The AI Ecosystem

Module 2

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What is an AI Ecosystem?

- When you talk AI, we mean models, platforms, s/w, and api's.
- AI spans different areas such as robotics, computer vision, image processing, natural language processing, chatbots, video, speech recognition, gesture control, etc.
- There are specialized components being developed in each of these areas. Hundreds of companies are working in each of these areas across the globe. This is the AI Ecosystem!

Objectives

- What is Intelligence?
- Define an intelligent agent (robot)
- Environments in which an agent operates
- Types of agents
- Components of an intelligent agent

What is Intelligence?

- The ability of a system to
  - Perceive the environment
  - Calculate & reason from the percepts
  - Learn from experience
  - Store and retrieve information from memory
  - Solve problems, comprehend complex ideas
  - Use natural language fluently
  - Classify, generalize, and adapt to new situations.

Intelligence Is...

- For our purposes, intelligence can be broken down into three components: *Sensing, reasoning,* and *acting*.
  - Sensing or Perception: (taking stuff in from the environment)
  - Reasoning (thinking about it)
  - Acting (Do something about it)

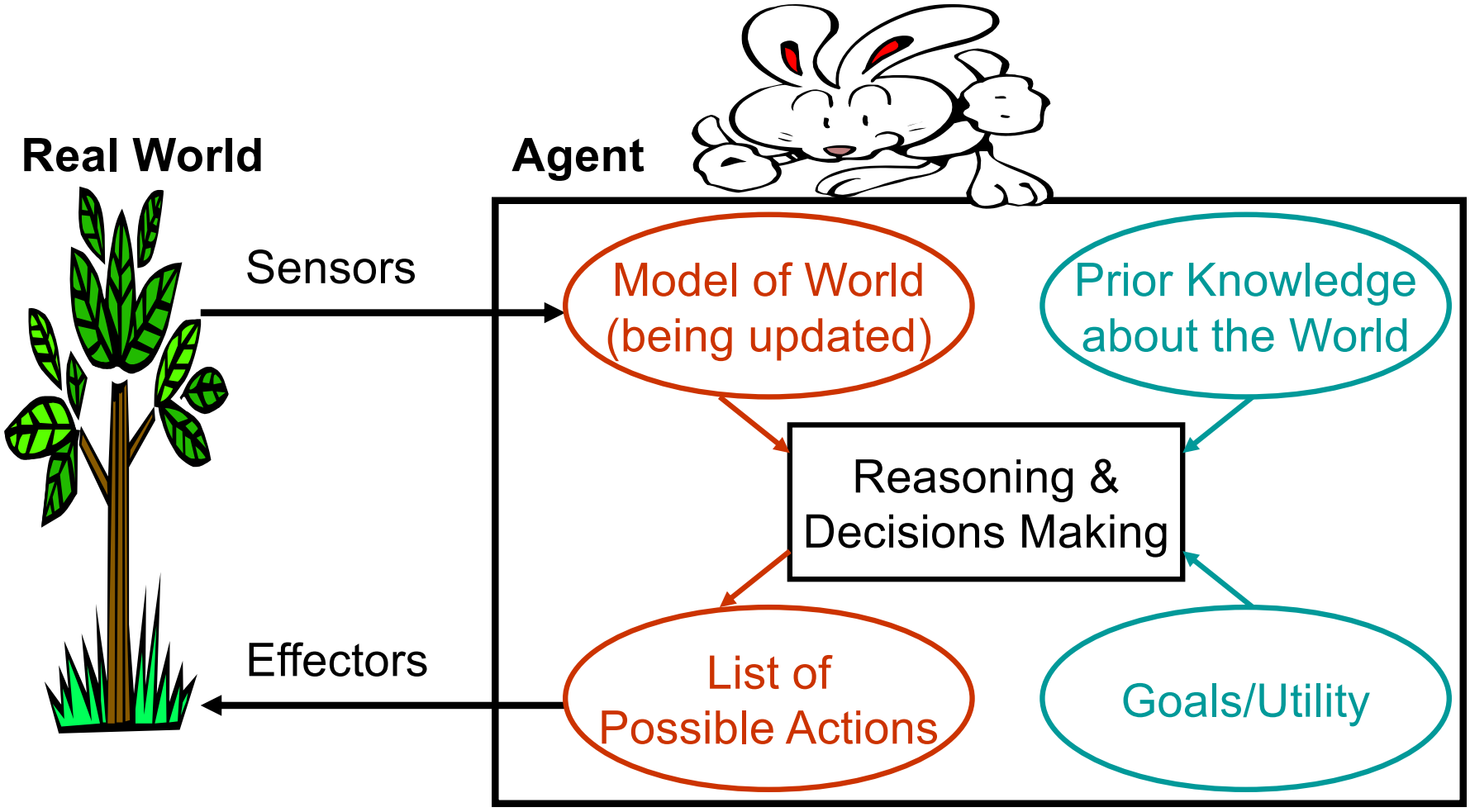
Environment

- Depending on the environment, these three activities can assume specific flavors
- Sensing: listening to a speech, looking at an image, etc.
- Thinking: logic-based reasoning, evidence-based reasoning, etc
- Acting: Speech generation, moving an arm, etc.
- An entity that can perform these activities is called an agent

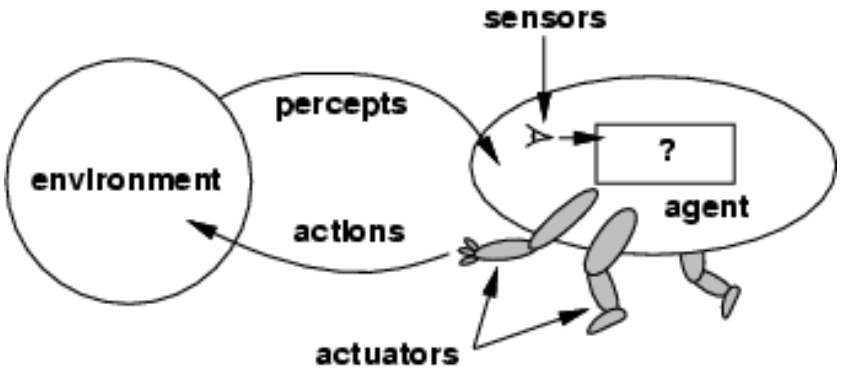
Intelligent Agent: Definition

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators
- Human agent:
  - Sensors: eyes, ears, and other organs
  - Actuators: hands, legs, and some body parts
- Robotic agent:
  - Sensors: cameras, range finders, etc.
  - Actuators: levers, motors, etc.
- Softbots (s/w agents)
  -

Agent Architecture



Agent: Representation



- 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*
- *f* = agent = architecture + program

Performance of Agent

- We need an objective measure to characterize how successful an agent is
  - –Power consumption, accuracy, profit, etc.

Specification of Agents: PEAS

- Specification of the setting for intelligent agent design has 4 coordinates: PEAS
  - Performance measure
  - Environment
  - Actuators
  - Sensors

PEAS: Example 1

- Automated taxi driver:
  - Performance measure: Safe, fast, legal, comfortable trip, maximize profits
  - Environment: Roads, other traffic, pedestrians, customers
  - Actuators: Steering wheel, accelerator, brake, signal, horn
  - Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard
  -

PEAS: Example 2

- Medical diagnosis system:
  - Performance measure: Healthy patient, minimize costs, lawsuits
  - Environment: Patient, hospital, staff
  - Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)
  - Sensors: Keyboard (entry of symptoms, findings, patient's answers)

Environments

- The simplest environment is
  - Fully observable, deterministic, episodic, static, discrete and single-agent.
- Most real situations are:
  - Partially observable, stochastic, sequential, dynamic, continuous and multi-agent.

Types of Agents

Concept

- Autonomous agent
- Rational agent
- Perfect rationality
- Bounded rationality

Type of Agent

- Table-driven agent
- Simple reflex agent
- Model-based reflex agent
- Goal-based agent
  - Problem-solving agent
- Utility-based agent
  - Can distinguish between different goals
- Learning agent

Autonomous Agent

- Autonomous: free, independent, sovereign, not subject to the rule or control of another.
- An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)
  - An autonomous agent decides autonomously which action to take in the current situation to maximize progress toward a goal

Rational Agent

- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform.
- 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.
- Rationality is not the same as omniscience (all-knowing with infinite knowledge)

Perfect Vs Bounded Rationality

- Perfect Rationality: Assumes that the rational agent “knows all” and takes action that maximizes her utility
  - Humans do not satisfy this definition
- Bounded Rationality: Because of the limitations of the human mind, humans use approximate methods to handle many tasks

Simplest Agent: Table-driven Agent

A table is a simple way to specify the mapping, [f: $\mathcal{P} \rightarrow \mathcal{A}$]

- Information comes from sensors: percepts
- Look it up in a table
- Triggers actions through effectors
- No notion of history. Action determined by current state

Drawbacks of Table-driven Agents

- Huge tables for mapping
  - Chess needs a table with 35^{100} entries
- Take a long time to build the table by the designer
- No autonomy – all actions are pre-determined

Key Challenge of AI

- The key challenge of **AI** is to frame efficient **agent** programs that produce rational behavior from a small program instead of a huge **table**.

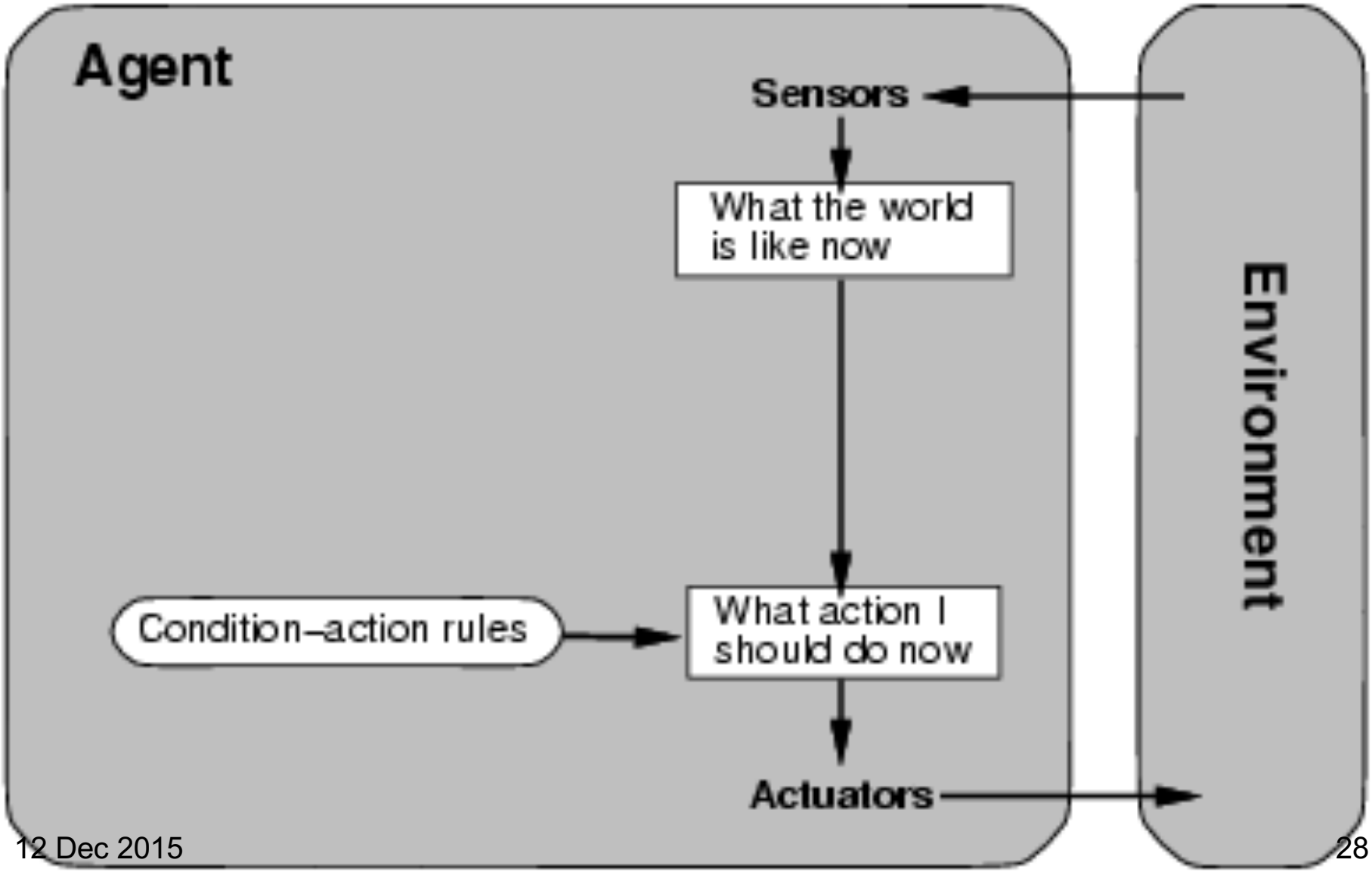
Types of AI Agents

- Simple Reflex Agents.
- Model-Based Reflex Agents.
- Goal-Based Agents.
- Utility-Based Agents.
- Learning Agent.

Simple Reflex Agent - 1

- A **simple reflex agent** is the most basic of the intelligent agents.
- It performs actions based on a **current situation**. When something happens in the environment, the simple reflex agent quickly scans its knowledge base for how to respond to the situation at hand, based on pre-determined rules.

Simple Reflex Agents - 2



Simple Reflex Agents - 3

- Select action based *only the current* percept.
- Implemented through *condition-action rules*
  - *If* dirty, *then* suck (Vacuum cleaner)

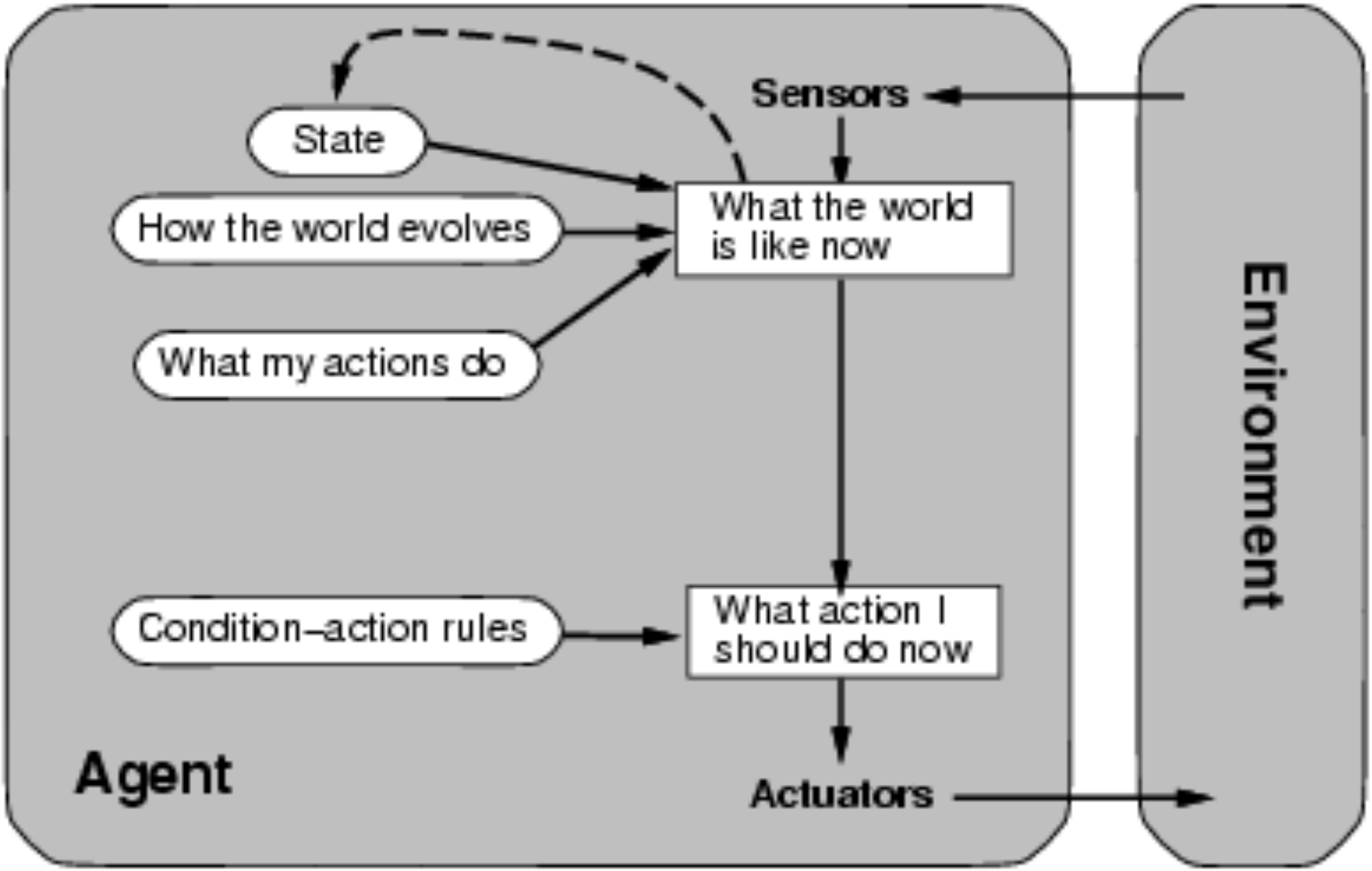
Example: Simple Reflex Agents

- A smart streetlight set to turn on at 6 p.m. every evening
- The light cannot recognize long summer days and will continue to turn the lamp on at 6 p.m. because that is the rule it follows.

Model-based Reflex Agents-1

- A **model-based reflex agent** is an intelligent agent that **uses** percept **history** and internal memory to make decisions by building a **model** of the environment
- Example: Google's self-driving car Waymo is a specific type of intelligent agent known as a model-based agent.

Model-based Reflex Agents - 2



Model-based Reflex Agents - 3

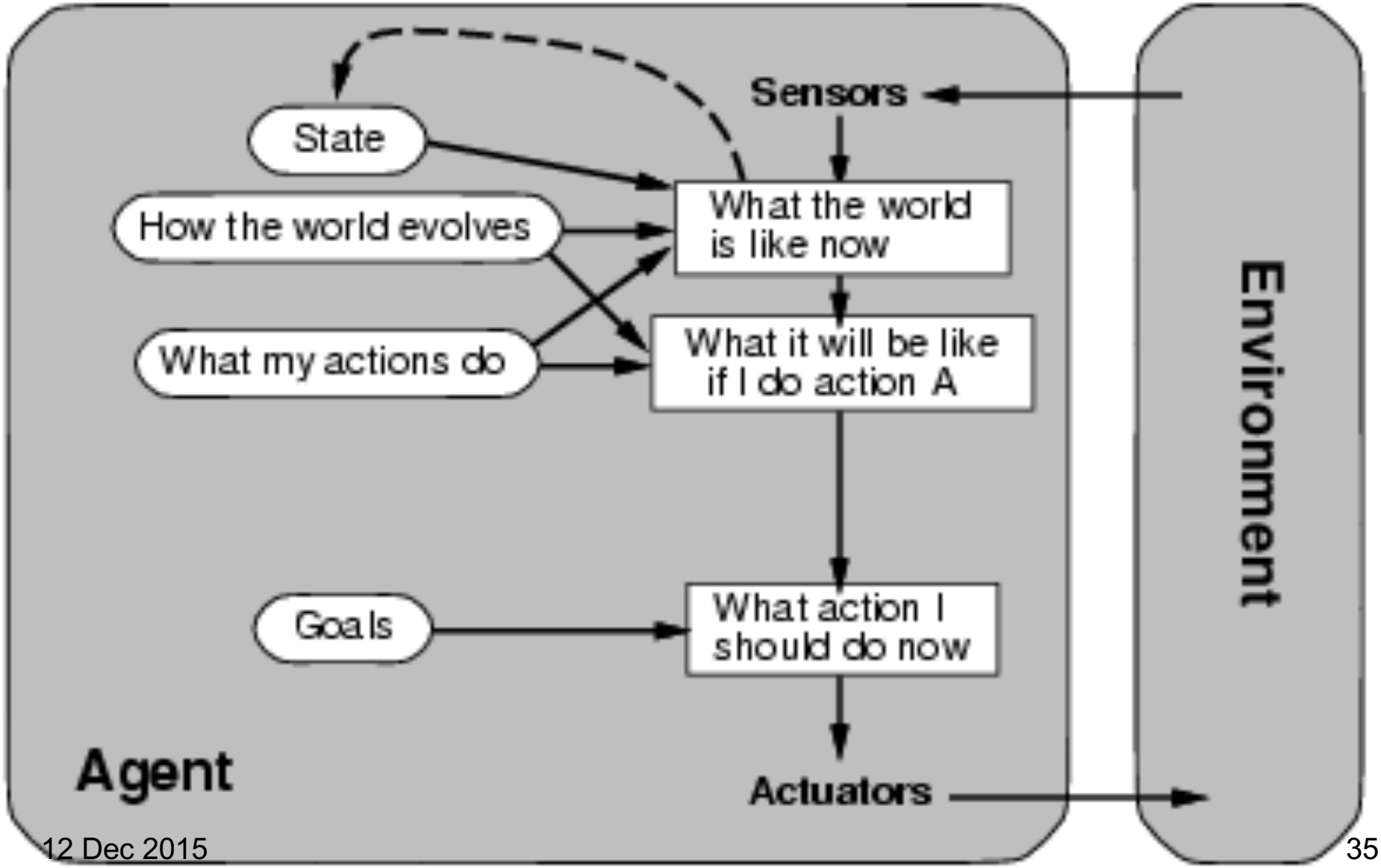
- To tackle *partially observable* environments.
  - Maintain internal state
- Update state using world knowledge
  - How does the world change.
  - How do actions affect world.

  $\Rightarrow$ *Model of World*
- State: What is the system doing?

Goal-based Agents - 1

- A **goal-based agent** takes it a step further by using a **goal** in the future to help make decisions about how best to reach that goal.

Goal-based Agents - 2



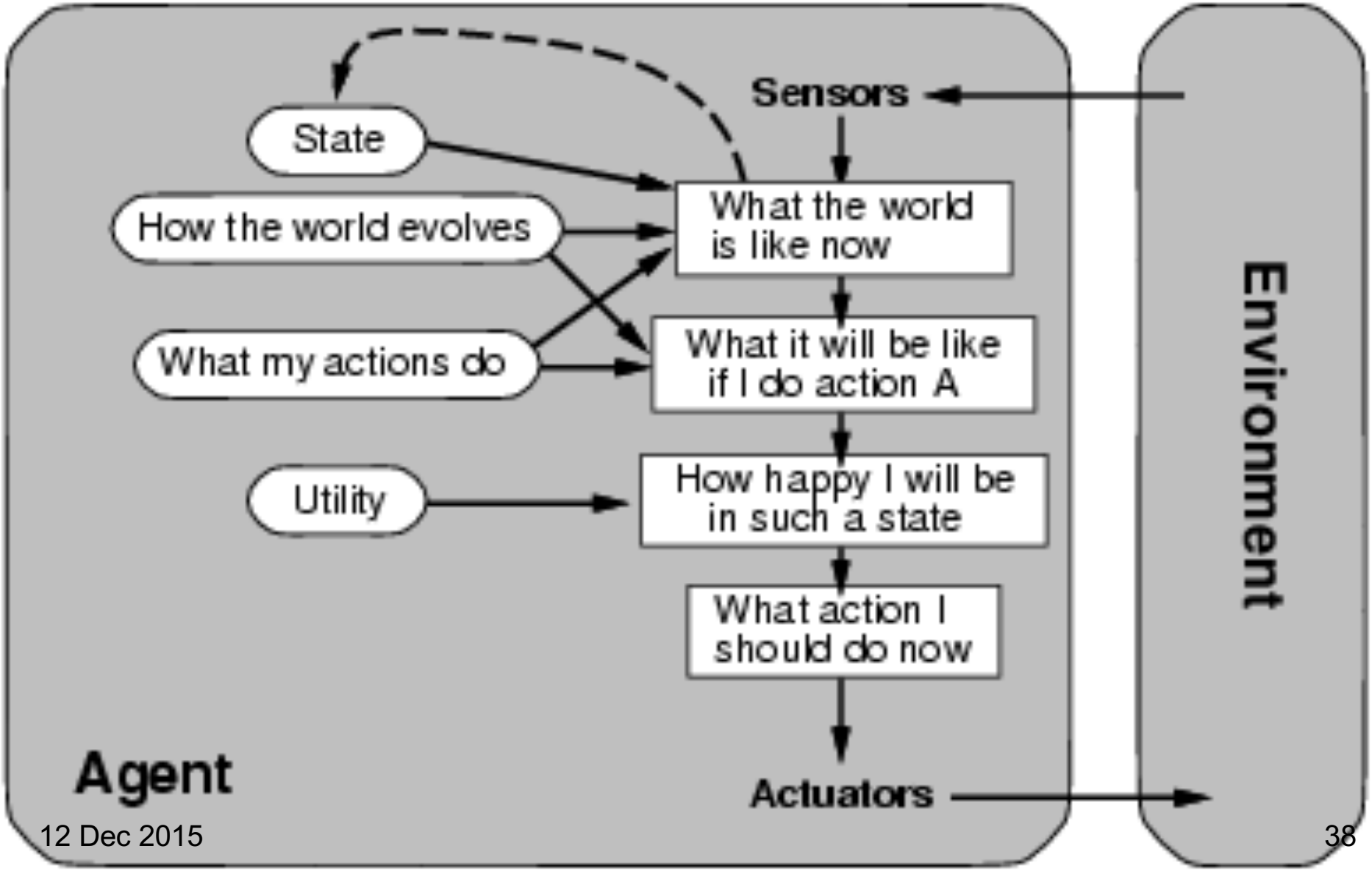
Goal-based Agents - 3

- The agent needs a goal to know which situations are *desirable*.
- The agent targets the goal ahead and finds the right action in order to reach it. **This is a search and planning** function. This helps a goal-based agent to be proactive rather than simply reactive
- Major feature: future is taken into considertion

Utility-based Agents - 1

- A **utility-based agent** is an **agent** that acts **based** not only on what the goal is, but the best way to reach that goal. In short, it is the *usefulness* or **utility** of the **agent** that makes itself distinct

Utility-based Agents - 2



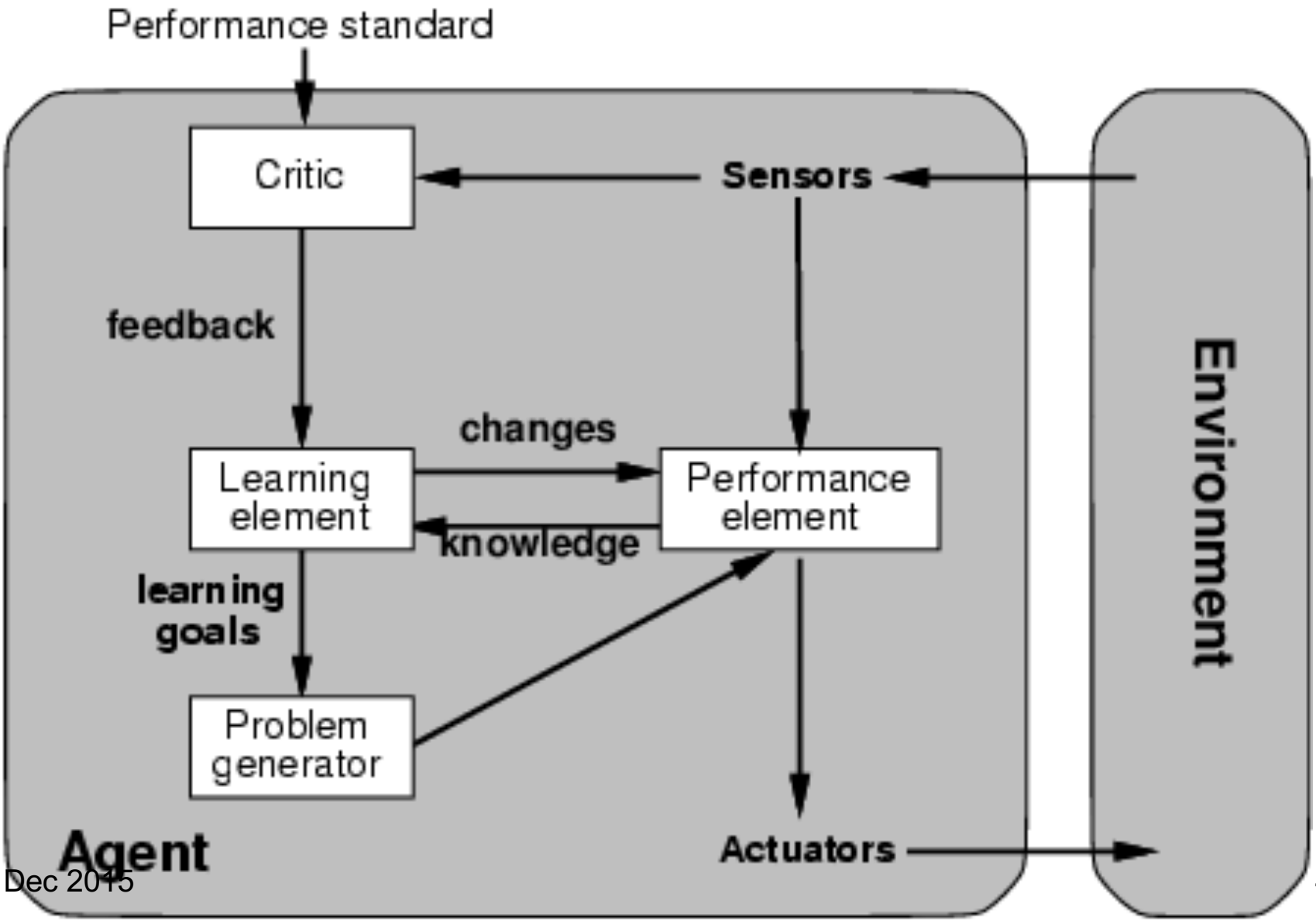
Utility-based Agents - 3

- Certain goals can be reached in different ways.
  - Some are better, have a higher utility.
    - A self-driving car can take you to a goal many ways. Some are cheaper, some are safer, some are faster
- Utility function maps a (sequence of) state(s) onto a real number.
- Improves on goals:
  - Selecting between conflicting goals
  - Select appropriately between several goals based on likelihood of success.

Learning Agents - 1

- A **learning agent** is capable of **learning** from its experiences. It starts with some basic knowledge and is then able to act and adapt autonomously

Learning Agents - 2



Learning Agents - 3

- All previous agent-programs describe methods for selecting *actions*.
  - Yet it does not explain the origin of these programs.
  - Learning mechanisms can be used to perform this task.
  - Teach them instead of instructing them.
  - "**teach**" vs a **instruct:** you can **teach** almost anything: concepts, ideas, theories. When you **instruct**, you're giving them tools to do a specific task.

Learning Agents - 4

- *Learning element*: introduce improvements in performance element.
  - Critic provides feedback on agent's performance based on a fixed performance standard.
- *Performance element*: selecting actions based on percepts.
  - Corresponds to the previous agent programs
- *Problem generator*: suggests actions that will lead to new and informative experiences.
  - Exploration vs. exploitation

Not one, but Many!

- The functionality we see in commercial products is the result of the integration of multiple components. Multiple approaches to different aspects of intelligence come together to create a complete experience.
- Consumer systems are designed for non-technical people. As such, they need to seem “human” as they both listen to and communicate directly with their users.

HW 2A

- List appropriate values for

a) Performance measure

b) Environment

c) Actuators

d) Sensors

If the agent is

  - (i) a robotic agent to play soccer
  - (ii) Internet book-shopping agent

HW 2B

- You normally wait at a bus stop to catch a City Bus. You would like to have a robotic agent at the stop that will announce when the next bus is arriving. Describe the features you would need in such an agent.
- Are there better ways of doing the same thing with a different design? Discuss.