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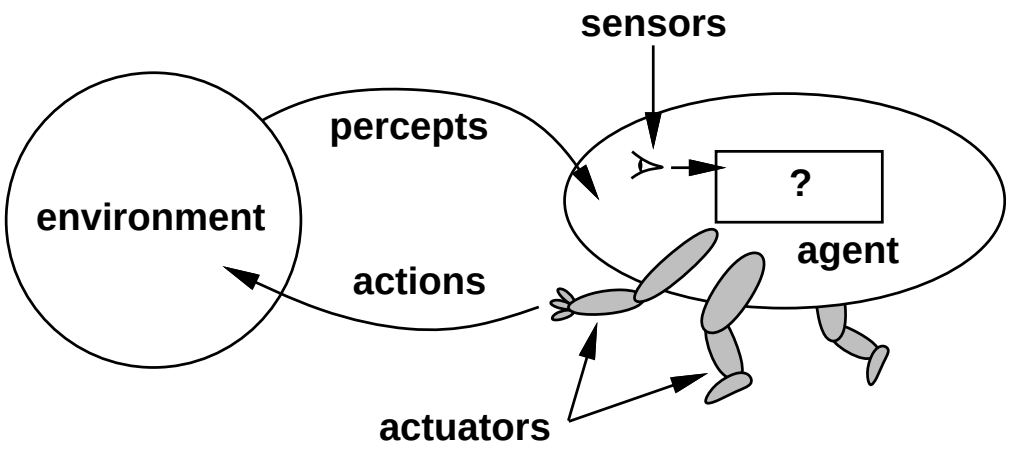
Intelligent Agents

CMSC 421: Chapter 2

Agents and environments



♢ Russell & Norvig's book is based on the notion of *intelligent agents*

- humans, robots, softbots, thermostats, etc.

♢ The *agent function* maps from percept histories to actions:

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

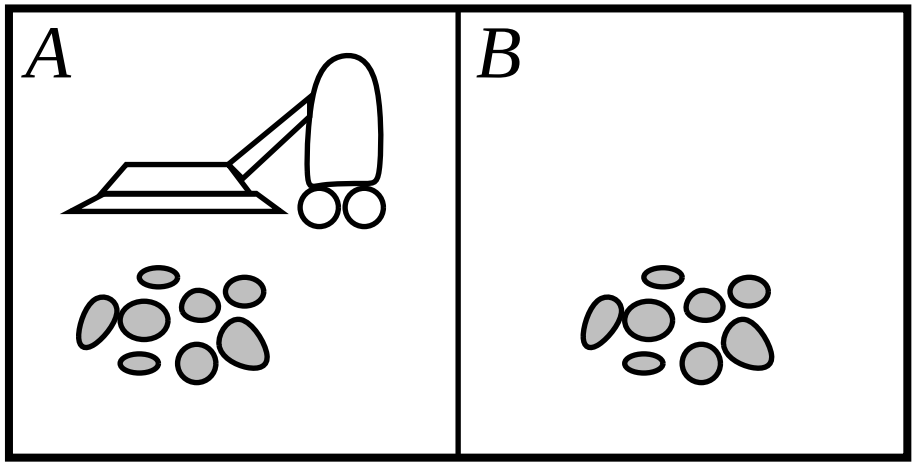
♢ The *agent program* runs on the physical *architecture* to produce f

Outline

Chapter 2 describes some basic concepts relating to agents

- ♢ Agents and environments
- ♢ Rationality
- ♢ The PEAS model of an environment
- ♢ Environment types
- ♢ Agent types

Vacuum-cleaner world



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

Actions: $Left$, $Right$, $Suck$, $NoOp$

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 $\neq$ omniscient
  - percepts may not supply all relevant information
- Rational $\neq$ clairvoyant
  - action outcomes may not be as expected
- Hence, rational $\neq$ successful
- Rational $\Longrightarrow$ 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? 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
Fully observable?				
Deterministic?				
Episodic?				
Static?				
Discrete?				
Single-agent?				

Environment types

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Environment types

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

*After the cards have been dealt

Episodic: task divided into episodes, each to be considered only by itself
Sequential: Current decision may affect all future decisions

Environment types

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

*After the cards have been dealt

Static: the world does not change while the agent is thinking

Environment types

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

*After the cards have been dealt

The environment type largely determines the agent design

Real world: partially observable, stochastic, sequential, dynamic, continuous, multi-agent

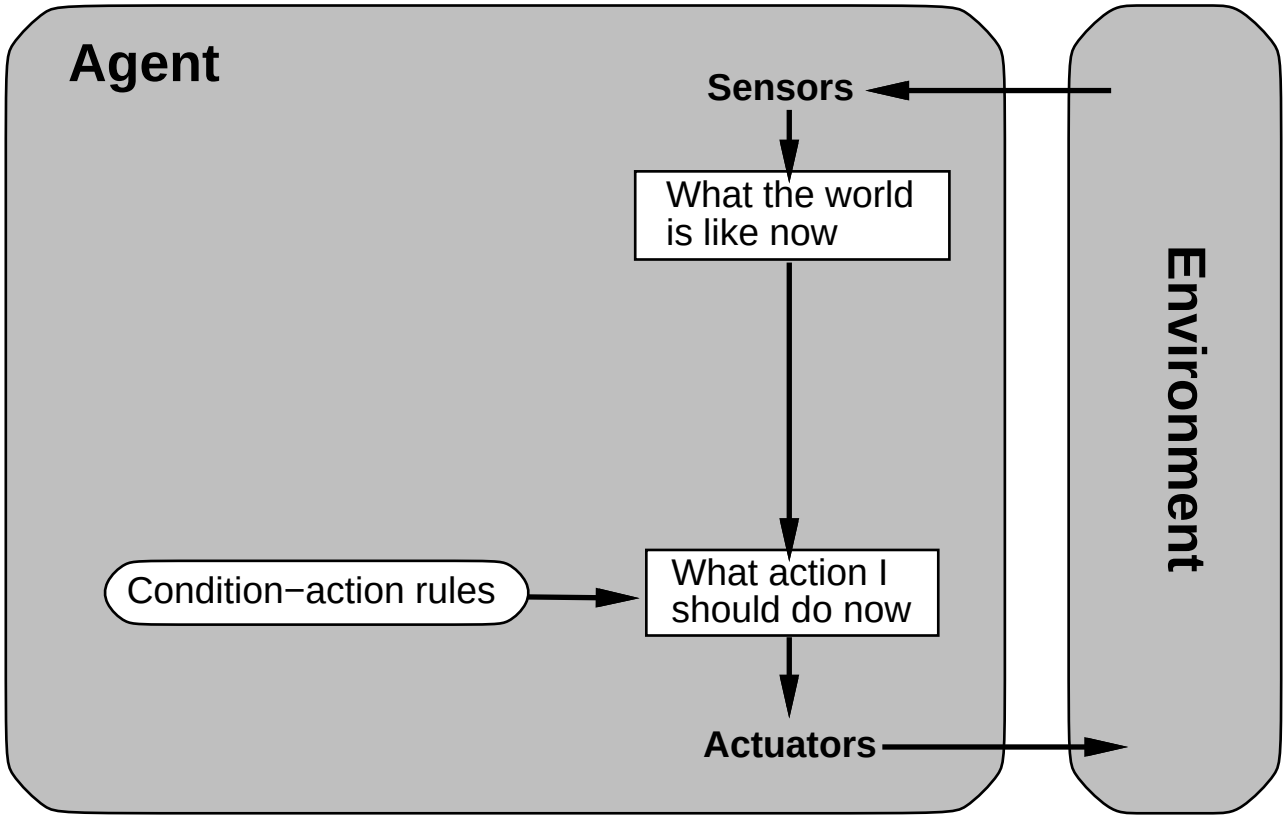
Agent types

♢ Four basic types in order of increasing generality:

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

♢ All of these can be turned into learning agents

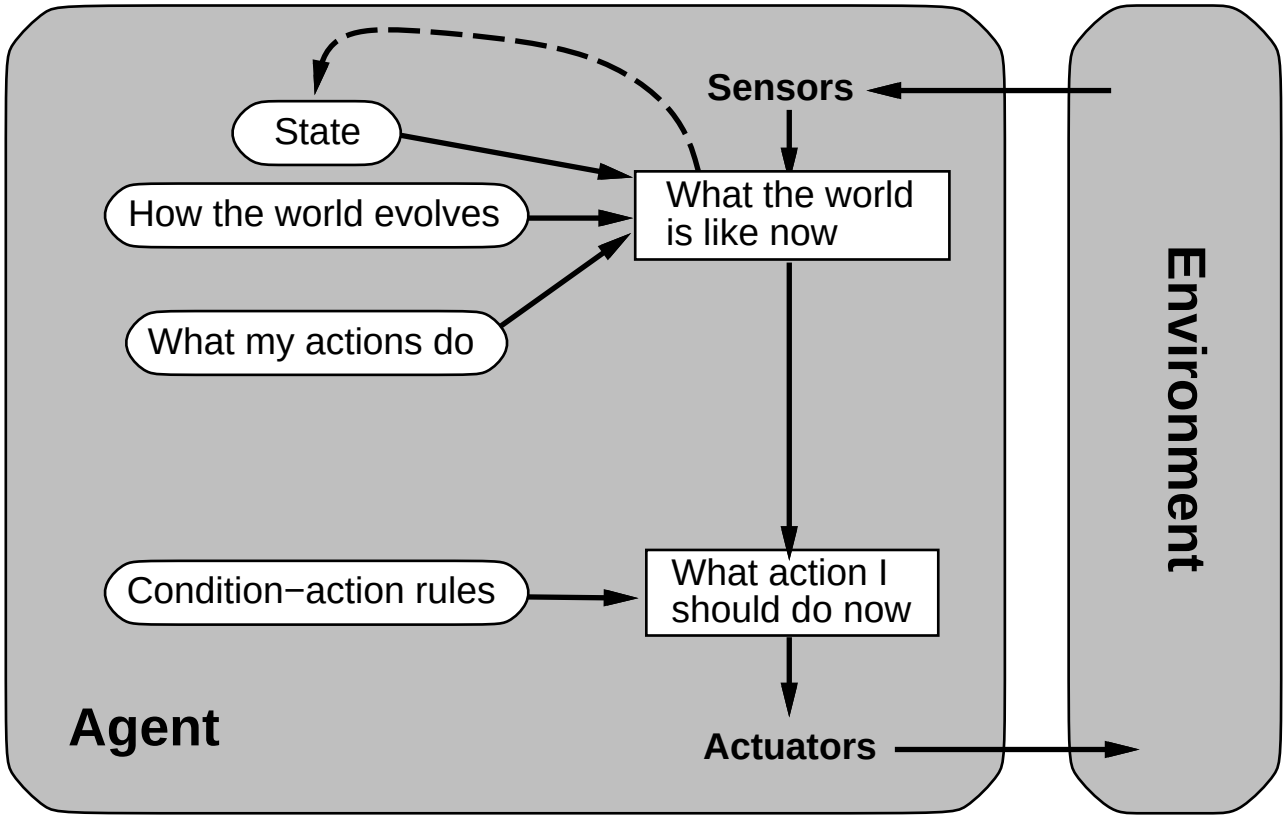
Simple reflex agent



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*

Reflex agent with state



♢ E.g., a vacuum-cleaning agent that can't sense what room it's in, but can remember its location

- next page ...

Example

Vacuum-cleaning agent that remembers its location:

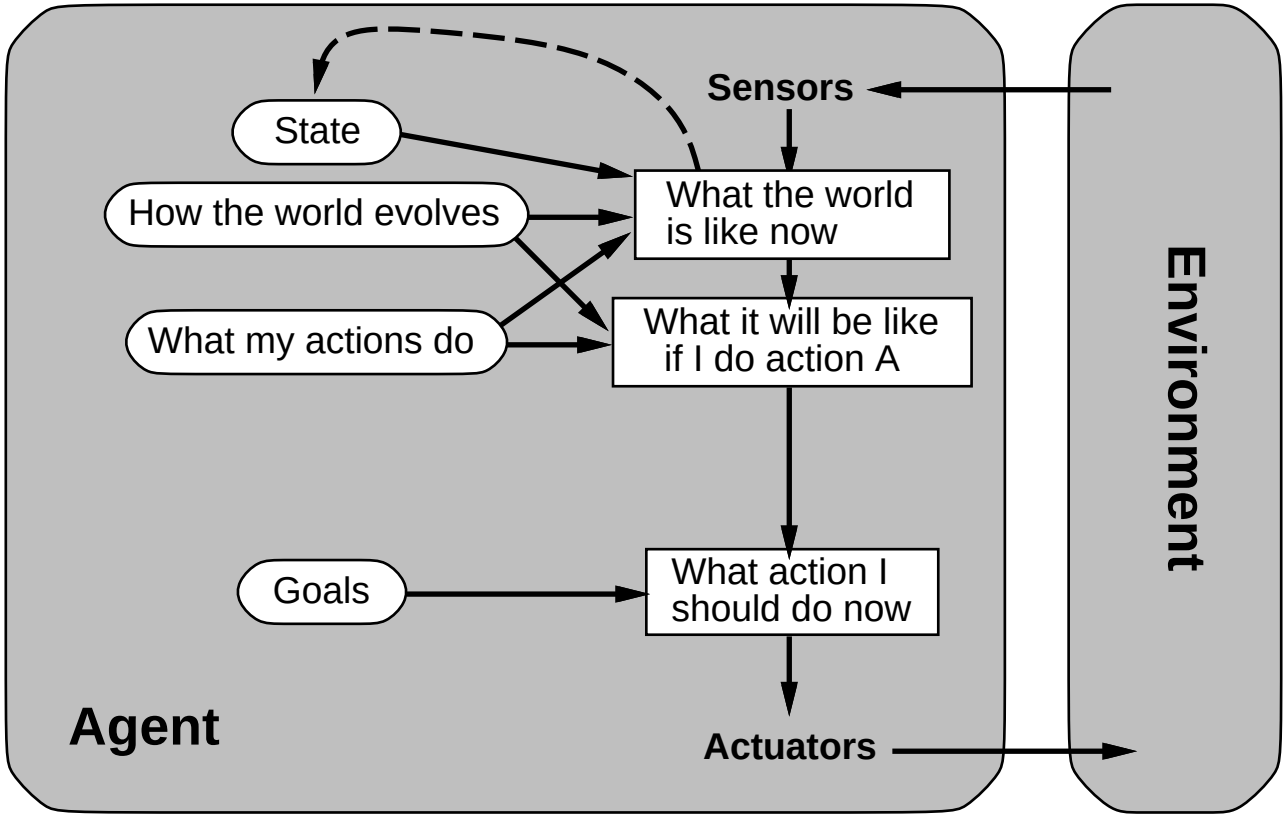
```
function VACUUM-AGENT-WITH-STATE( [location]) returns an action
static: location, initially A

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

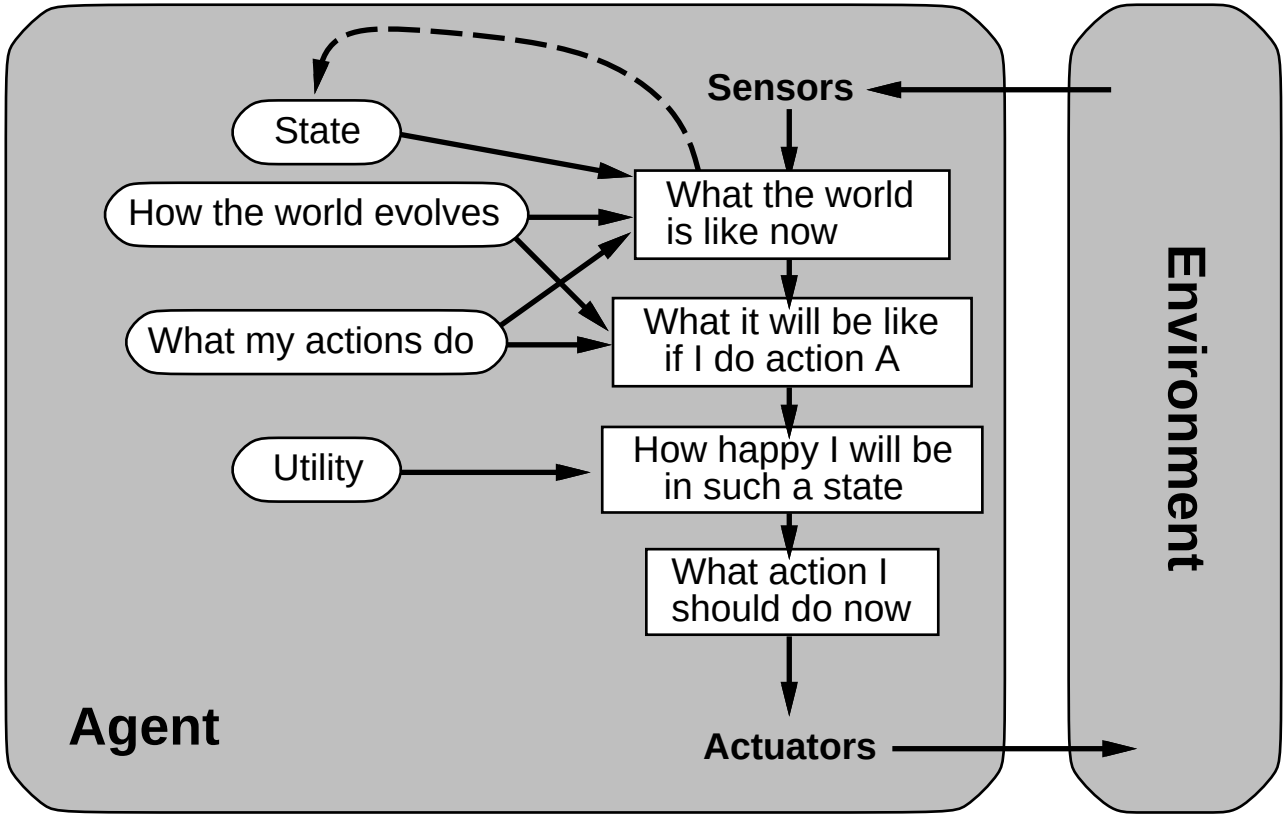
♢ The pseudocode assumes the agent always starts out in room A.

- What if we didn't know this?

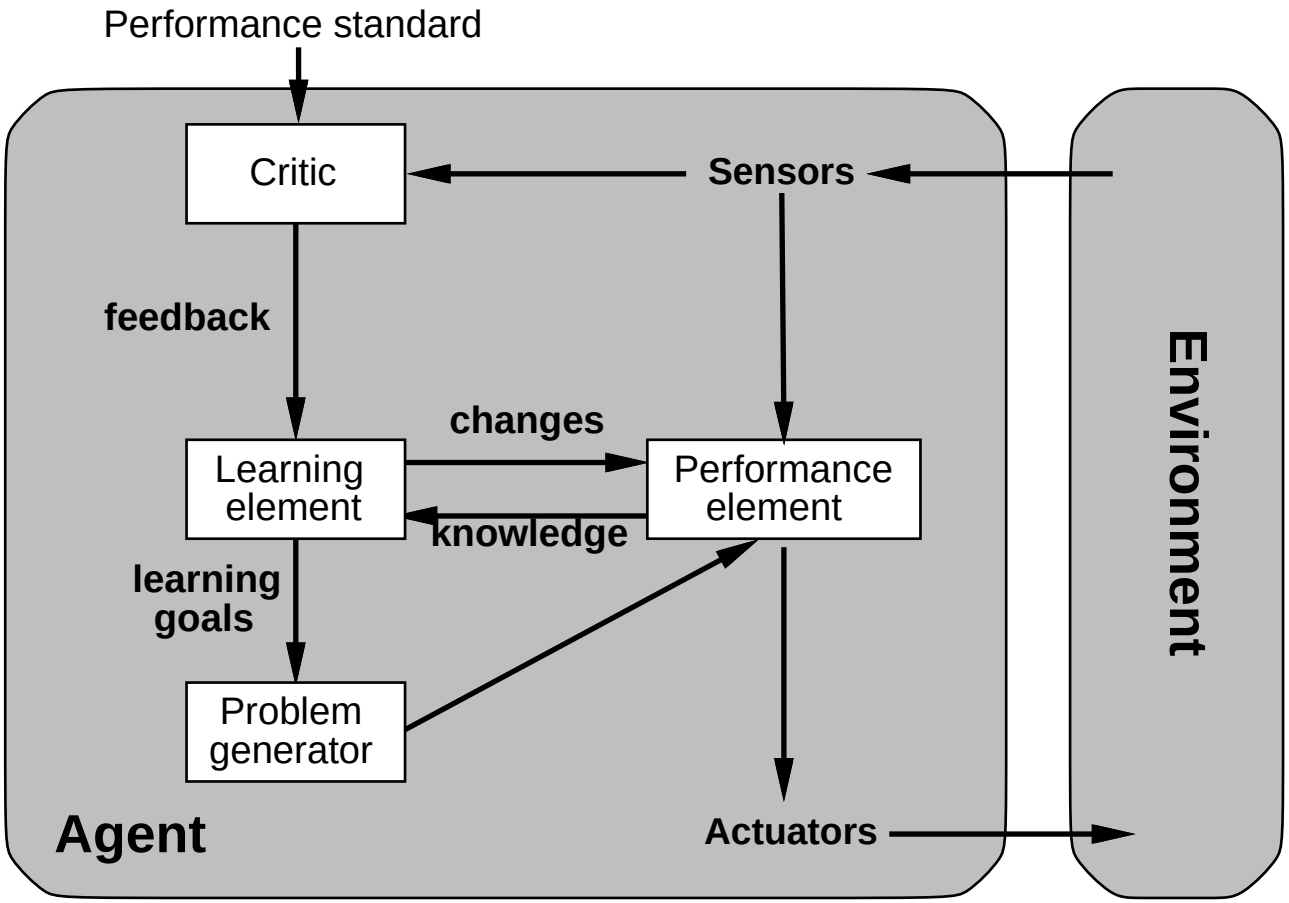
Goal-based agent



Utility-based agent



Learning agent



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*
- ♢ Some basic agent architectures:
  - *reflex*, *reflex with state*, *goal-based*, *utility-based*