Artificial Intelligence

CS482, CS682, MW 1 – 2:15, SEM 201, MS 227

Prerequisites: 302, 365

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Question

- Are reflex actions rational? Are they intelligent?

Question

- How could introspection – reporting on one's inner thoughts – be inaccurate? Could I be wrong about what I am thinking?

Question

- To what extent are the following computer systems instances of artificial intelligence?
    - Supermarket bar code scanner
    - Web search engines
    - Voice-activated telephone menus
    - Internet routing algorithms that respond dynamically to the state of the network

Question

- Which tasks can currently be solved by computers?
  - Playing a decent game of table tennis
  - Driving in the center of Cairo, Egypt
  - Driving in Victorville, CA
  - Buying a week's worth of groceries at the market
  - Buying a week's worth of groceries on the web
  - Playing a decent game of bridge at a competitive level
  - Discovering and proving mathematical theorems
  - Writing an intentionally funny story
  - Giving competent legal advice in a specialized area of law
  - Translating spoken English into Swedish in real-time
  - Performing a complex surgical operation

Agents

- What is a rational agent?
  - Optimizes performance
- What are design principles for building rational agents (intelligent agents)?
- Agent performance will depend on their operating **Environment.** Some environments will be more difficult than others
- Types of environments
- Design considerations for agents in these different types of environments
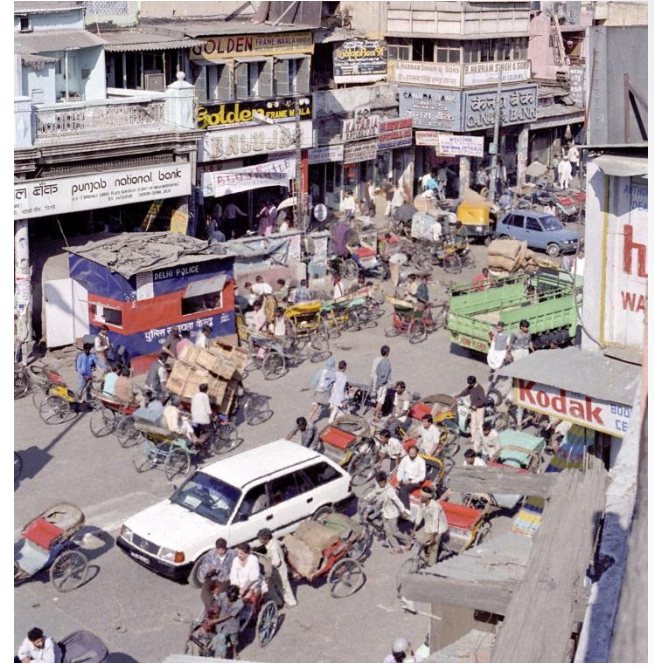
What is an agent?

- Perceives an **environment** through **sensors** and acts on the environment through **actuators**
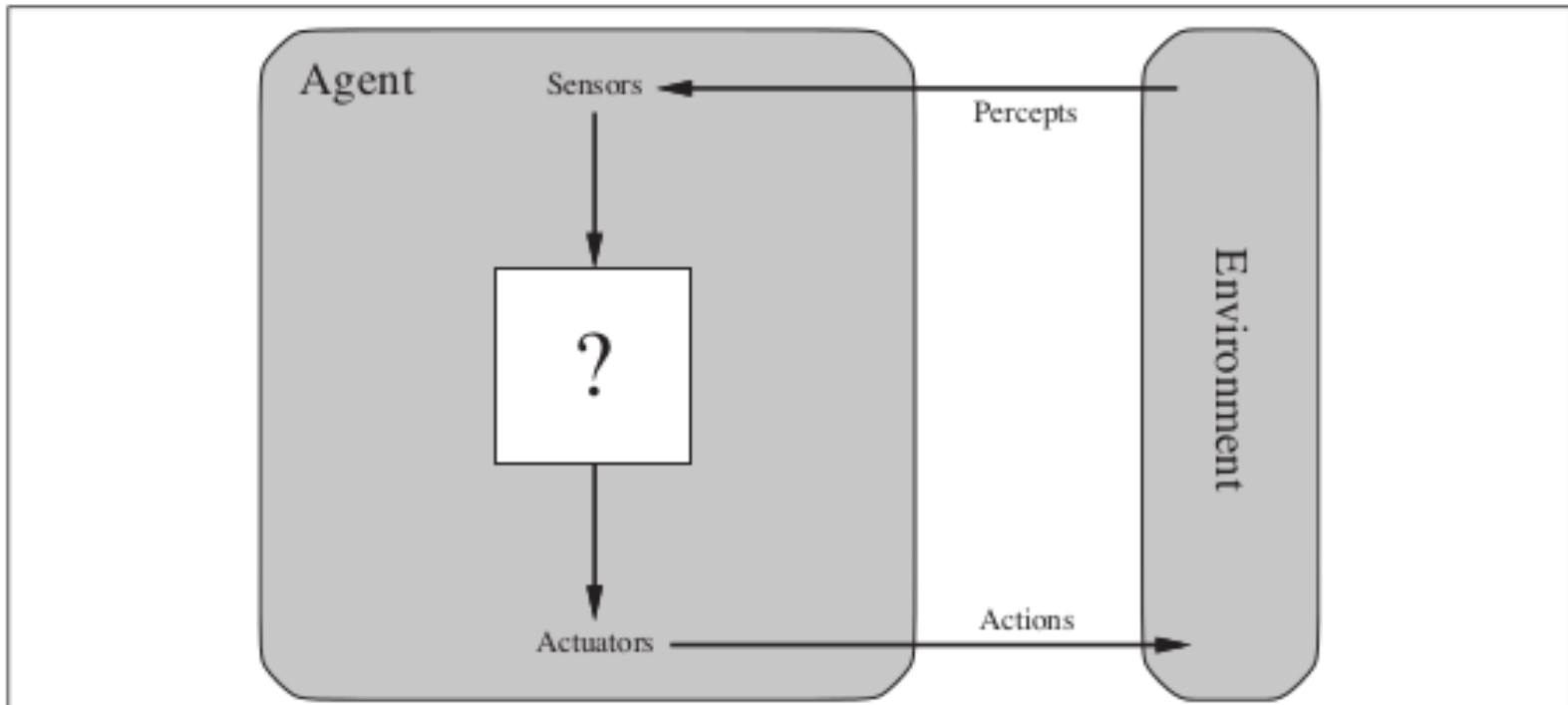

Figure 2.1 **FILES: figures/agent-environment.eps (Tue Nov 3 16:22:19 2009).** Agents interact with environments through sensors and actuators.

What is an Agent?

- **Percept**: Agent's perceptual inputs at any given **instant** of time

- Percept sequence is the complete history of everything the agent has ever perceived

- Agent's choice of action usually depends on percept sequence but not on anything it has not perceived

- Behavior is governed by an **agent function** that maps **percept sequence** to actions
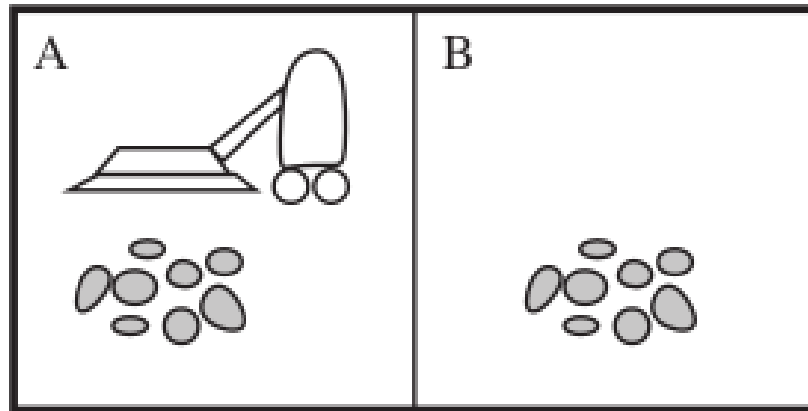
Agent example

Figure 2.2   FILES: figures/vacuum2-environment.eps (Tue Nov 3 16:24:01 2009). A vacuum-cleaner world with just two locations.

Agent (Behavior) function

F (Percept sequence) → Action

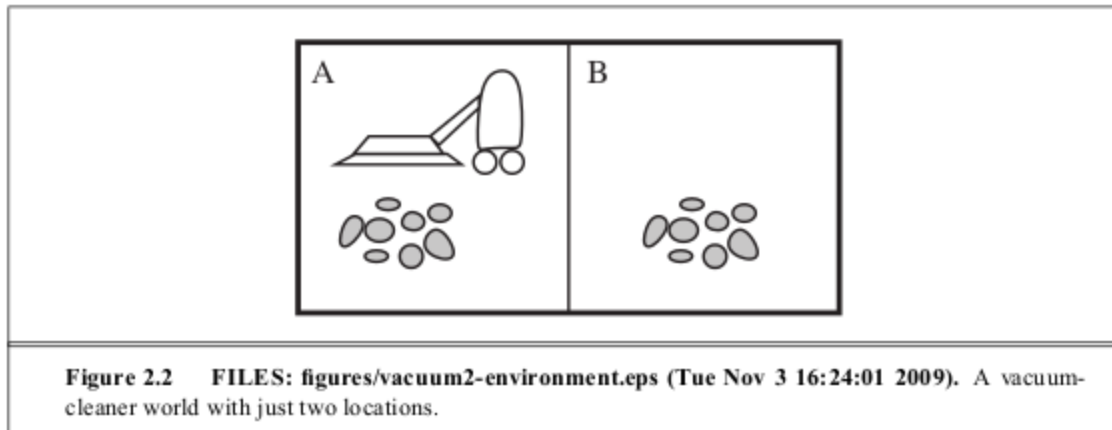| Percept Sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck

Agent **programs** implement agent functions on some architecture

This is **just** a table, with percept sequences on the left and actions on the right

Behavior function

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
…	
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
…	

This is **just** a table, with percept sequences on the left and actions on the right
But how big?

Vacuum Cleaner world

Figure 2.2 FILES: figures/vacuum2-environment.eps (Tue Nov 3 16:24:01 2009). A vacuum-cleaner world with just two locations.

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*

Add action "No-Op"

Rational
Behavior versus **Good** behavior

- Agent's action affect environment → changes environment's state
- A sequence of agent actions → a sequence of environment states
- A performance measure on **environment states** differentiates good behavior from bad
  - Is our vacuum cleaner agent rational?
    - What is the performance metric?
    - What is the agent's prior knowledge?
    - What percept sequence has the agent seen?
    - What actions can agent perform?
  - Suppose the performance measure is just concerned with the first T time steps of the environment, show that a rational agent's action may depend not just on the state of the environment but also on time step
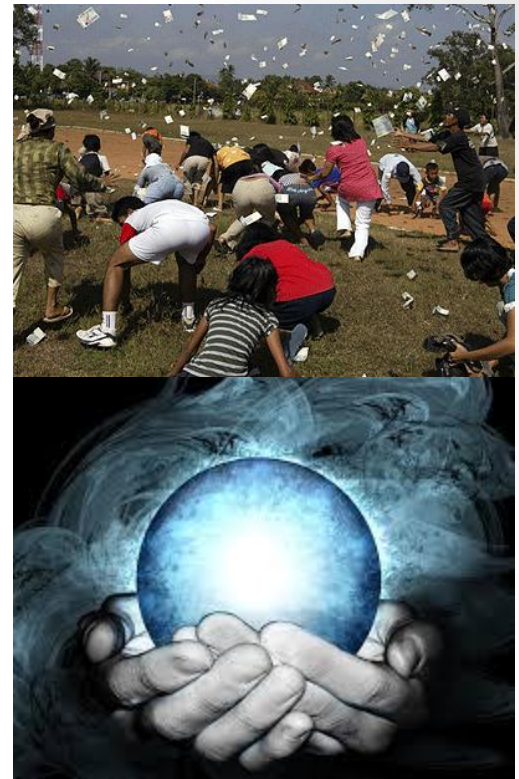
Rationality

- Performance metric
  - 1 point per square cleaned?
  - 1 point per square cleaned in time T?
  - 1 point per square per time step minus one per move?
  - Penalty for > k dirty squares?
  - …
- A rational agent chooses whichever action maximizes expected value of performance measure given the precept sequence to date

Rationality

- Rational != omniscient
- Rational != clairvoyant
- Rational != successful

- Rational implies
  - Exploration
  - Learning
  - Autonomy

PEAS

- To design a rational agent, we need to specifying a **task environment**
- Consider automated taxi
  - Performance metric?
  - Environment?
  - Actuators?
  - Sensors?

PEAS

- To design a rational agent, we need to specifying a **task environment**
- Consider automated taxi
  - Performance metric?
    - Safety, destination, profits, legal, comfort, speed, cost
  - 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 metric?

- Environment?

- Actuators?

- Sensors?

Internet shopping agent

- Performance metric?
  - Price, quality, efficiency, appropriateness
- Environment?
  - Current and future websites, vendors, shippers, shoppers
- Actuators?
  - Display to use, follow URL, fill forms
- Sensors?
  - HTML pages (text, graphics, scripts)

Interactive English Tutor

- Performance Metric
- Environment
- Actuators
- Sensors

Interactive English Tutor

- Performance Metric
  - Score on test
- Environment
  - Students, testing agency
- Actuators
  - Display of exercises, suggestions, corrections, …
- Sensors
  - Keyboard, mouse

Types of task environments

Task Env	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword						
Chess with Clk						
Poker						
Taxi Driving						
Medical Diagnosis						
Image analysis						
Part-picking robot						
Refinery Controller						
Interactive English Tutor						

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Types of agents

- Simple reflex agents

```
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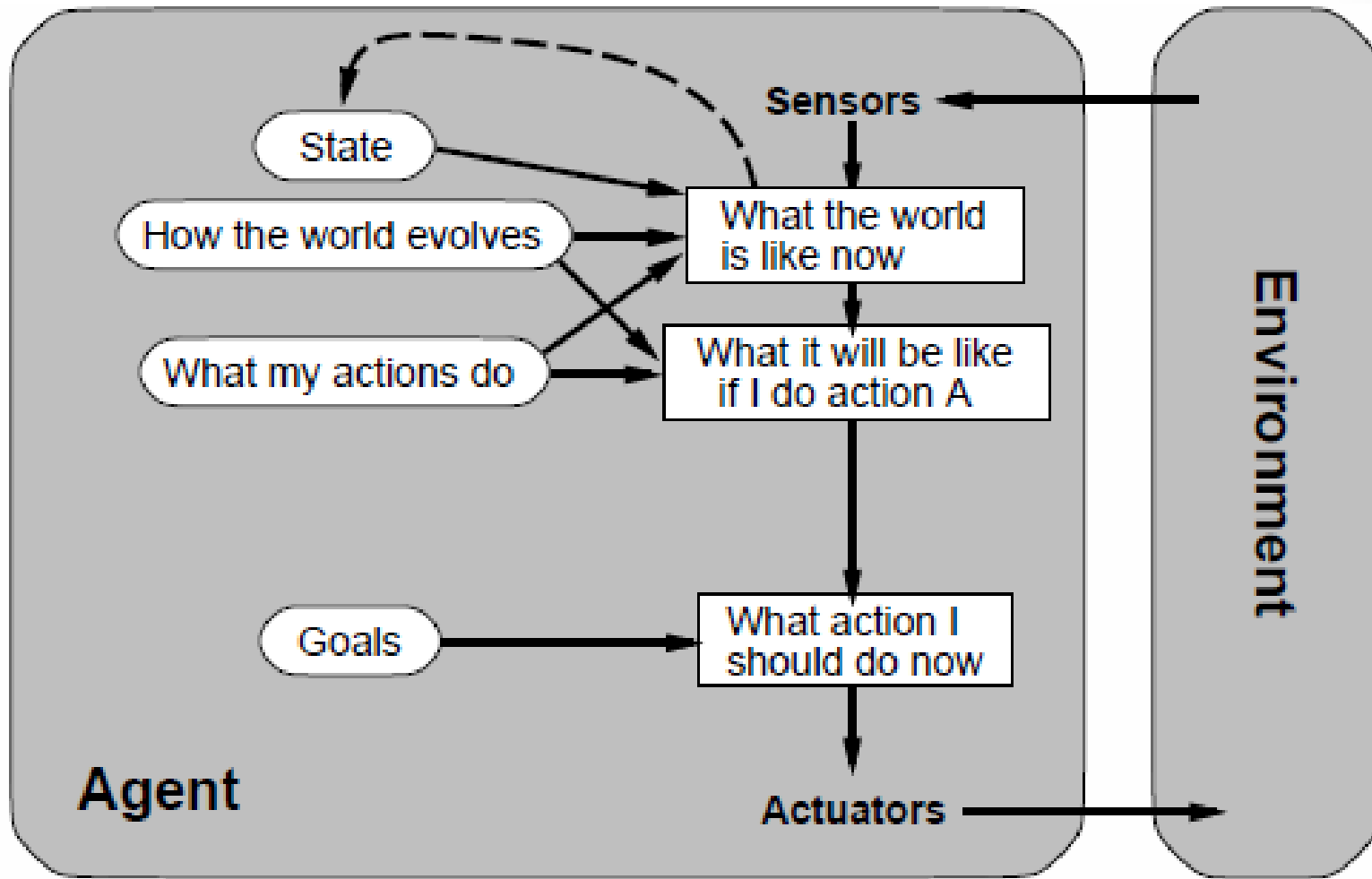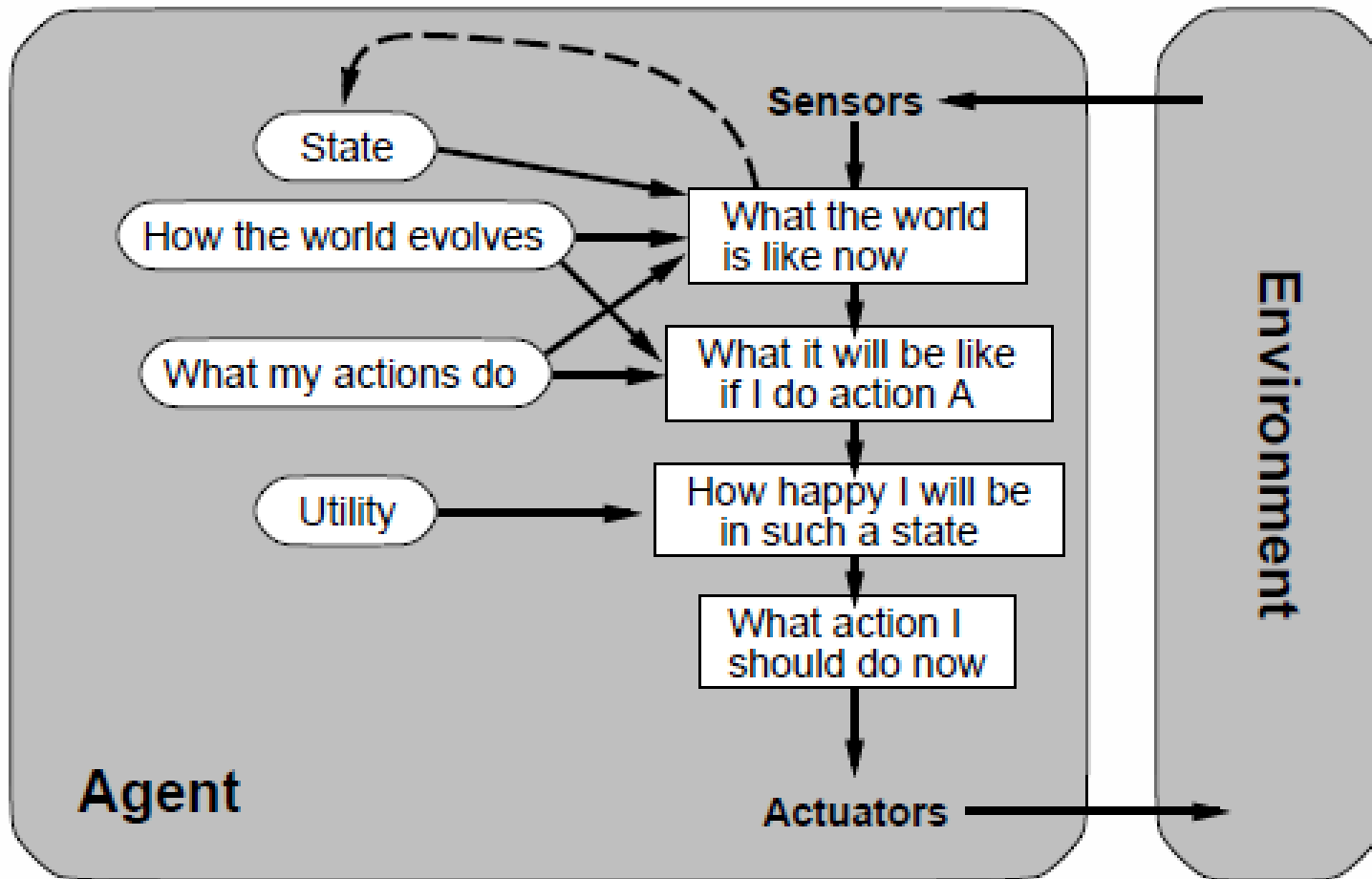
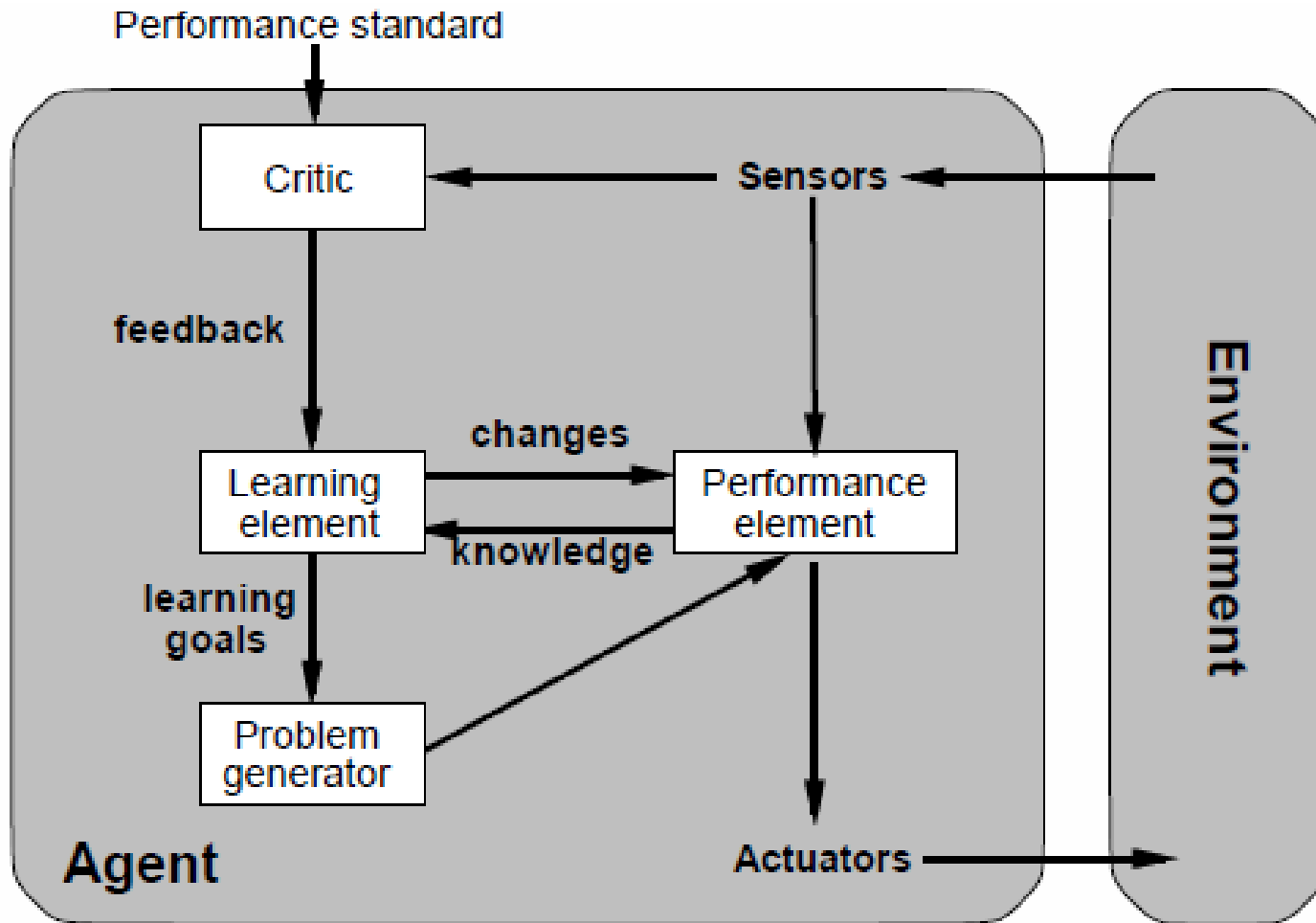- Reflex agents with state
- Goal based agents
- Utility-based agents

- All can be turned into learning agents

Simple reflex agents
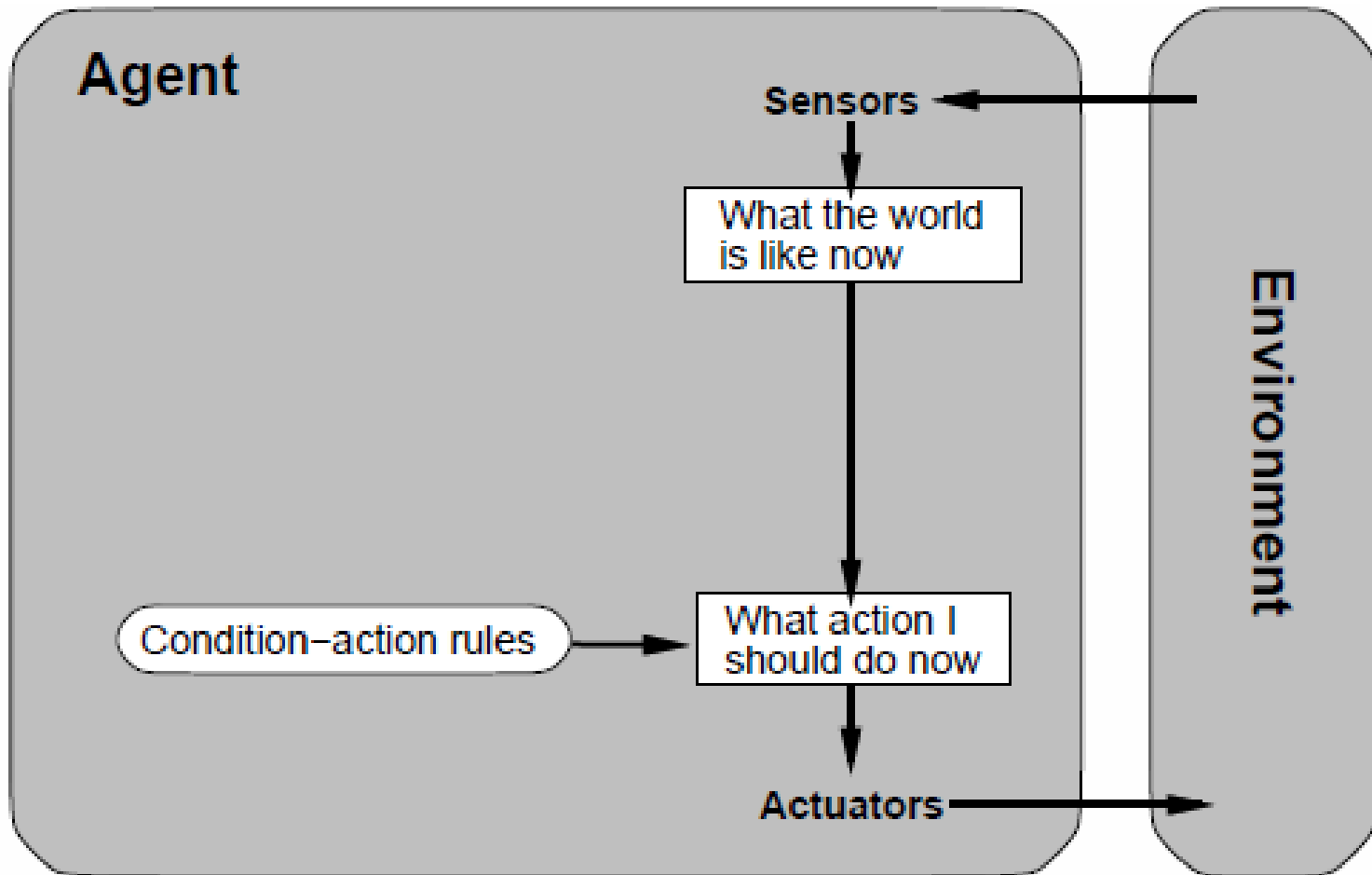
Reflex agent with state
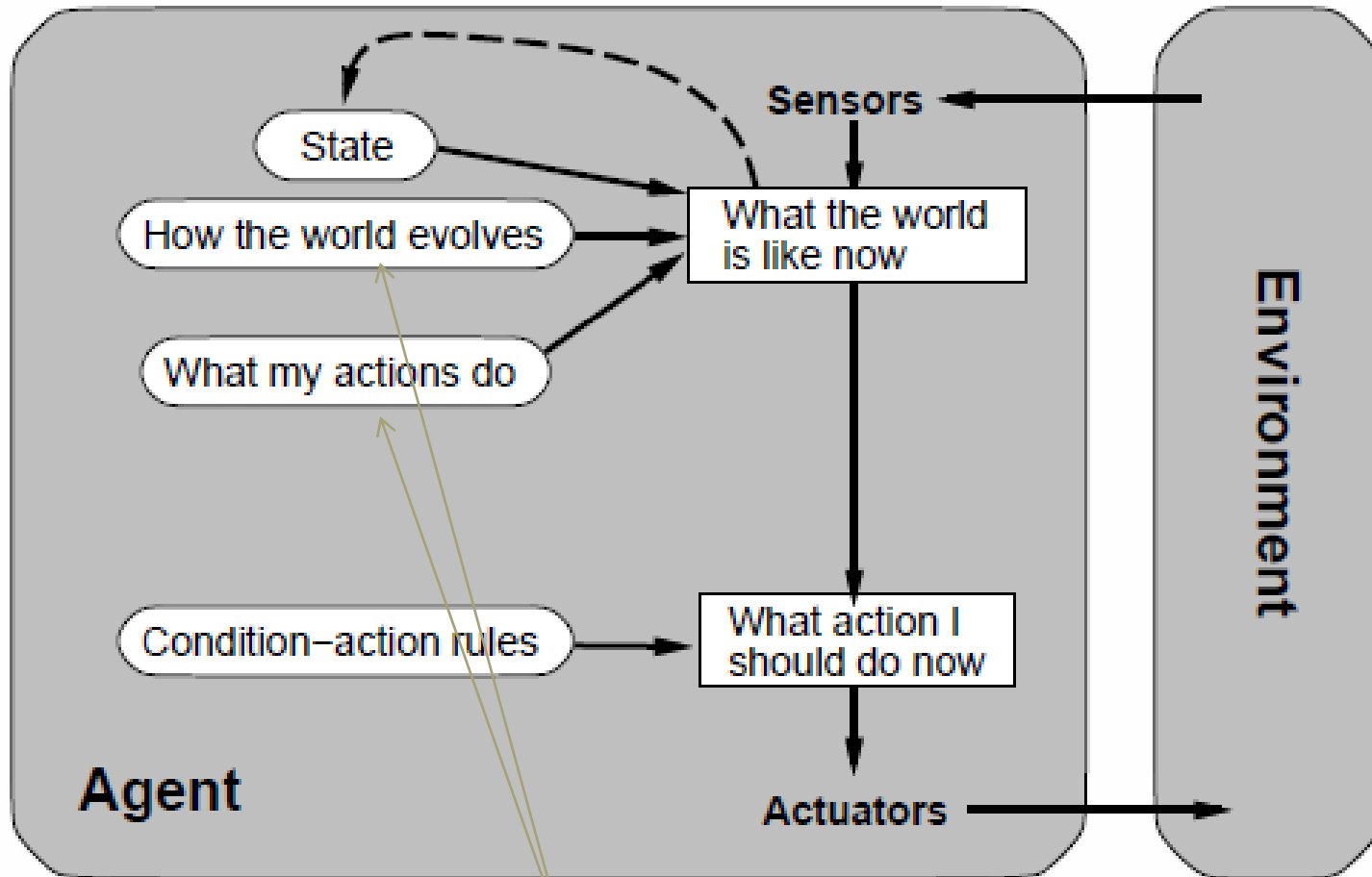
Model-based agent

Goal-based agent

Search for ways to achieve goals. Make plans to achieve goals. Searching for plans
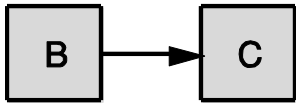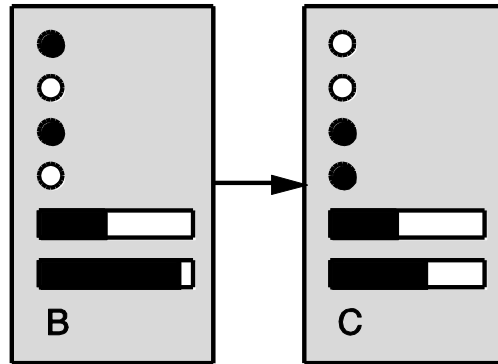
Utility-based agent

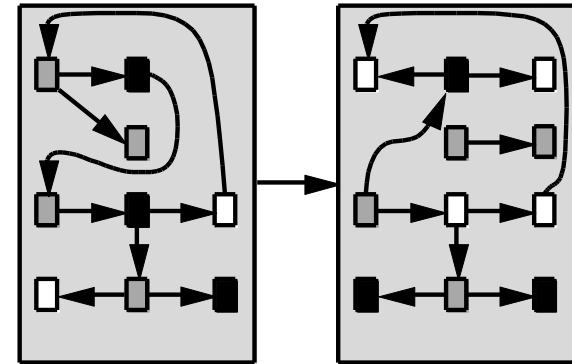Maximizes **expected** utility

Learning agents

Representing environmental states

(a) Atomic   (b) Factored   (b) Structured

Less expressive ———————————→ More Expressive

Summary

- Agents interact with environment with actuators and sensors
- Agent function describes agent behavior
- Performance measure evaluates the environment sequence produced by agent actions
- A perfectly rational agent maximizes expected performance
- Agent programs implement agent functions on some architecture
- PEAS descriptions define task environments
- Environments can be categorized along
  - Observerable, deterministic, episodic, static, discrete, single-agent
- Several basic single-agent architectures exist
  - Reflex, reflex with state, goal-based, utility-based, learning