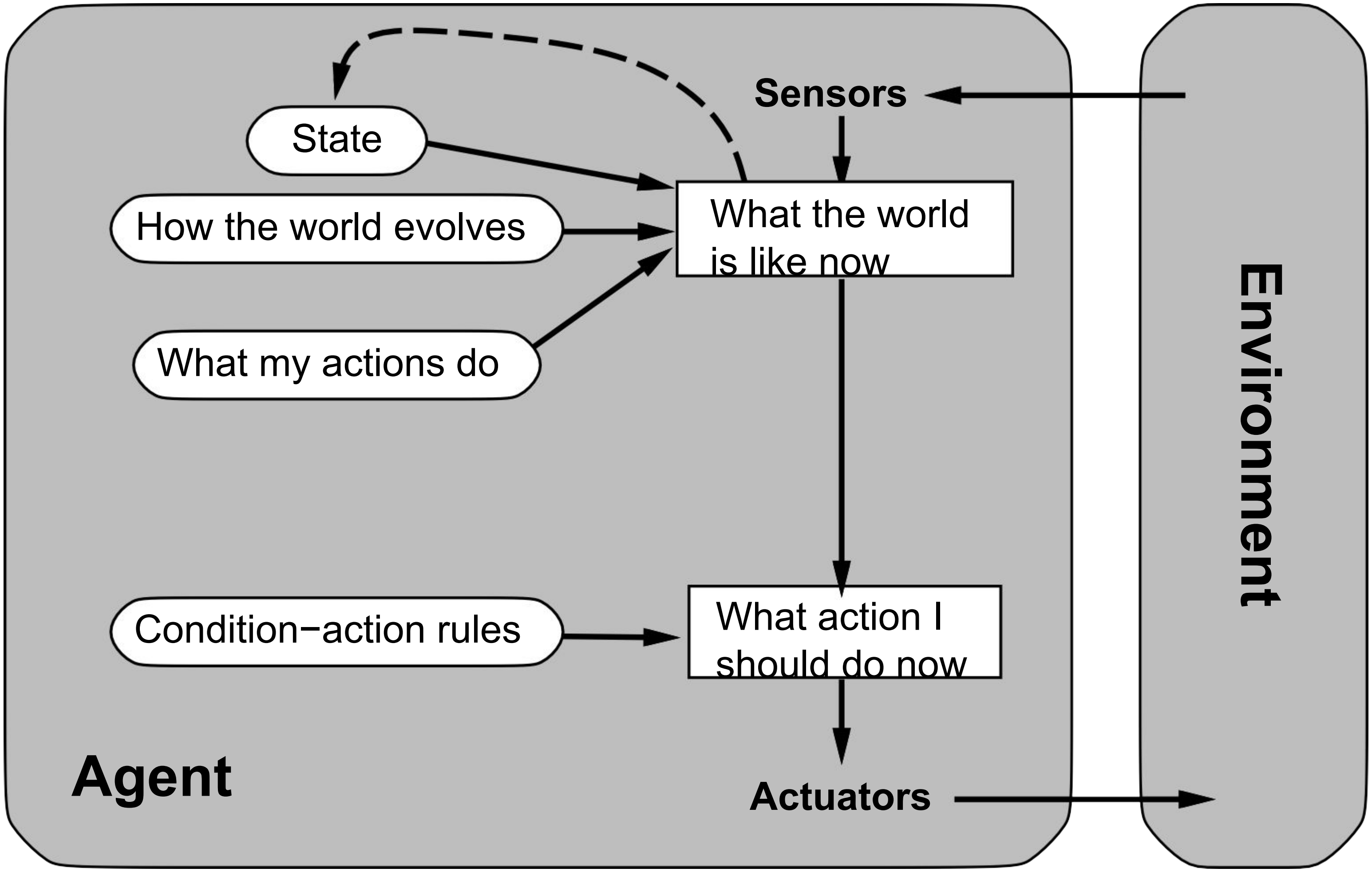
Example

```
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

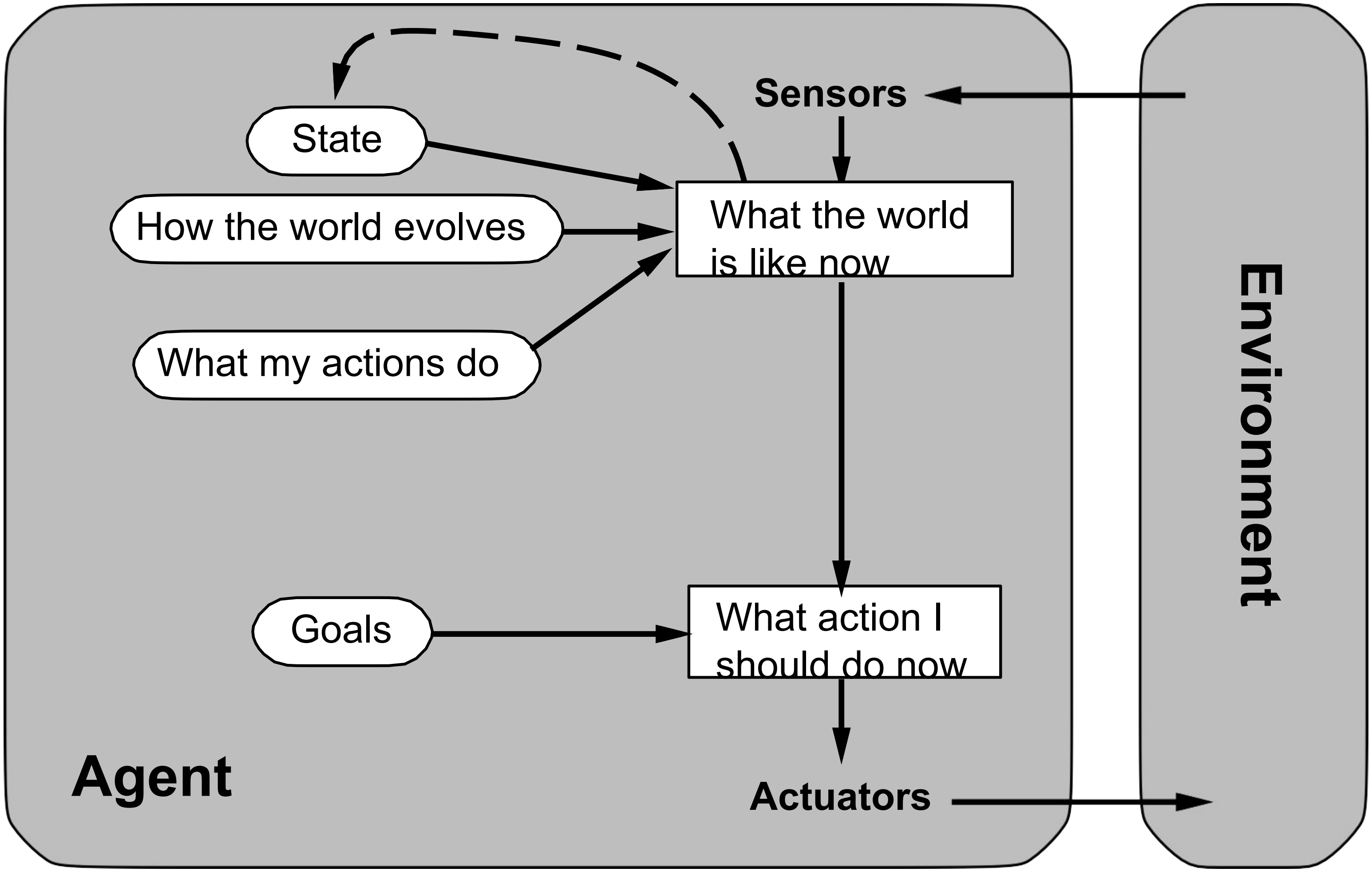


Example

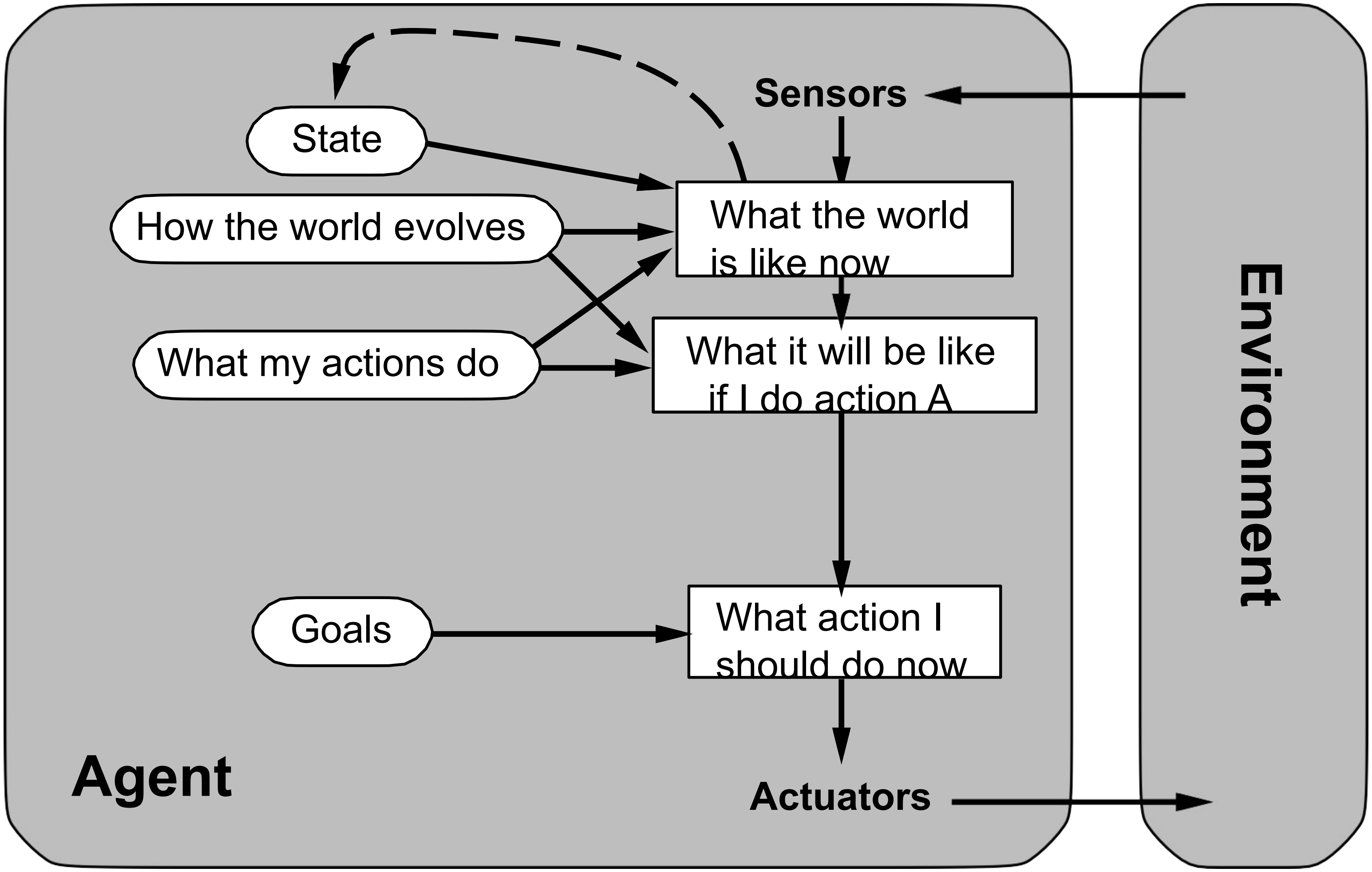
```
function Reflex-Vacuum-Agent( [location,status]) returns an action
static: last_A, last_B, numbers, initially ∞
    if status = Dirty then . . .
```

```
(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)))))))
```

Model-based agents

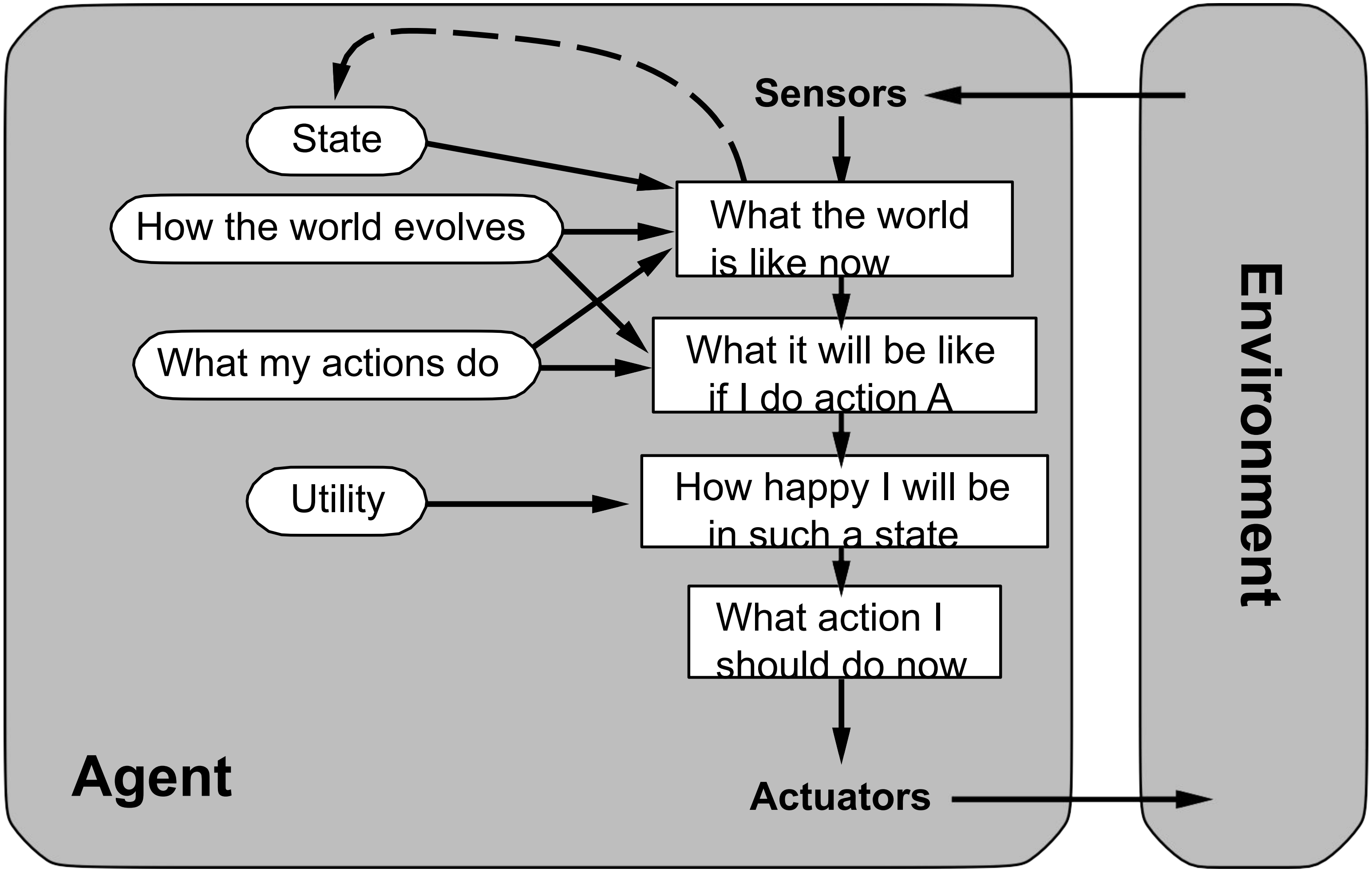


Goal-based agents

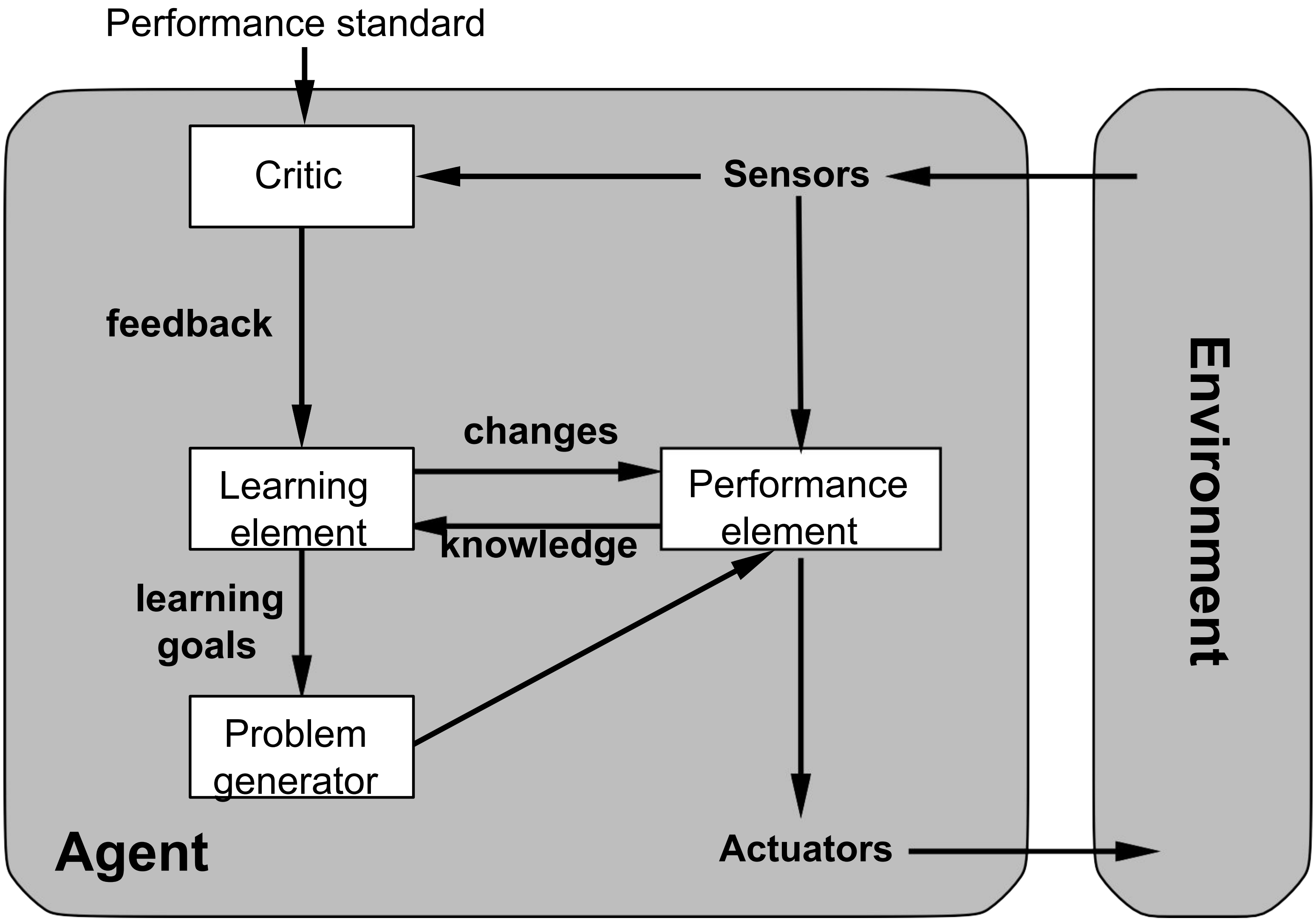


Sensors
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Goals
What action I should do now
Agent
Actuators
Environment

Utility-based agents


Sensors
State
How the world evolves
What my actions do
Utility
What the world is like now
What it will be like if I do action A
How happy I will be in such a state
What action I should do now
Agent
Actuators
Environment

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