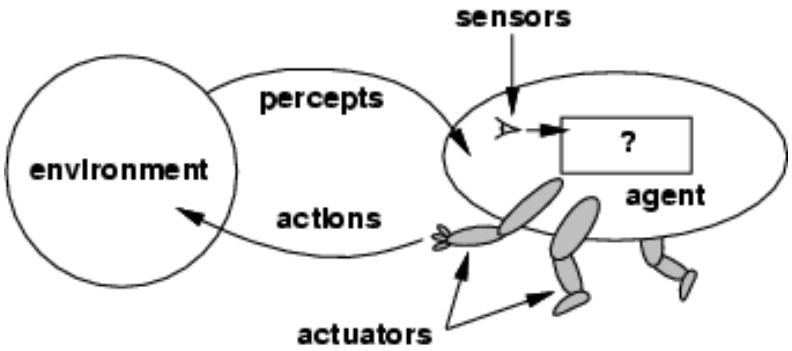
Chapter 2. Agents

Agents

- An agent is anything that can be viewed as perceiving its environment through sensors（传感器） and acting upon that environment through actuators（执行器）

- Agents include humans, robots, softbots（软件机器人）, thermostats（自动调温器）, etc.
  - Human agent:
    - eyes, ears, and other organs for sensors;
    - hands, legs, mouth, and other body parts for actuators
  - Robotic agent:
    - cameras and infrared range finders for sensors;
    - various motors for actuators

Agents and environments



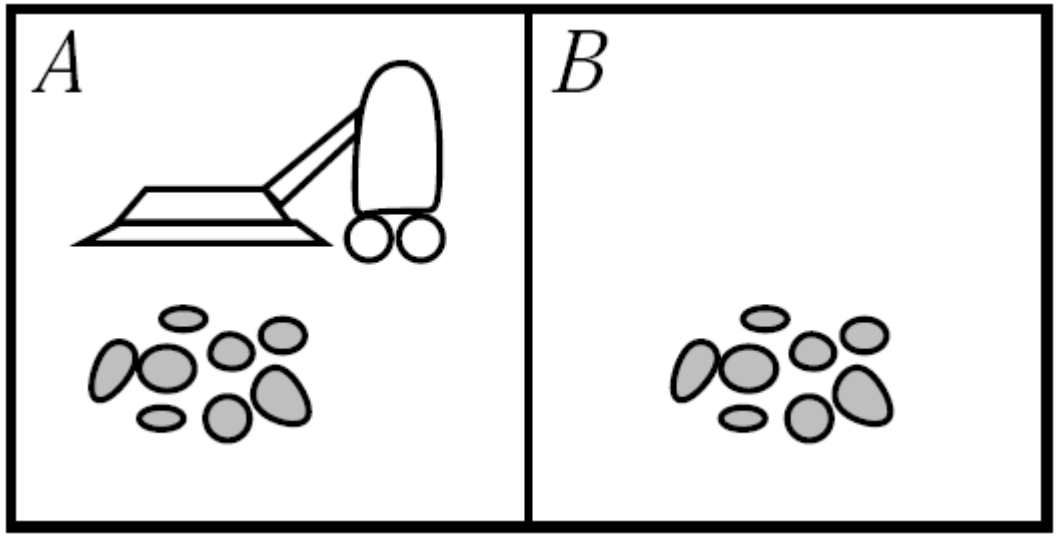
- The agent function maps from percept histories to actions:

$$[f: \mathcal{P}^{\star} \rightarrow \mathcal{A}]$$

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

- agent = architecture + program

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?

Rational agents

- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform. The **right action** is the one that will cause the agent to be most successful

- Performance measure（性能度量）: An objective criterion for success of an agent's behavior

- E.g., performance measure of a vacuum-cleaner agent could be:
  - amount of dirt cleaned up
  - amount of time taken
  - amount of electricity consumed
  - amount of noise generated, etc.

Rational agents

- Rational Agent: For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

理性智能体：对于每一个可能的感知序列，理性智能体应该基于已知的感知序列提供的信息，和智能体已有的先验知识，选择能够使它的性能度量最大化的行为。

Rational agents

- Rationality is distinct from omniscience (all-knowing with infinite knowledge全知的)
- Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)
  - 为修改未来的感知信息而采取行动——信息收集
- An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)
  - 理性智能体应该能够尽可能地学习，以弥补不全面或不正确的先验知识。

Rationality

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

- Rational ≠omniscient(全知的)
  — percepts may not supply all relevant information
- Rational ≠ clairvoyant(洞察力)
  — action outcomes may not be as expected
- Hence, rational ≠ successful

- Rational ⇒ exploration, learning, autonomy

PEAS

Agent: automated taxi

- Performance measure??
- Environment??
- Actuators??
- Sensors??

PEAS

Agent: 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

- Fully observable (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.

- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)

- Episodic (vs. sequential)片断式（vs. 延续式）: The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

如装配线上检测次品零件的机器人只需要把每次决策建立在当前零件基础上，不用考虑以前的决策。

Environment types

- Static (vs. dynamic): The environment is unchanged while an agent is deliberating（思考）. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does)

- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions.

- Single agent (vs. multiagent): An agent operating by itself in an environment.

Environment types

	Chess with a clock	Chess without a clock	Taxi driving
Fully observable	Yes	Yes	No
Deterministic	Strategic	Strategic	No
Episodic	No	No	No
Static	Semi	Yes	No
Discrete	Yes	Yes	No
Single agent	No	No	No

- The environment type largely determines the agent design
- The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agent functions and programs

- An agent is completely specified by the agent function mapping percept sequences to actions
- One agent function (or a small equivalence class) is rational

- Aim: find a way to implement the rational agent function concisely

Table-lookup agent

- \input{algorithms/table-agent-algorithm}

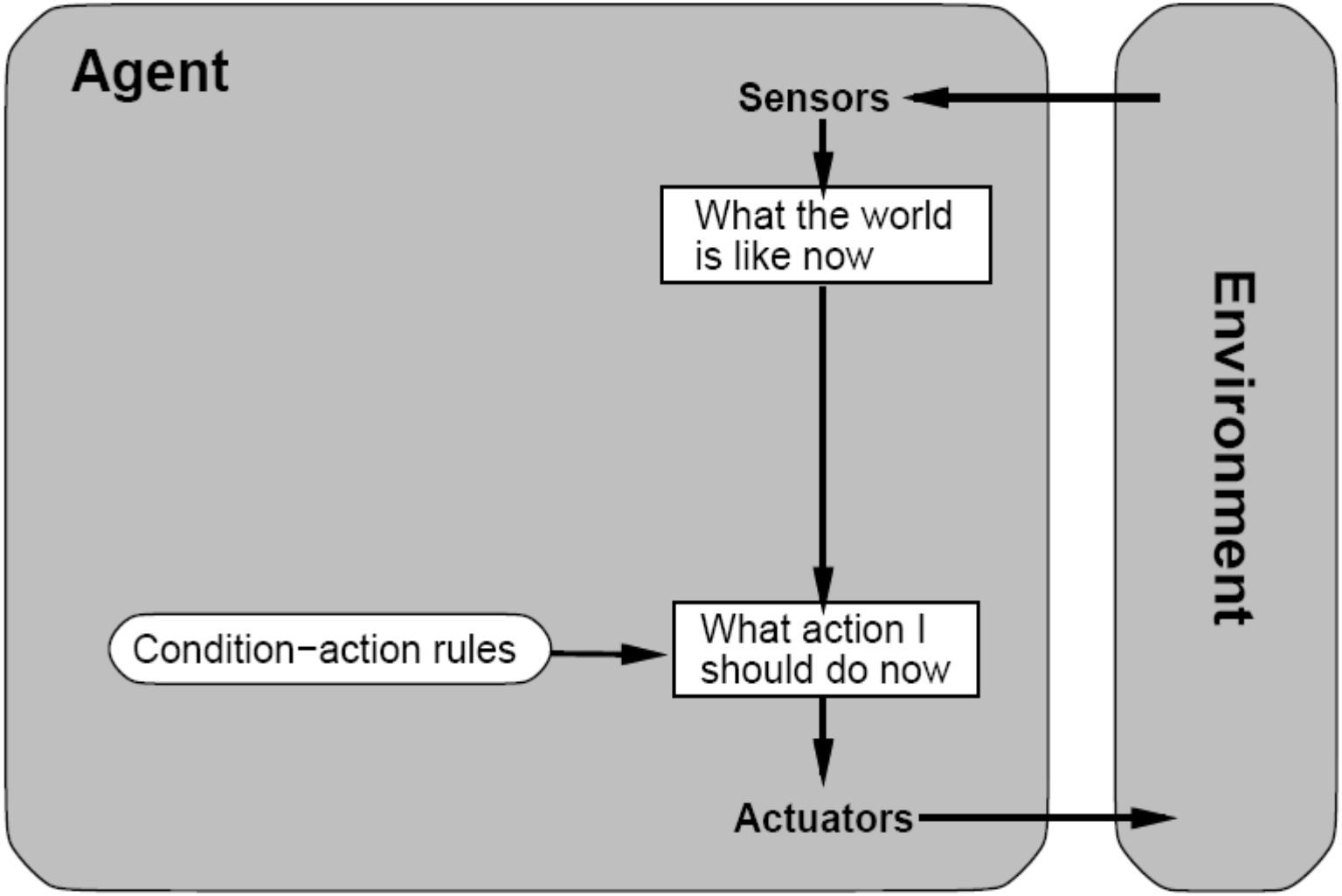
- Drawbacks:
  - Huge table
  - Take a long time to build the table
  - No autonomy
  - Even with learning, need a long time to learn the table entries

Agent types

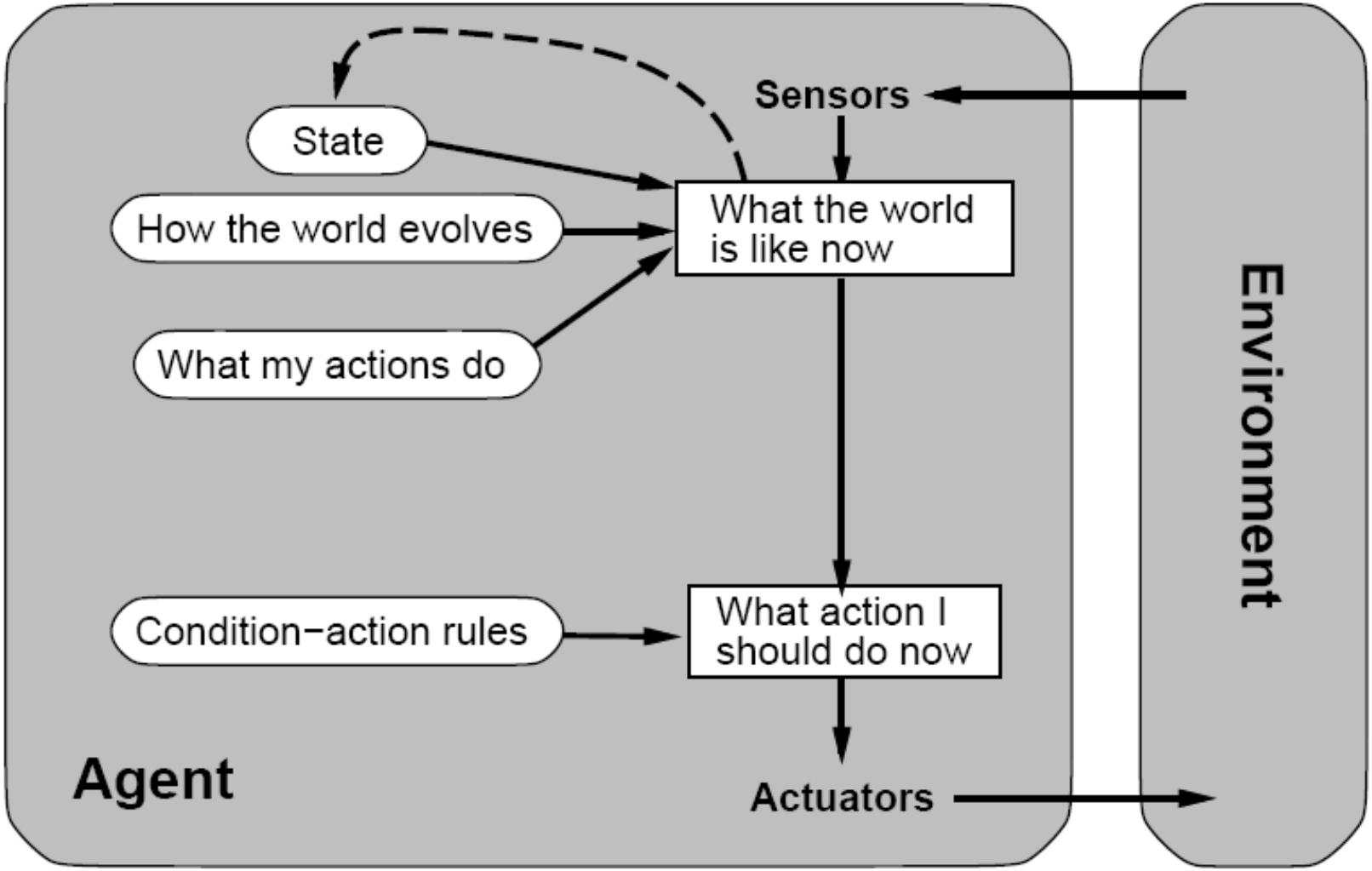
- Four basic types in order of increasing generality:
  - simple reflex agents
  - reflex agents with state
  - goal-based agents
  - utility-based agents

- All these can be turned into learning agents

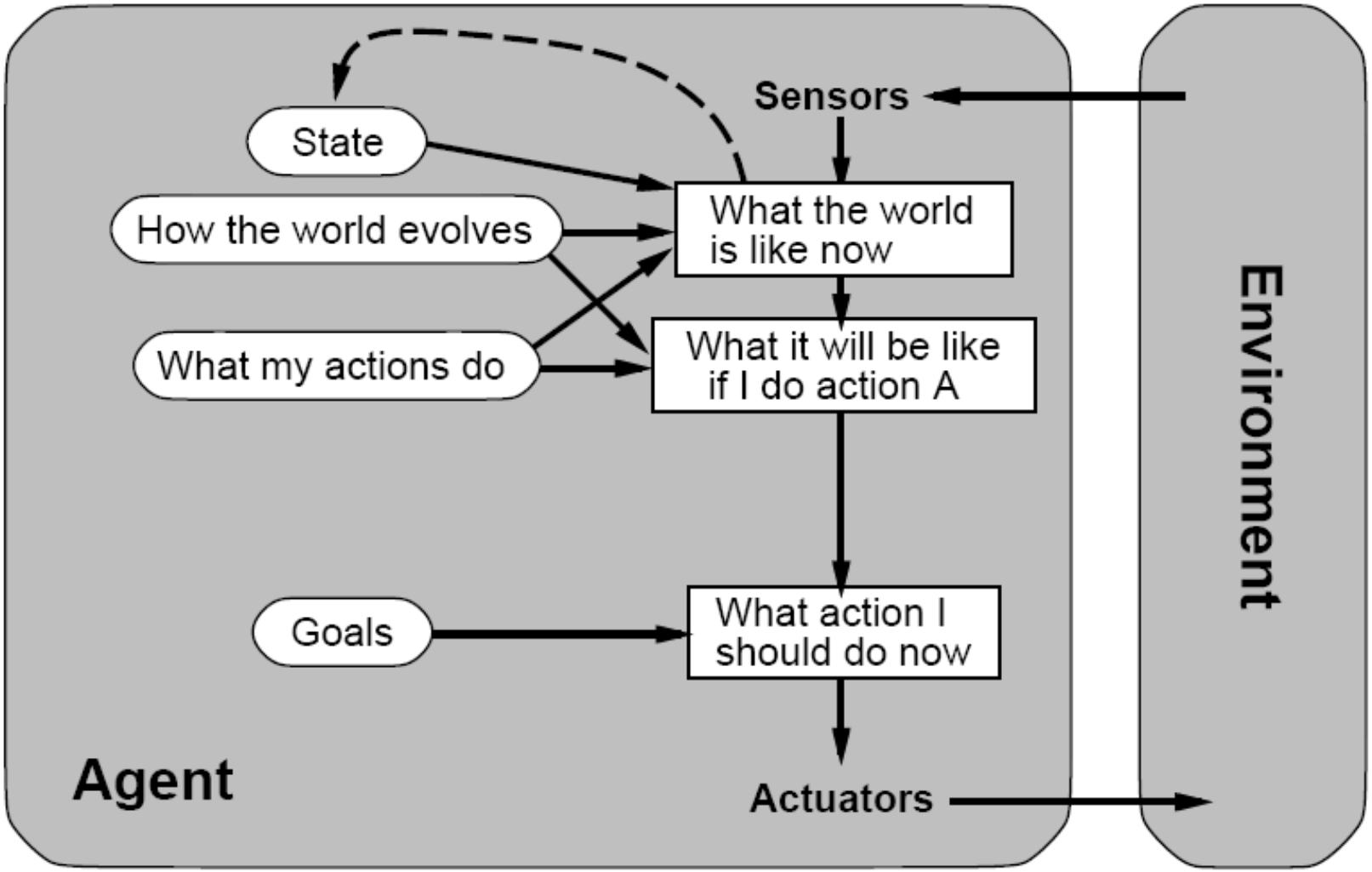
Simple reflex agents



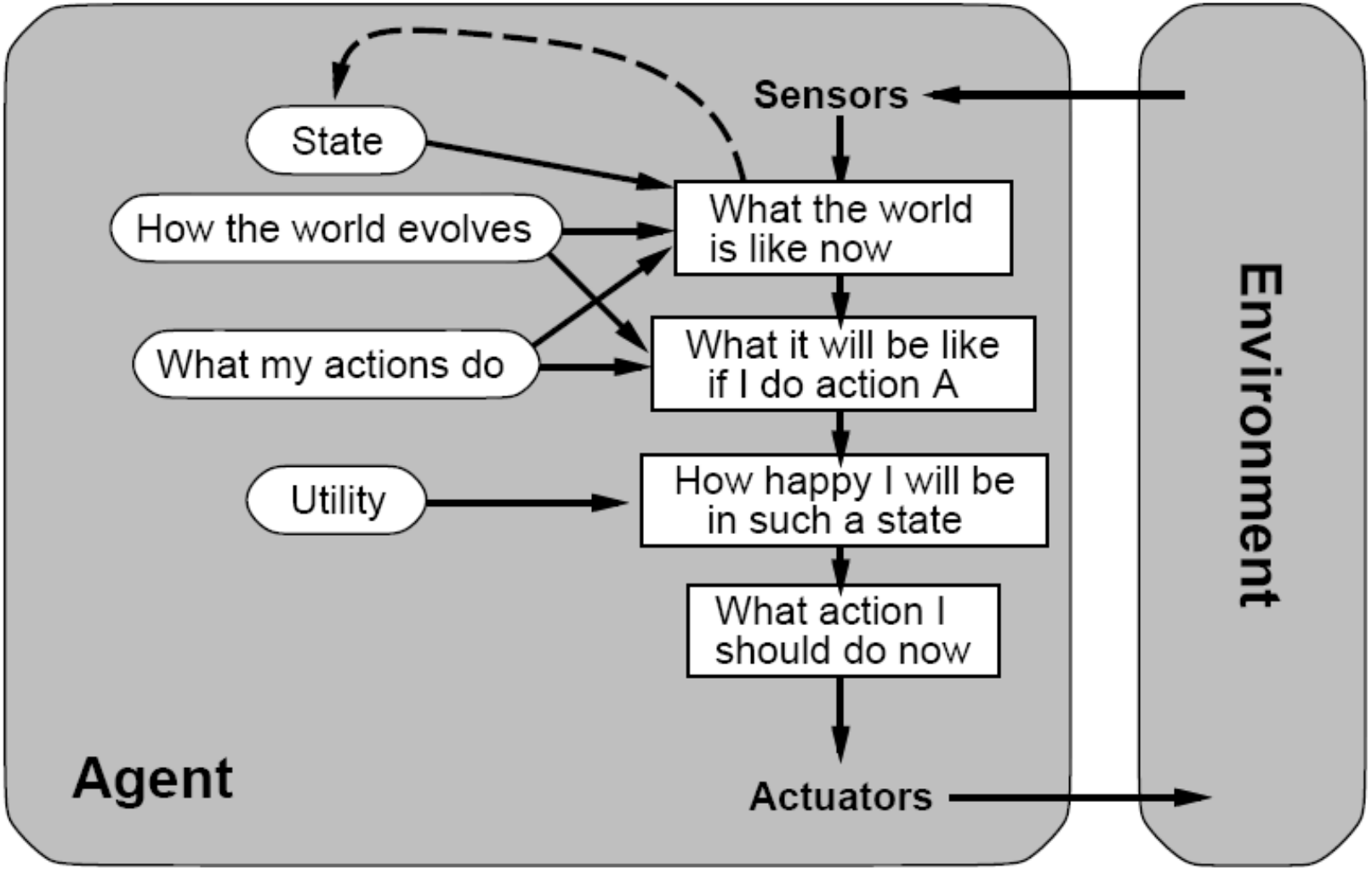
Reflex agents with state



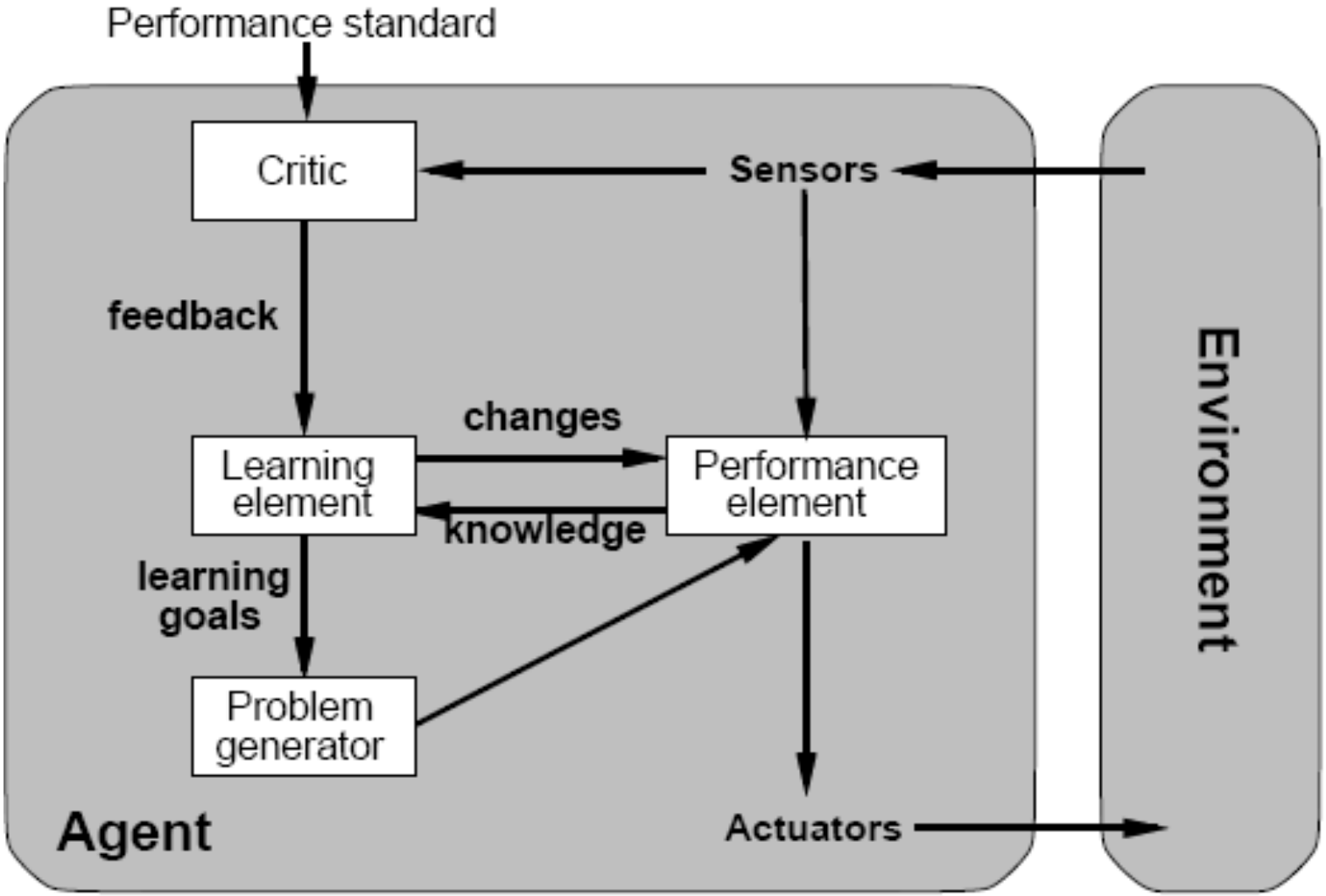
Goal-based agents



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

Next…

- Main intelligent capabilities of agents
  - 问题求解/Search (chapters 3,4,5,6)
  - 知识与推理/Logic (chapters 7,8,9,10)
  - 不确定知识与推理/Uncertainty
  - 学习/Learning (chapters 18,19,20,21)