Chapter 2: Intelligent Agents

Outline

- Last class, introduced AI and rational agent

- Today's class, focus on intelligent agents
  - Agent and environments
    - Video lecture available
  - Nature of environments influences agent design
    - Video lecture available
  - Basic "skeleton" agent designs
    - Review by yourself

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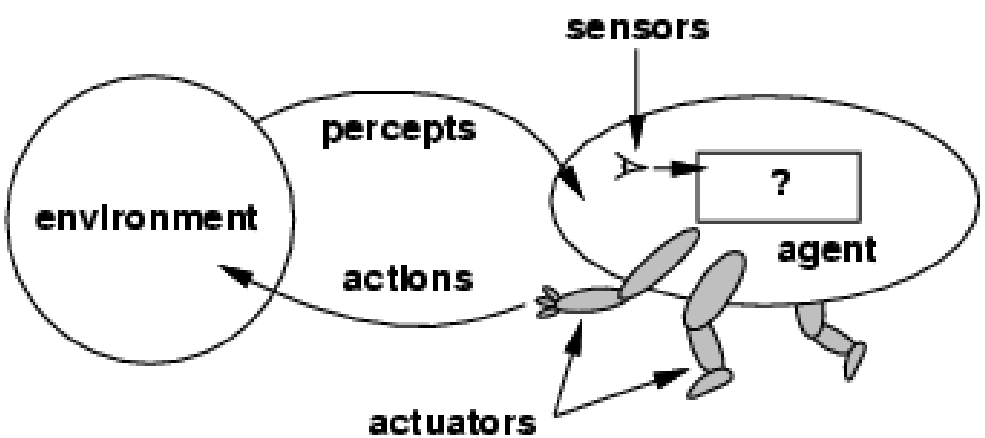
Agents

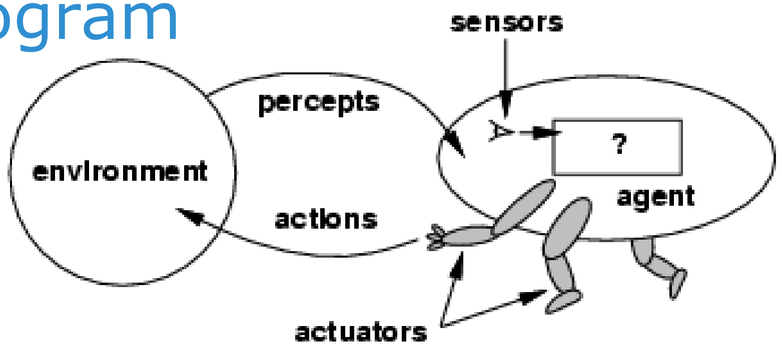
- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

- Examples:
  - Human agent
  - Robotic agent
  - Software agent



Terminologies

- Percept: the agent's perceptual inputs
- Percept sequence: the complete history of everything the agent has perceived
- Agent function maps any given percept sequence to an action [$f: p^* \rightarrow A$]
- The agent program runs on the physical architecture to produce f
- Agent = architecture + program

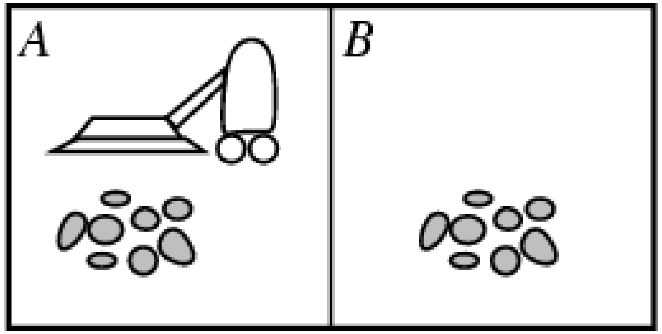


Questions

- Can there be more than one agent program that implements a given agent function?

- Given a fixed machine architecture, does each agent program implement exactly one agent function?

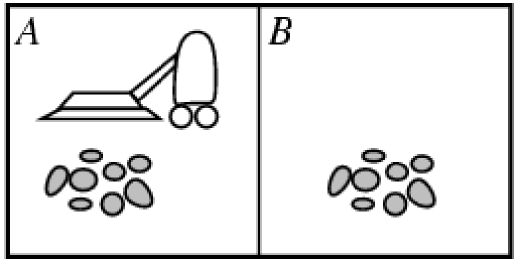
Vacuum-Cleaner World



- Percepts: location and contents, e.g., [A, dirty]
- Actions: Left, Right, Suck, NoOp

A Simple Agent Function

Percept sequence	**Action**
[A, Clean]	?
[A, Dirty]	
[B, Clean]	
[B, Dirty]	
[A, Clean], [A, Clean]	
[A, Clean], [A, Dirty]	
…	
[A, Clean], [A, Clean], [A, Clean]	
[A, Clean], [A, Clean], [A, Dirty]	
…	



Rationality

- An agent should "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: An objective criterion for success of an agent's behavior

- Back to the vacuum-cleaner example
  - Amount of dirt cleaned within certain time
  - +1 credit for each clean square per unit time

- General rule: measure what one wants rather than how one thinks the agent should behave

Rational Agent

- Definition:
  - 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.

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Vacuum–Cleaner Example

- A simple agent that cleans a square if it is dirty and moves to the other square if not
- Is it rational?
- Assumption:
  - performance measure: 1 point for each clean square at each time step
  - environment is known a priori
  - actions = {left, right, suck, no-op}
  - agent is able to perceive the location and dirt in that location
- Given different assumption, it might not be rational anymore

Omniscience, Learning and Autonomy

- Distinction between rationality and omniscience
  - expected performance vs. actual performance
- Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)
- An agent can also learn from what it perceives
- An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)

In-Class Exercise #2.1

- Given the assumption on slide 12. Describe a rational agent function for the modified performance measure that deducts one point for each movement. Does the agent program require internal state?

- Discuss possible agent designs for the cases in which clean squares can become dirty and the geography of the environment is unknown.

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PEAS

- Specifying the task environment is always the first step in designing agent

- PEAS:
  - **P**erformance, **E**nvironment, **A**ctuators, **S**ensors

Taxi Driver Example

Performance Measure	Environment	Actuators	Sensors
safe, fast, legal, comfortable trip, maximize profits	roads, other traffic, pedestrians, customers	steering, accelerator, brake, signal, horn, display	camera, sonar, speedometer, GPS, odometer, engine sensors, keyboard, accelerator

DARPA urban challenge 07:

http://www.youtube.com/watch?v=SQFEmR50HAk

Medical Diagnosis System

Performance Measure	Environment	Actuators	Sensors
healthy patient, minimize costs, lawsuits	patient, hospital, staff	display questions, tests, diagnosis, treatments, referrals	keyboard entry of symptoms, findings, patient's answers

Mushroom-Picking Robot

Performance Measure	Environment	Actuators	Sensors
Percentage of good mushrooms in correct bins	Conveyor belt with mushrooms, bins	Jointed arm and hand	camera, joint angle sensors

Properties of Task Environments

- 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):
  - next state of the env. determined by current state and the agent’s action
  - If the environment is deterministic except for the actions of other agents, then the environment is strategic

- Episodic (vs. sequential):
  - Agent's experience is divided into atomic "episodes"
  - Choice of action in each episode depends only on the episode itself

Properties of Task Environments

- Static (vs. dynamic):
  - The environment is unchanged while an agent is deliberating
  - Semidynamic if the environment itself doesn’t change with 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
  - Competitive vs. cooperative

Examples

Task Environment	Oberservable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	fully	deterministic	sequential	static	discrete	single
Chess with a clock	fully	strategic	sequential	semi	discrete	multi
Taxi driver	partially	stochastic	sequential	dynamic	conti.	multi
mushroom-picking	partially	stochastic	episodic	dynamic	conti.	single

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

In-Class Exercise #2.2

- Develop PEAS description for the following task environment:
  - Robot soccer player
  - Shopping for used AI books on the Internet
- Analyze the properties of the above environments

In-Class Exercise #3: True/False Questions

- 1. An agent that senses only partial information about the state cannot be perfectly rational.

- 2. Suppose an agent selects its action uniformly at random from the set of possible actions. There exists a deterministic task environment in which this agent is rational.

- 3. It is possible for a given agent to be perfectly rational in two distinct task environments.

- 4. A perfectly rational poker-playing agent never loses.

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Agent = Architecture + Program

- The job of AI is to design the agent program that implements the agent function mapping percepts to actions
- Aim: find a way to implement the rational agent function concisely
- Same skeleton for agent program: it takes the current percept as input from the sensors and returns an action to the actuators

Agent Program vs. Agent Function

- Agent program takes the current percept as input
  - Nothing is available from the environment
- Agent function takes the entire percept history
  - To do this, remember all the percepts

Table-Driven Agent

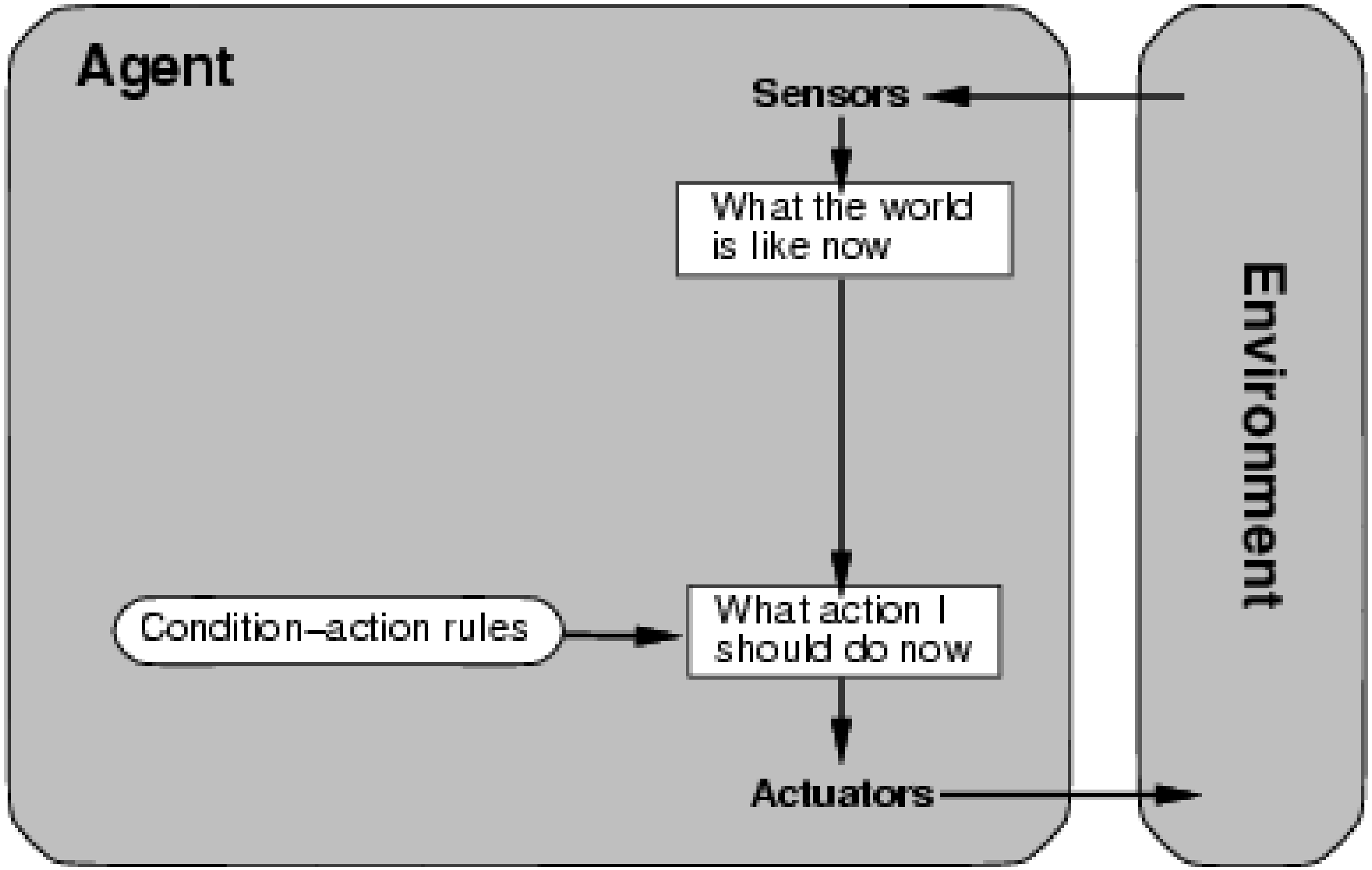
- Designer needs to construct a table that contains the appropriate action for every possible percept sequence

- Drawbacks?
  - huge table
  - take a long time to construct such a table
  - no autonomy
  - Even with learning, need a long time to learn the table entries

Five Basic Agent Types

- Arranged in order of increasing generality:
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents; and
  - Learning agents

Simple Reflex Agent



Pseudo-Code

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  static: rules, a set of condition–action rules

  state ← INTERPRET-INPUT(percept)
  rule ← RULE-MATCH(state, rules)
  action ← RULE-ACTION[rule]
  return action
```

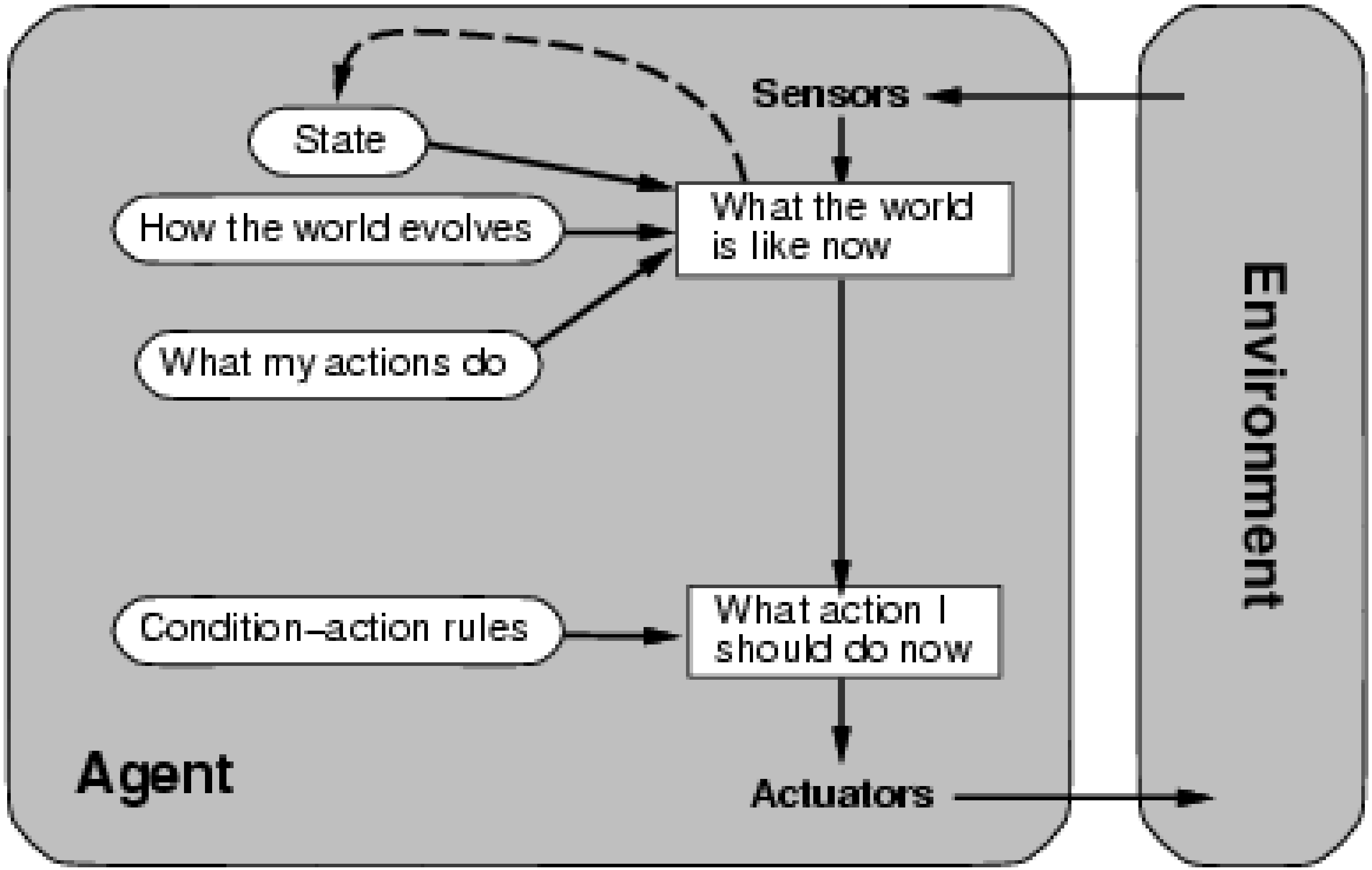
Example: write a simple reflex agent for the vacuum cleaner example

- Infinite loops are often unavoidable for simple reflex agent operating in partially observable environments
  - No location sensor

- Randomization will help
- A randomized simple relfex agent might outperform a deterministic simple reflex agent

- Better way: keep track of the part of the world it can’t see now
  - Maintain internal states

Model-Based Reflex Agent

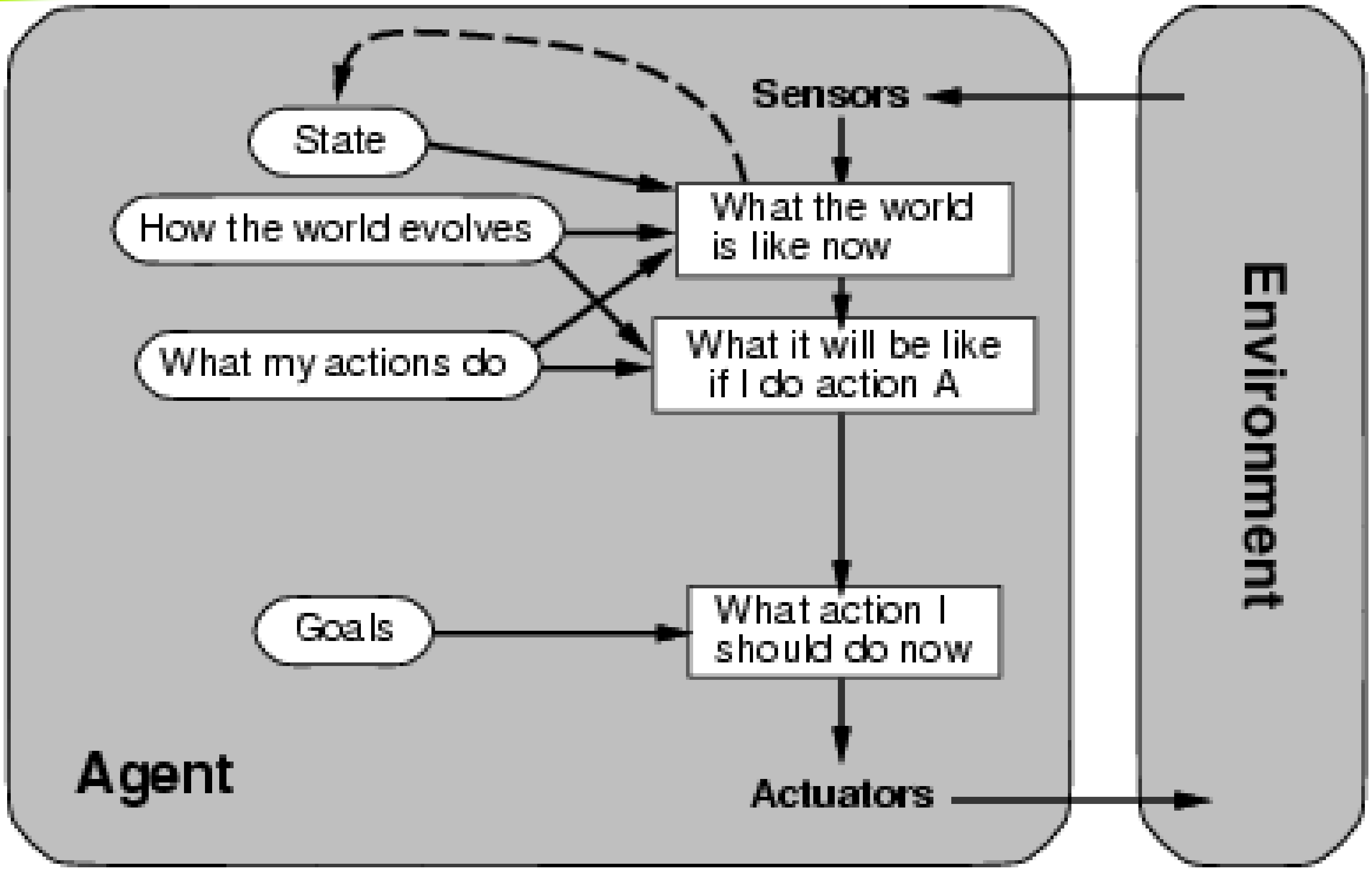


Pseudo-Code

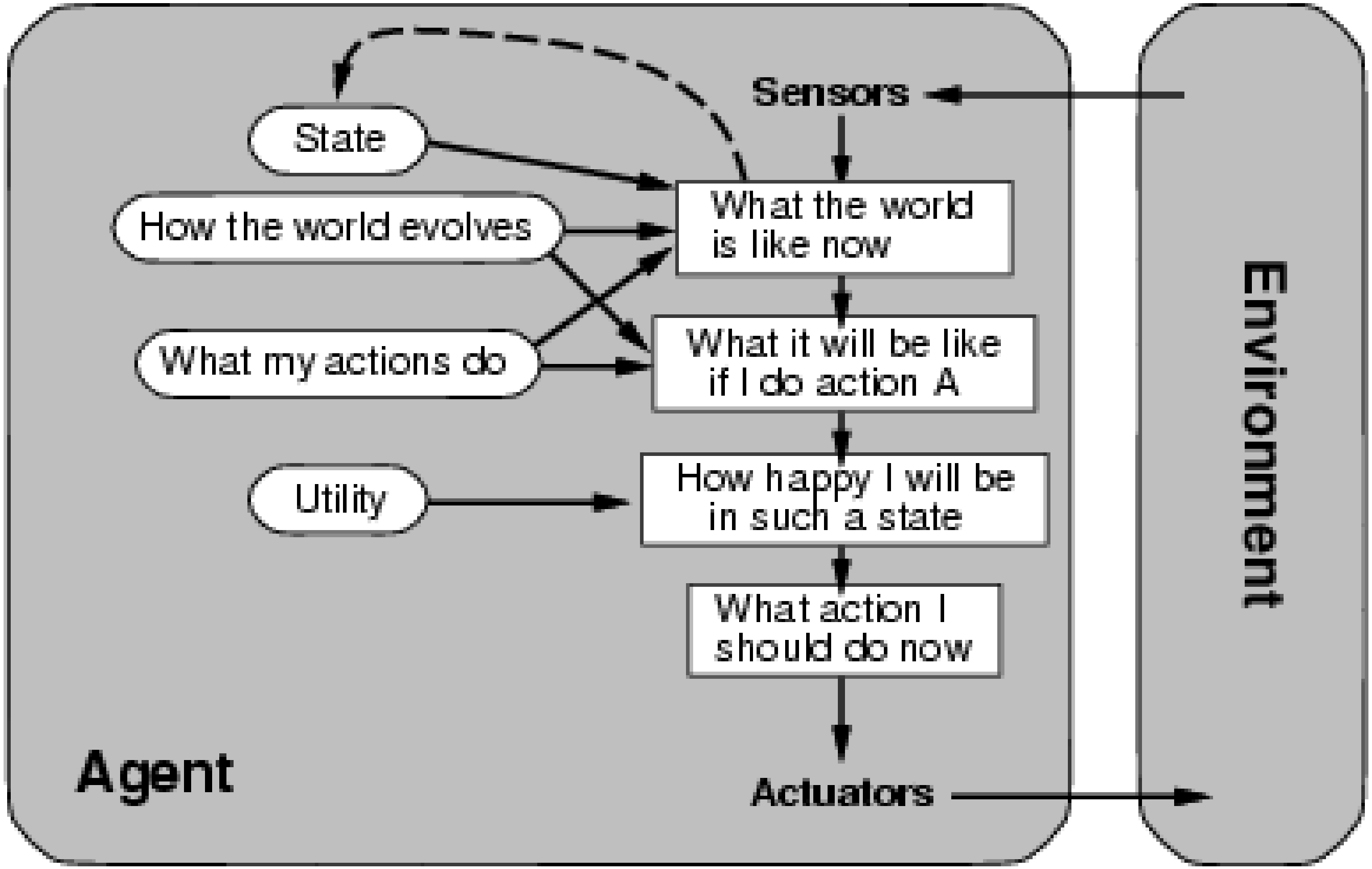
function REFLEX-AGENT-WITH-STATE(*percept*) **returns** an action
  static: *state*, a description of the current world state
    rules, a set of condition–action rules
    action, the most recent action, initially none

  state ← UPDATE-STATE(*state*, *action*, *percept*)
  rule ← RULE-MATCH(*state*, *rules*)
  action ← RULE-ACTION[*rule*]
  return *action*

Goal-Based Agent



Utility-Based Agent

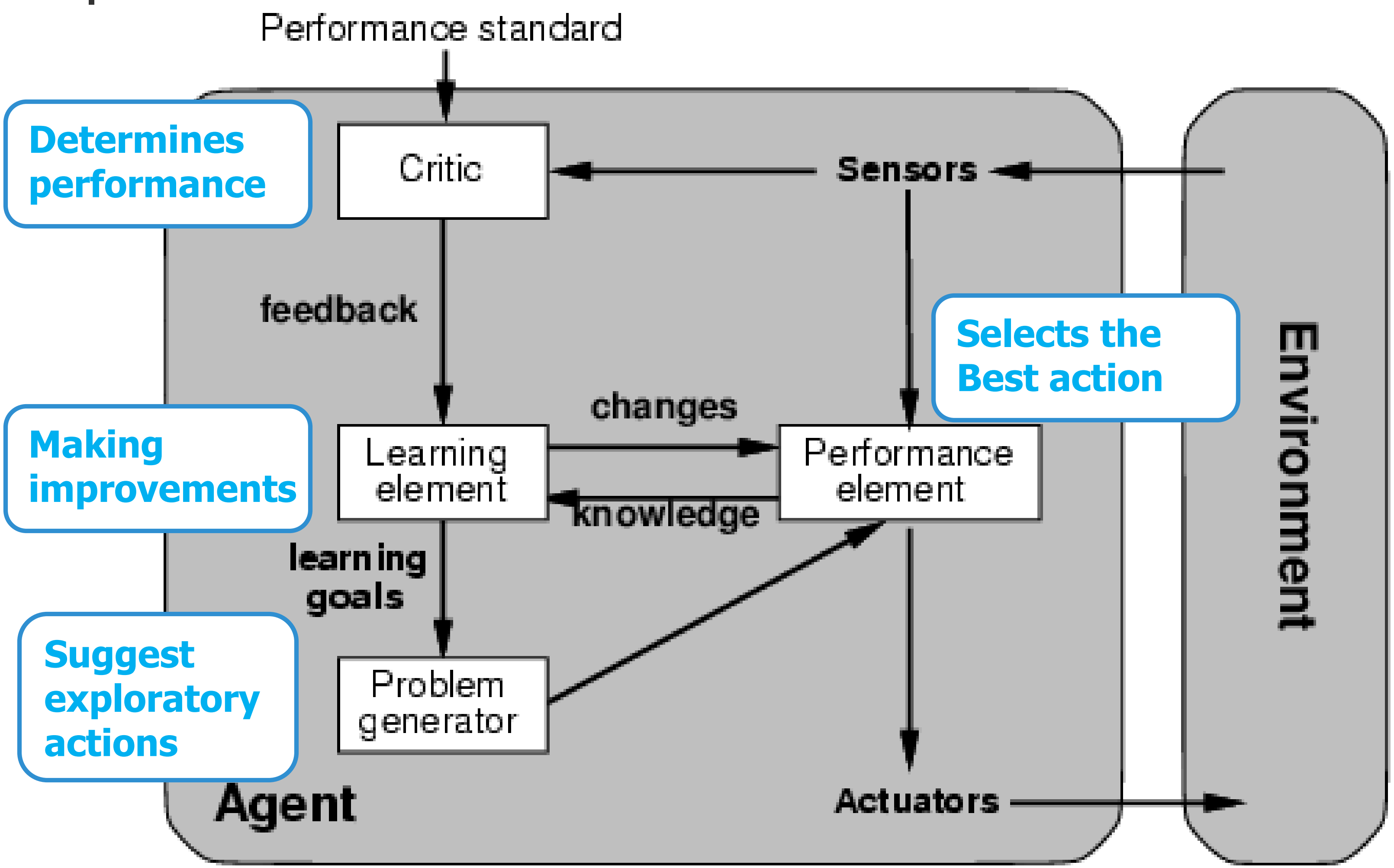


Utility Function

- Utility function maps a state or a sequence of states onto a real number → degree of happiness

- Conflicting goals
  - Speed and safety
- Multiple goals

Learning Agent



Thinking Exercise

- Select a suitable agent design for:
  - Robot soccer player
  - Shopping for used AI books on the Internet

Summary

- Agent, agent function, agent program
- Rational agent and its performance measure
- PEAS
- Five major agent program skeletons

- Next, solving problems by searching