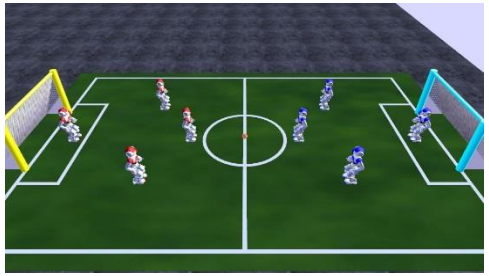
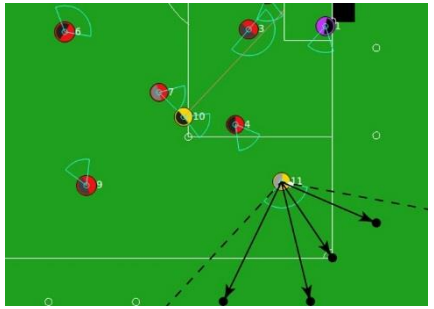
Advanced Artificial Intelligence

Intelligent Agents, Environments,
Knowledge Representation and Reasoning

Intelligent Agent (Entities)

- Program running on an architecture
  - fullfills a purpose
  - input, output, performs changes in the environment
  - agent function f(input) = output
  - agent program implements the agent function
  - runs autonomously
  - might interact
    - with users, with other agents, with the environment
  - behaves intelligently





What is intelligence?

- Intelligence (Oxford dictionary)
  - “The ability to acquire and apply knowledge and skills.”

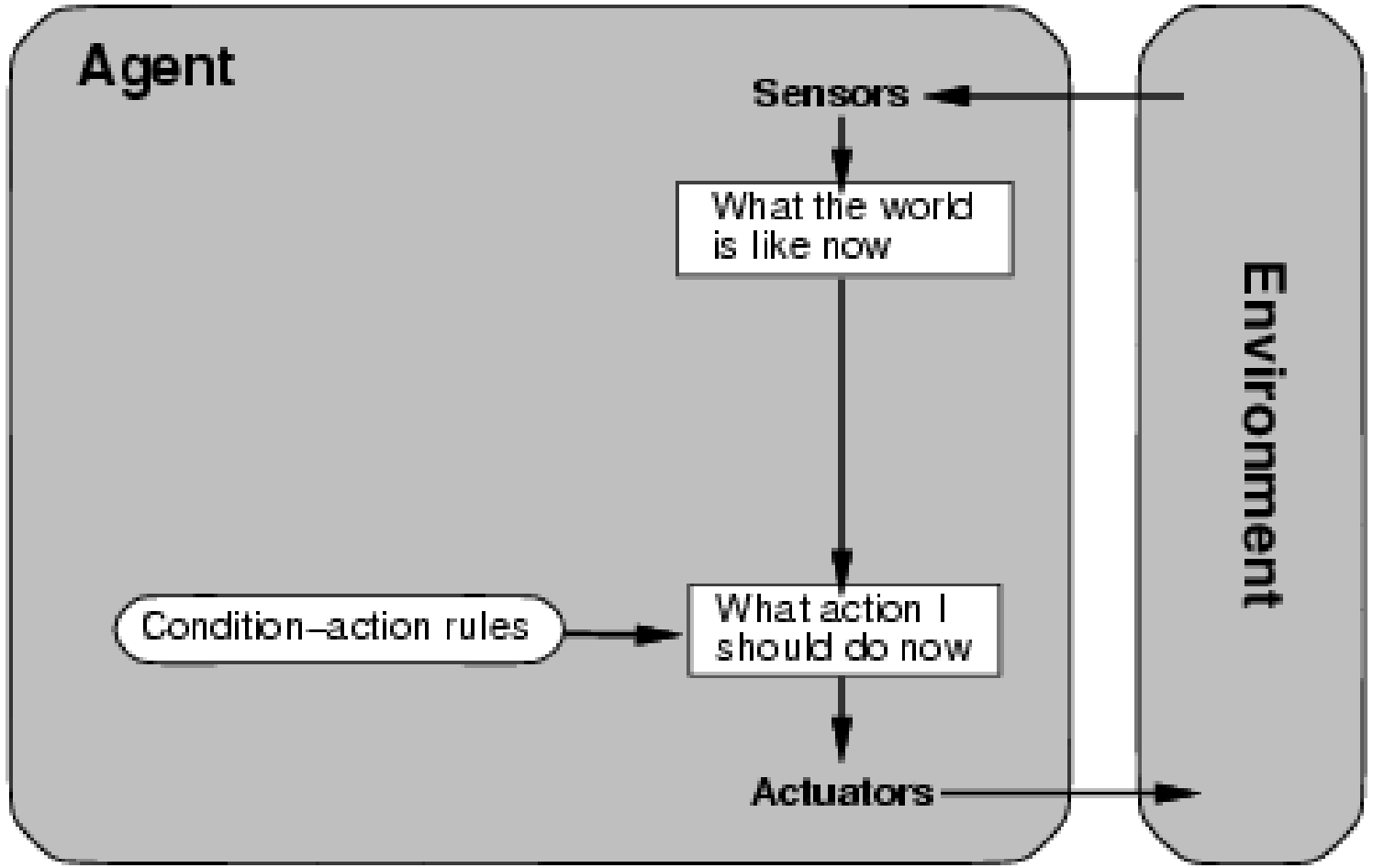
- It became a common understanding
  - An entity is intelligent when it behaves intelligently
  - For intelligent behavior, the acquisition of knowledge e.g. context knowledge for the situation is necessary and general knowledge about the task the entity needs to fulfill, in order to make the right decision in the given situation.

Intelligent Behaviour

- Intelligent Behaviour = Rational Behaviour
- Rational Behaviour is based on
    - what the agent has perceived so far
    - what the agent knows about the environment
    - the actions the agent can perform
    - performance measure
- An agent behaves rationally when given the four things above it chooses the action that maximises its overall performance.

Agent types

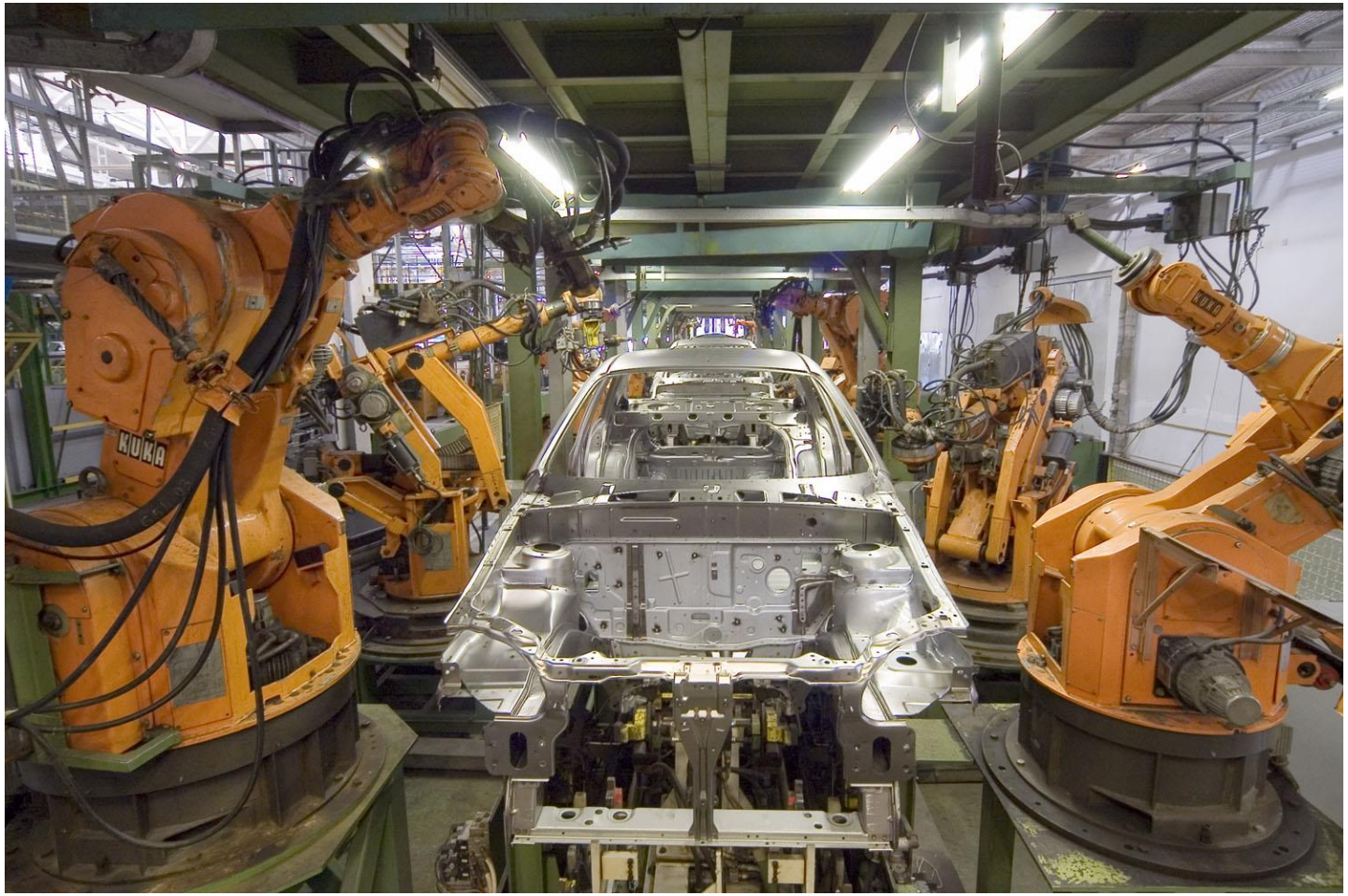
Simple Reflex Agent



Simple reflex agents

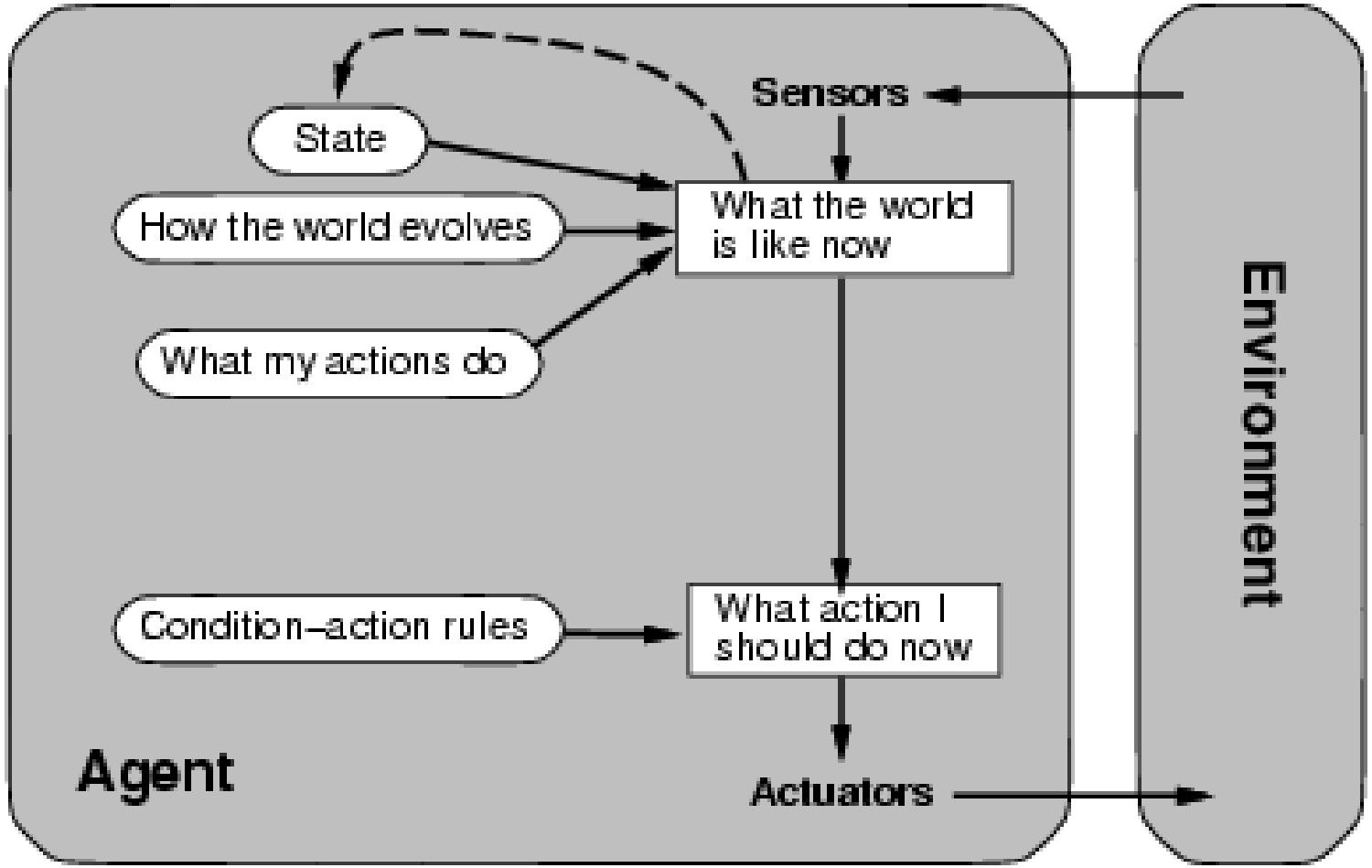
- Thermostat
- Door alarm
- Some simple forms of autonomous vacuum cleaners
  - If dirt -> suck
  - If bump -> turn right
  - If not dirt or bump -> move forward

Industrial Robots



KUKA Roboter GmbH, Germany

Model-based reflex agent

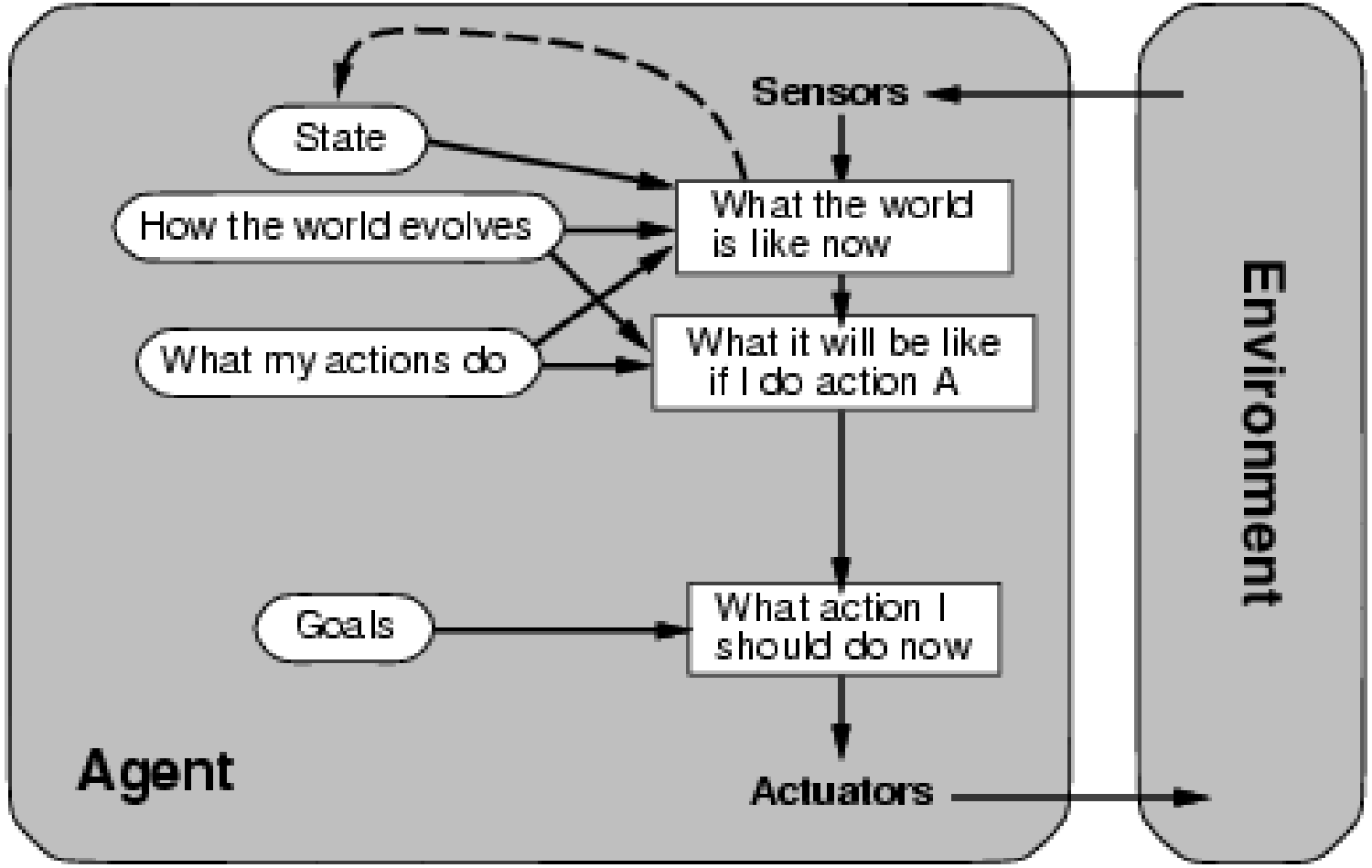


Model based reflex agent

- Internal state
  - Keeps track of the part of the world it can’t see
  - Builds up a ”complete” (maybe somewhat outdated) picture of the world

- Simple driving agent
  - It reacts on the environment with predefined actions
  - Can e.g. look left and right before crossing a street

Goal-based agent

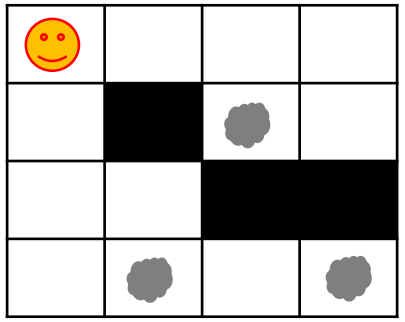


Goal based agent

- Can make decisions
  - Provided it has the right knowledge coded into it.
- Autonomous vacuum cleaner
  - If the goal is to clean the whole carpet
  - Keep track of where it has been (internal state)
  - When turn is needed decide where to turn based on where it has not been yet.
- Autonomous taxi driver
  - Have a destination where it wants to go
  - Which of the available turns at a crossing brings it closer to the goal?
  - It needs to be able to plan ahead (planning and searching)

- It needs some means of gathering/finding all the valid alternatives that it could choose
  - E.g. which routes will bring it to the goal?
- It needs some means to decide which of the alternatives is the best one (evaluation function)
  - E.g. which of the routes is the best/shortest/quickest/nicest?

Autonomous vacuum cleaner

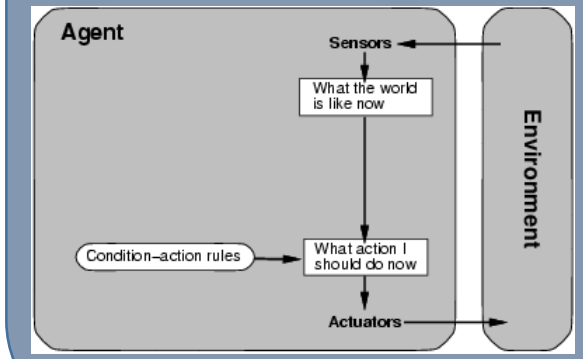


Simple reflex agent

If dirt->suck

If bump -> turn right

If not dirt and not bump -> move forward



Model-based reflex agent

Can build up a map of the world

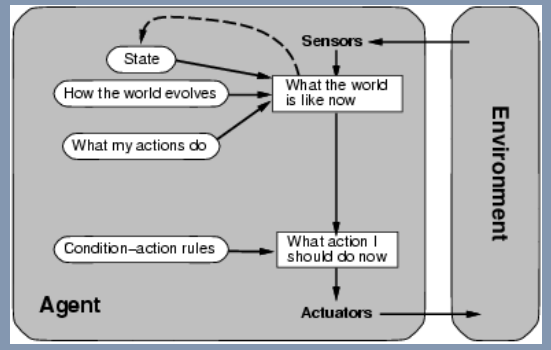
Can learn the layout of your home

Can learn where there are hinder

If bump mark that space in map as ”hinder”

If dirt-> suck and mark space in map as clean

…



Goal-based reflex agent

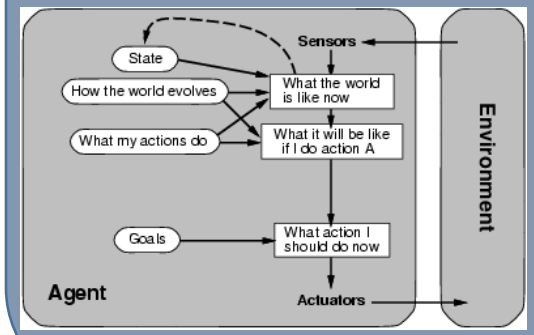
Can build map of the world, etc.

Goal to clean the whole apartment

Counts: how many unvisited fields are there?

Goal: no unvisited fields

Every time it does an action it choses the action that brings it closer to the goal (i.e. an action the decreases the unvisited field counter)



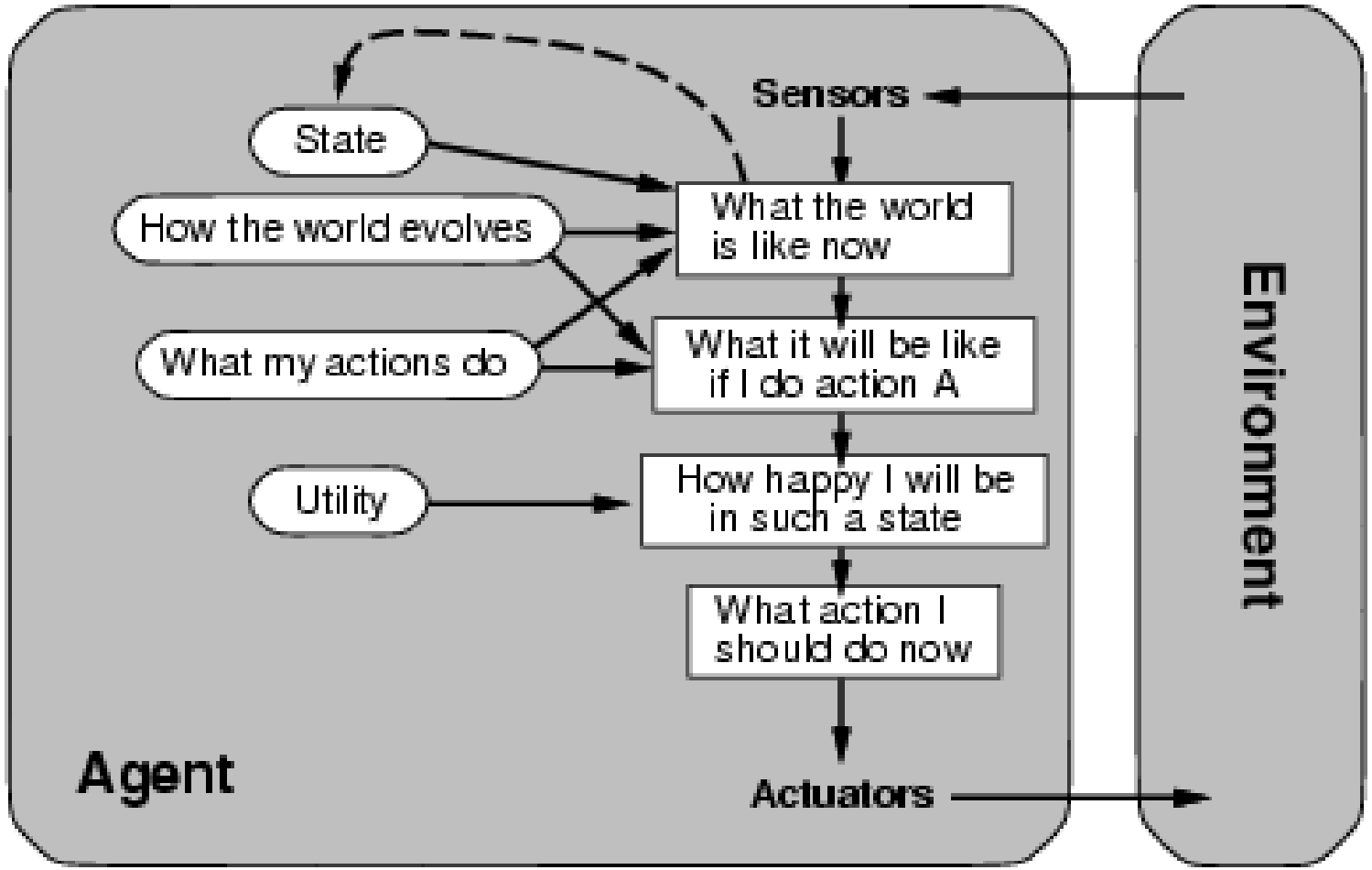
Service Robots

Asimo, Honda

GPS


NDRIVE
Lijnbaansgracht
Rozengracht
Hazenstraat
Elandsstraat
s100
Marnixstraat
De Clercqstraat
Hugo de Grootkade
1m30s
1.4
km
50
0 Kmh
Menu
1.0
km
De Clercqstraat
G400

Utility-based agent



Utility-based agents

- Can manage conflicting goals
- Chooses the alternative that brings it closer to the combined goal (maximizes the utility)
- It needs
  - Internal state to keep track of
  - Knowledge about the environment and how it will develop in the future
  - Searching and planning skills
  - Utility evaluation function

Utility-based agent

- Autonomous car that takes into account
  - A short route to save gasoline and be environmental friendly
  - A quick route to get you there in time, avoid a long journey in the car
  - A safe route, at a safe speed, to make sure you are safe and comfortable

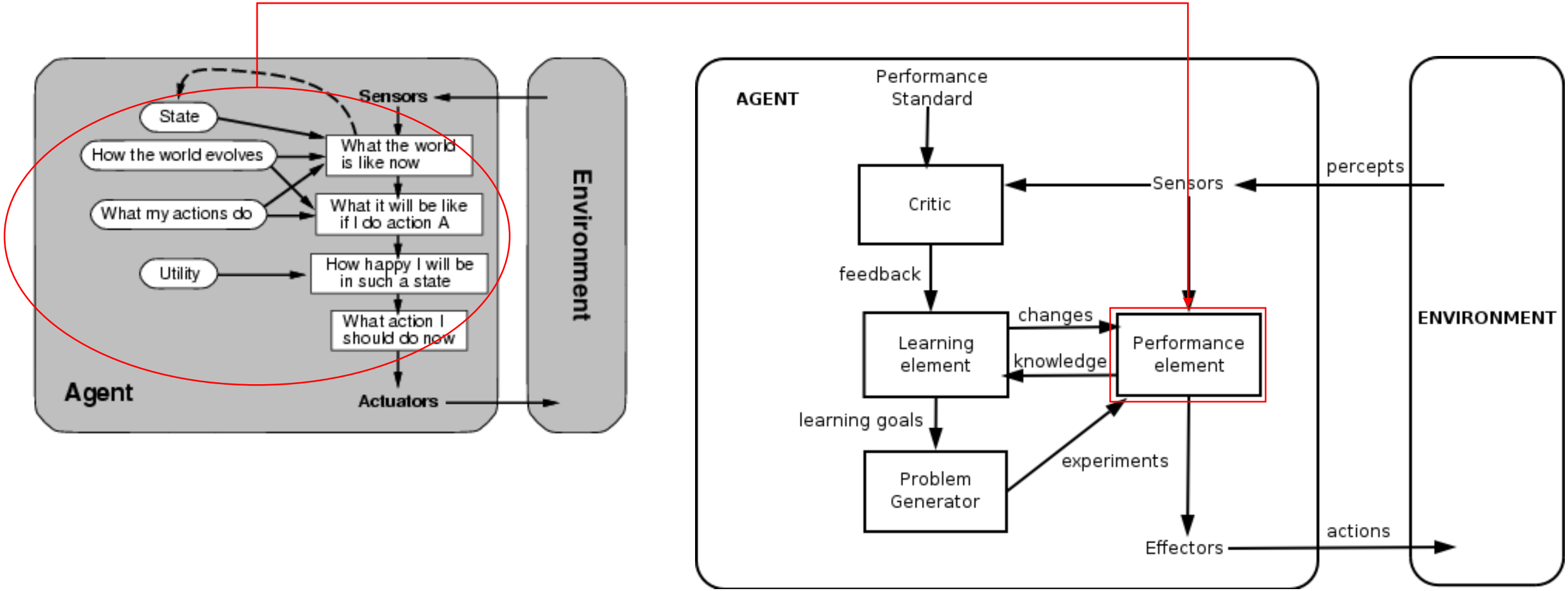
  - The result may be a route that is neither the shortest nor the quickest, nor the safest, but that is (hopefully) in comparison to the possible alternatives the best option considering the combination of short, quick and safe.

Intelligent Agent

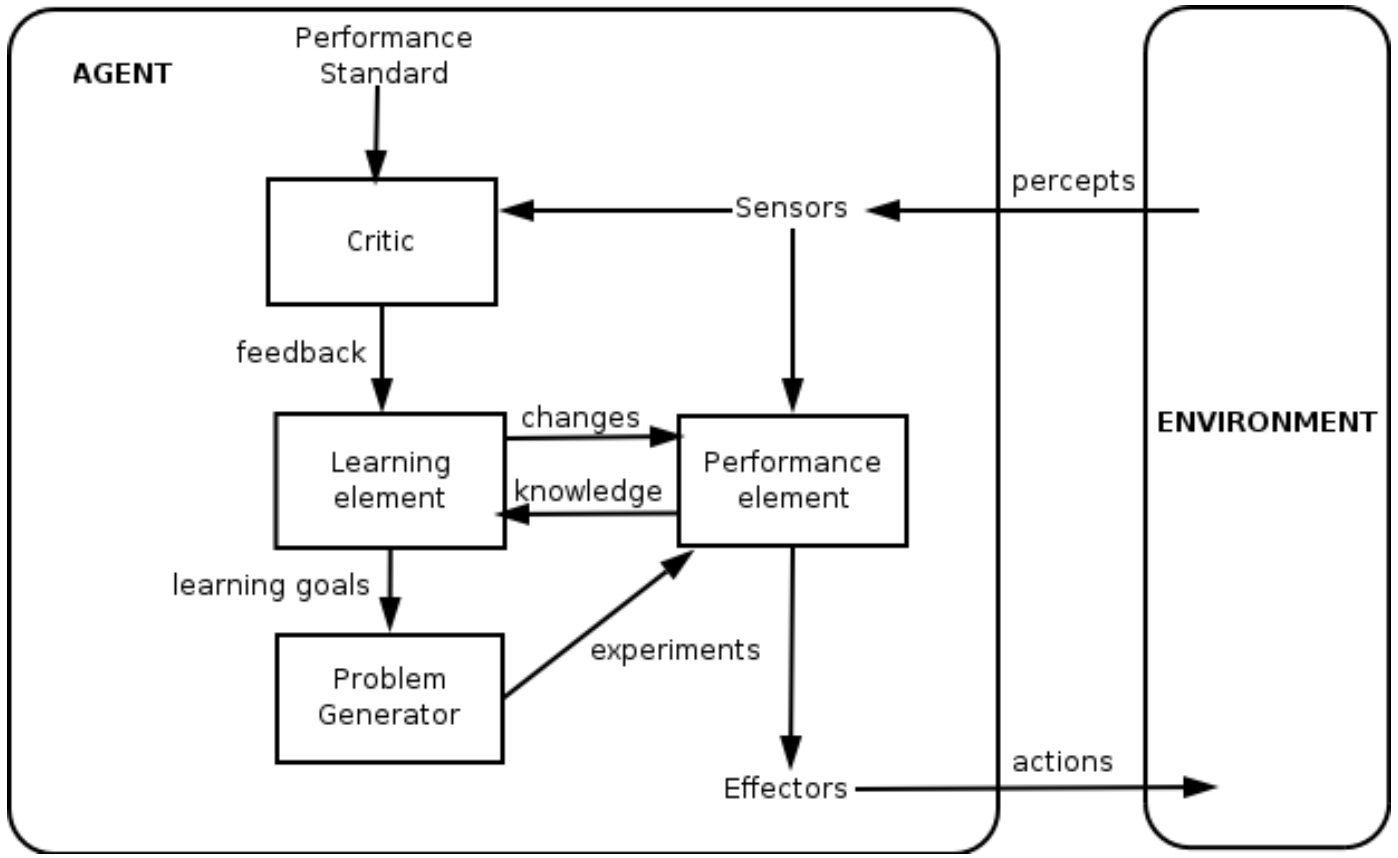
- Agent program
  - implements the agent function, f(input) = output
- Agent architecture
  - “Sensors” (means for input)
  - “Actuators” (means for output)

- Simple reflex agent
  - No internal representation
  - No goals, just reflexes
- Model based reflex agent
  - Internal representation
  - No goals, just reflexes
- Goal based agent
  - Internal representation
  - Goal (probably needs to do searching and planning to be able to achieve the goal)
- Utility based agent
  - Internal representation
  - Several (possibly conflicting) goals (needs searching and planning skills)
  - Makes balanced decisions

Learning agent



Learning agent



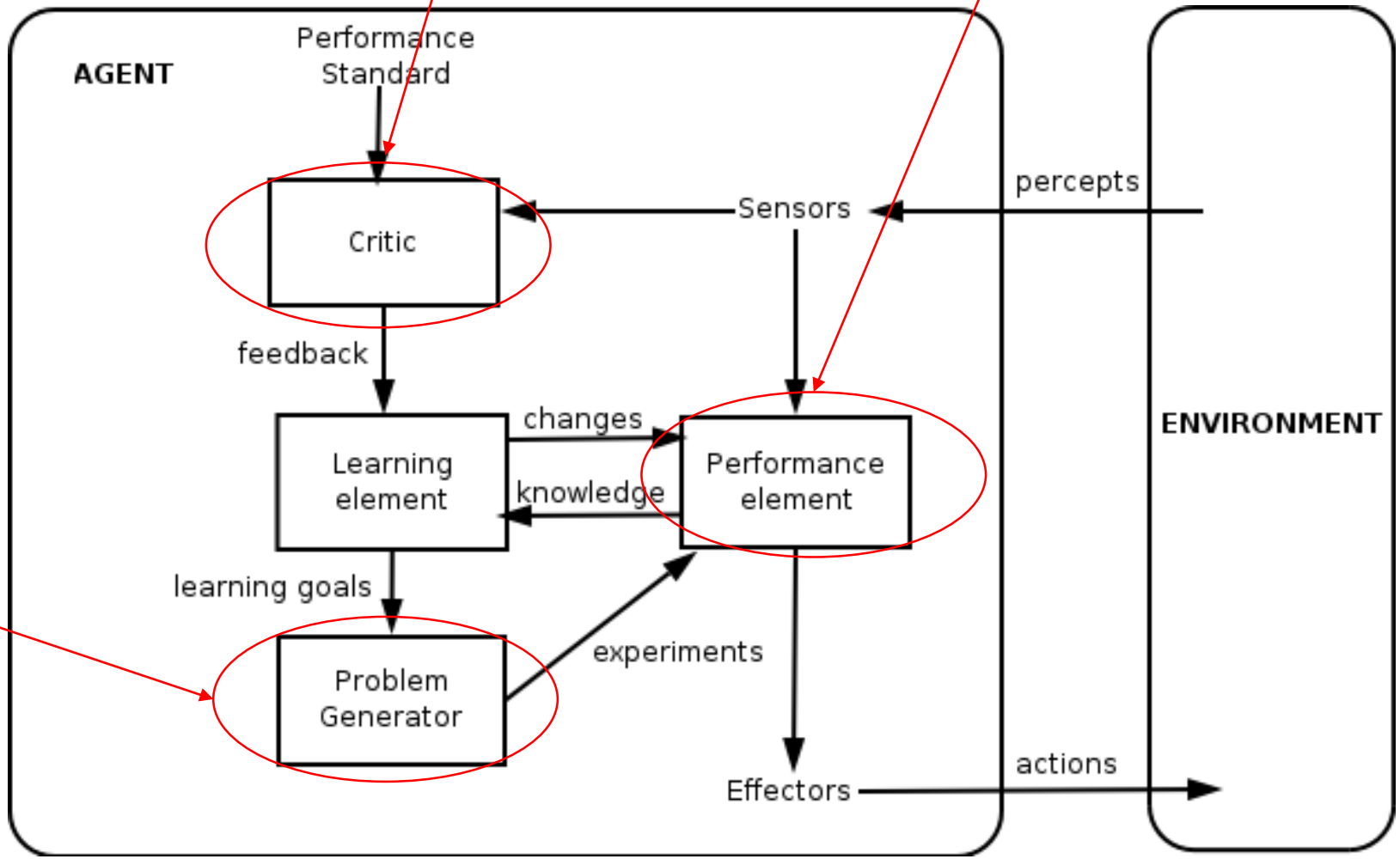
Learning agent

- The performance element includes
  - the agent program (e.g. what is needed for a simple reflex agent or a utility-based agent, etc.)
  - The learning process is another part of the learning agent that, by learning, improves the performance element over time.
- This is what is called machine learning

Learning agent

Checks the results of the agents action

Agent Program



Proposes actions that would be good for learning

Types of Learning

- Supervised learning
  - Learning from examples
    - E.g. learn to distinguish between cats and dogs by looking at many cat and dog pictures that are labeled until you can identify cats and dogs on unseen pictures good enough
- Unsupervised learning
  - Figuring out the differences themselves
    - E.g. knowing there are two groups to divide the pictures into, comparing the pictures and find the most important combination of variables that are different and hence divide the pictures into two groups.
      - You don’t know what the agent learns.
      - It could be cats vs dogs. It could be sunny pictures vs rainy pictures regardless of the animal in the pictures.
- Reinforcement learning
  - Figuring out the right action (sequence of actions) to do in order to achieve the goal of getting the highest reward
  - The agent choses the action(s) to do it by itself
  - It needs an evaluation function to decide if the action(s) lead to something good or not so good and presenting it with the reward

Intelligent Agent

Internal representation of the world
Representation of actions, modeling

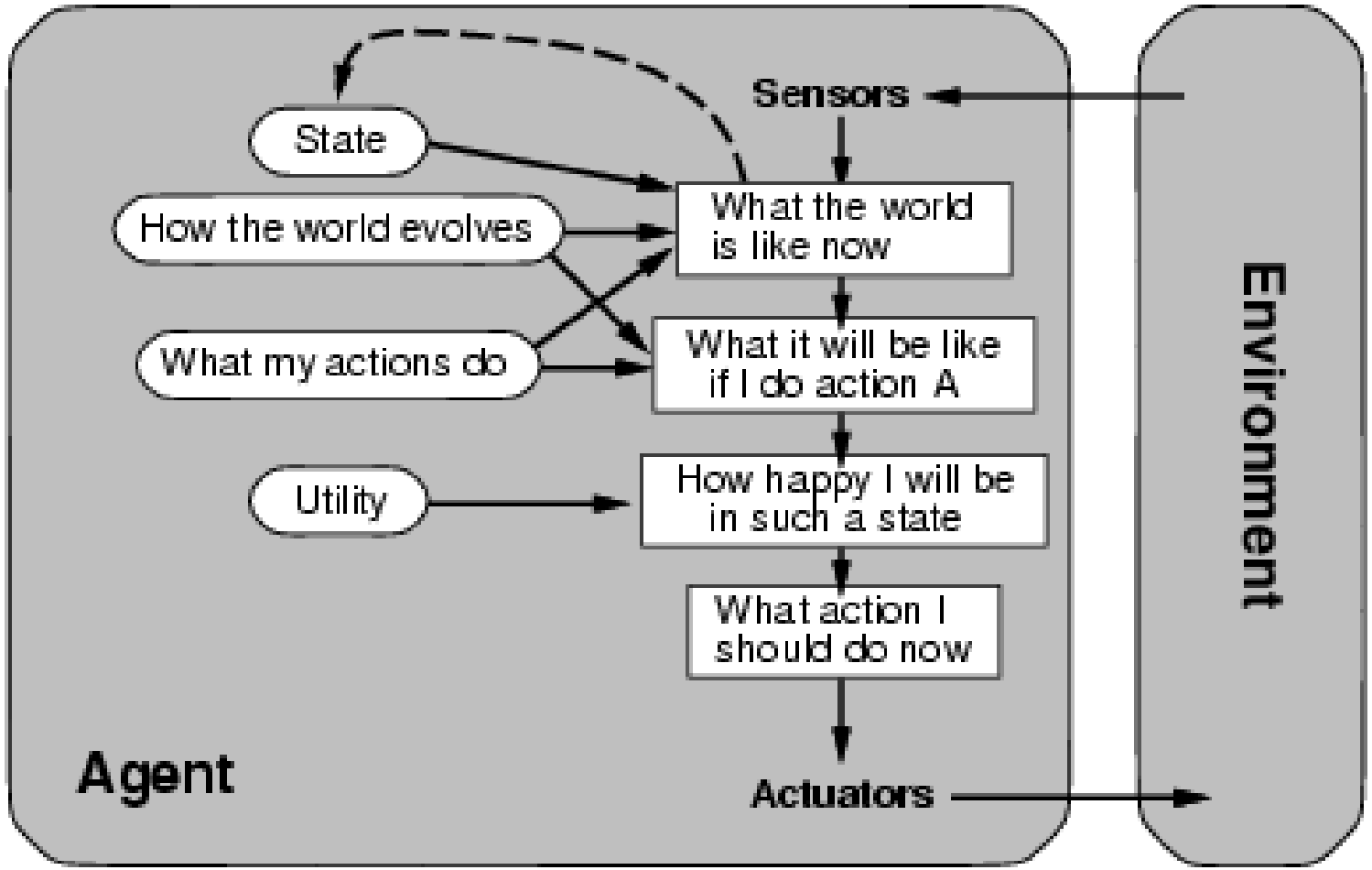
Logical inference
Statistical analysis
Decision making

Machine Learning

Constraint satisfaction
Search algorithms

Agent Environments

Utility-based agent



What does the Agent need to know?

- What aspects of the environment?
  - Does an autonomous car need to know about moon phases?
  - Does an ambient intelligence need to know who Mr. Data is?
  - Does an autonomous car need to distinguish between a rabbit and a cat?
  - Does an autonomous car need to distinguish between different individual cats?
  - Does your alarm system need to be able to distinguish between your and other cats?

- What isn't modeled does not exist
  - We cannot expect the agent to act on it, if it does not know about it

  Closed World Assumption

Gambling Agent

- Do you need to model
  - 36 possible outcomes of one throw?
  - Die standing on edge?
  - Die standing on corner?
  - Die disappearing?
  - Color of die?
  - Who throws the dies?
  - The weather outside?
  - The location of the facility the dice are in?
  - The rules of the game?
  - What is a good and a not-so good outcome?
  - When one has won or lost?

Types of Environment

Fully observable environment

all aspects of the environment can be seen at All times

- Chess playing agent knows at any time
  - Where all the chess pieces are
  - That there is only one opponent
  - And it knows who's turn it is, it also knows when the environment will change by the opponent and when it will change due to own actions.

Partially observable

Some aspects of the environment are not or sometimes not available

- An autonomous vacuum cleaner
  - Does not know where there is dirt unless it senses it in immediate proximity
  - Does not know where there is a wall until it bumps into it
- Autonomous car
  - Can not see around the corners or many miles ahead
- A poker playing agent
  - It can only see some cards but not all of them
    it needs to make decisions even though it does not know all the facts.

Single agent Environment

- This agent is the only one in the environment
- No other agent will influence the environment

- An agent that stocks the shelfs in a supermarket alone after opening hours.
  - Where it did not put an item there will be no item
  - If it does not take any item away, the item will remain there.

Multi Agent Environment

competitive

- A gaming agent playing against an opponent
  - E.g. chess, go, tic-tac-toe

cooperative

- Two agents stocking the shelfs in the supermarket dividing the work
- Fleet of taxi agents covering the area, trying to optimize passengers waiting time, fuel consumption and profit

Types of environments

- Deterministic
  - Next state of the environment can be predicted given the current state and action to be executed
- Nondeterministic
  - Actions have possible outcomes but no definite outcomes (e.g. throwing a die)
- Stochastic
  - Next state of the environment can (sometimes) not be predicted

Types of environments

- Episodic
  - The next action is not influenced by the outcome of the previous action (e.g. simple vacuum cleaner)
- Sequential
  - The choice of the next action is influenced by the choice of the previous action (shelf stocking agent)
- Static
  - The environment only changes due to the agent's actions
- Dynamic
  - The environment can change due to other causes
- Semi-dynamic
  - The environment does not change by itself
  - The agents performance measure does (e.g. negative performance for too long inactivity)

Types of environments

- Discrete
  - Finite number of distinct states
- Continuous
  - No distinct states
- Known
  - Agent knows everything there is to know about the environment
- Unknown
  - Agent does not know about the environment and how it works and has to discover it