MAI4CAREU
Master programmes in Artificial Intelligence 4 Careers in Europe

University of Ruse

INTELLIGENT COMPUTER SYSTEMS

Svetlana Stefanova

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LECTURE 3

SPECIFICS OF INTELLIGENT SYSTEMS

1. Biological intelligent system
2. Intelligent system specifics
3. Types of intelligent computer systems
4. Agents

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Biological IS - skills

- for adaptation and survival;
- for obtaining new knowledge (curiosity);
- for copying other IS.

CONTENT 1

Basic functions of IS

- **receiving information** from the outside environment;
- **remembering** previous events;
- **decision making and reaction** towards the relevant situation;
- **ability to learn new behavioral rules**, by adapting and improving towards the surrounding environment.

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CONTENT 2

Elements of ICS

- sensors for perception of the environment;
- memory;
- algorithms for decision making;
- calculating elements;
- managing mechanisms;
- source of energy.

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CONTENT 2

Features of modern ICS

- **Manageability** - allow refinement, diagnosis and repair from a distance;
- **Connectivity** - constant sharing of data (with people, with each other and in a "cloud" environment);
- **Security** - thanks to information encryption algorithms.

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CONTENT 2

ICS at home

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CONTENT 2

ICS in the industry

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CONTENT 3

ICS according to the resources used

- Centralized;
- Distributed.

CONTENT 3

Centralized ICS

The idea:

Ability to model real-world processes by adopting the idea of centralized intelligence, autonomy and power of a machine using all available information resources. For each individual task, ICS provides access to various information sources and integrates the obtained results.

Imposed requirements:

- **the need for a huge amount of knowledge for various tasks** - this places high demands on the hardware;
- **need for reprogramming** - to be able to interact with other software or with new information sources;

Risk:

Reaching dead-end states due to the lack of interaction with other systems for cooperative solving of the problem.

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Distributed ICS

The idea:

- the intelligent solution does not require a centralized memorization of the knowledge, processed by a general purpose inference scheme.
- intelligence is situational and active in individual tasks, enabling each solver to process the task without knowing the decision process in the rest of the system.

Questions:

- How to solve problems by systems, consisting of multiple distributed solvers?
- How to coordinate the distributed systems?

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Advantages of distributed ICS

- **extracting information from dispersed sources** and solutions, where the expert knowledge is distributed;
- **parallel problem solving -** difficult for one agent, due to resource limitations or due to the high risk of operation of centralized systems;
- **possibility of interconnection and exchange with existing systems** (intelligent and conventional) - changing business needs require renewal of existing systems, as complete rewriting is expensive or impossible;
- **higher speed of operation**;

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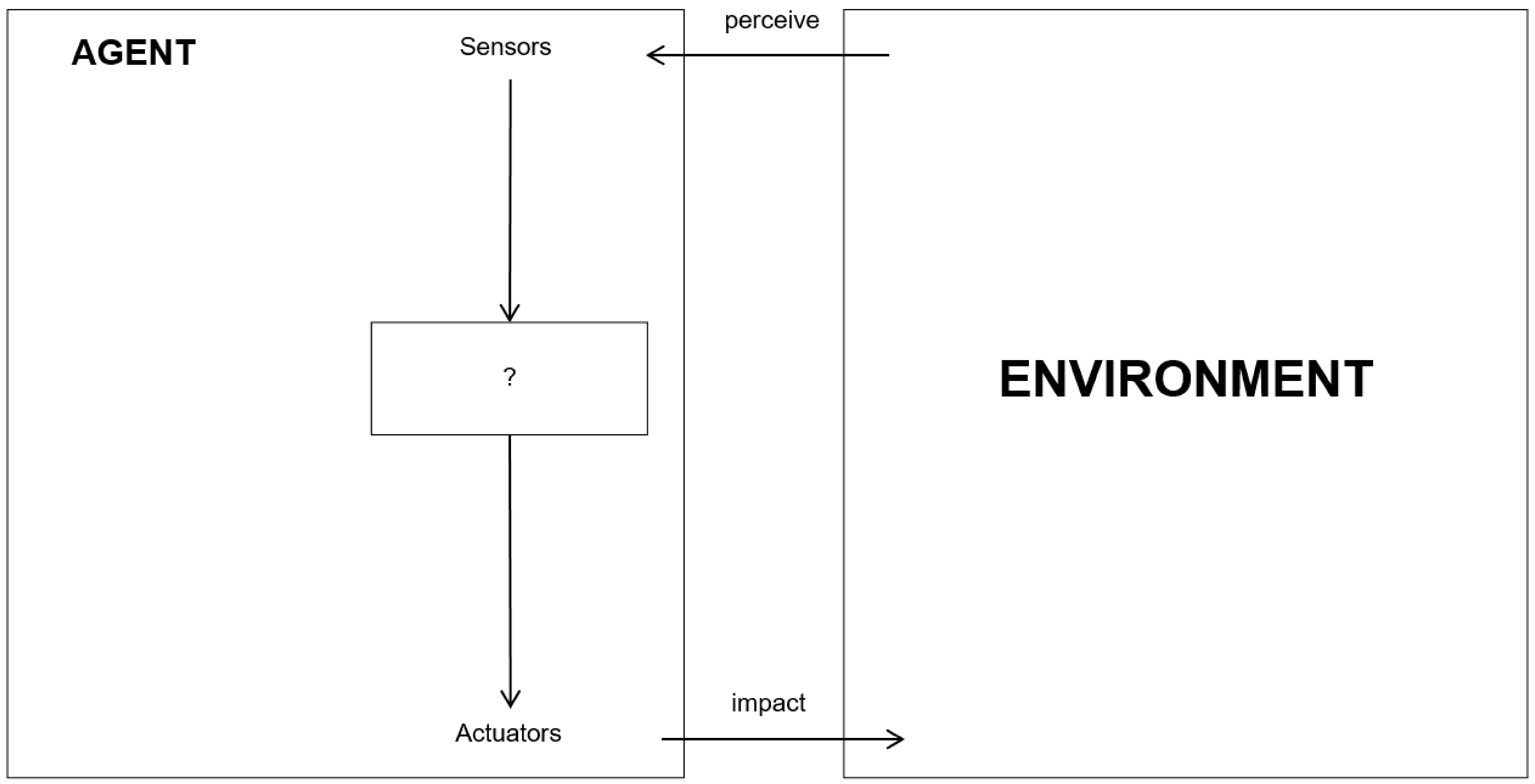
CONTENT 4

Agents

Key concept - ICS shape agents.

CONTENT 4

Agents



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Mathematical description of an agent

- **Behavior of the agent** - can be described by a function, which maps to each perceptual sequence - a certain action.
- **External feature of the agent** - the function can be filled in a table by experimenting.
- **Internal feature of the agent** – the function will be implemented by the agent’s program.

The function of the agent is an abstract mathematical description, and the program is a specific application implemented on the agent's architecture.

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ICS’s task

To build a program of the agent, which applies the function in a way that it could map an action to each perception.

If the program is executed on a computing device with physical sensors and actuators, we call that architecture:\

Agent = architecture + program

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Task environment

PEAS (Performance, Environment, Actuators, Sensors)

Agent	Performance	Environment	Actuators	Sensors
autonomous car	comfortable, safe, fast, no traffic rules violations	roads, other participants in traffic: vehicles, pedestrians, customers	steering wheel, accelerator pedal, brake, etc.	cameras, mileage, GPS, engine sensors, etc.

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Task environment features

- ***Single agent/multi-agent*** – according to the number of agents in the environment. For example, the game of chess is multi-agent, Sudoku - single agent.
- ***Fully/partially visible*** – if the agent's sensors give access to the full state of the environment at any point of time, i.e. define all the aspects that are necessary in choosing an action, then it is fully visible.
- ***Defined/fuzzy*** – if the next state of the environment is fully determined by the current state and action performed by the agent, then the environment is defined.
- ***Static/dynamic*** – if the environment can change as the agent is making a decision, then it is dynamic. Static environments are easier to implement, as the agent does not have to track the world when deciding what action to take.
- ***Episodic/associated*** – the agent's experience can be divided into separate episodes, each consisting of the agent's perception and the execution of a single action. The next episode does not depend on the actions taken in previous episodes.

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Steps when problem solving

- **Goal formulation** - based on current situation and performance measure. A goal can be considered as a set of states in which it is successful.
- **Problem formulation** - the process of deciding what actions and states to consider for a given goal. Actions of the type "moving forward 1 cm" would hardly lead to the resort village.
- **Search process** - to move from city to city, the correct path must be chosen if there is more than one. In order to choose the better one, the region must be known, i.e. to have prior knowledge.
- **Execution phase** - the search algorithm takes the problem as input and returns a solution in the form of a sequence of actions. Once a solution is found, the actions it recommends are performed.

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Knowledge of the environment

- **prior** – known in advance.
- **acquired** - obtained from monitoring the environment or from measurements using sensors. Measurements may contain "noise" which can lead to errors.

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Sensible agent

It reaches the best outcome or the best expected result.

Performance measure - a criterion for the success of the agent's behavior.

When an agent is placed in an environment, it generates a sequence of actions based on the impacts it receives. This sequence of actions causes the environment to go through a sequence of states. If this sequence is desired, the agent performs well.

There is no measure, that is appropriate for all agents.

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Simple reflex agents

They choose actions based on current perception.

Example: autonomous taxi. If the car in front of us is stopping and its break lights light up, we need to notice this and also start stopping. Such a connection is called a rule of the type “condition-action”/ “if-then” or a **production rule**.

If *the car in front of us is stopping* ***then*** *we stop.*

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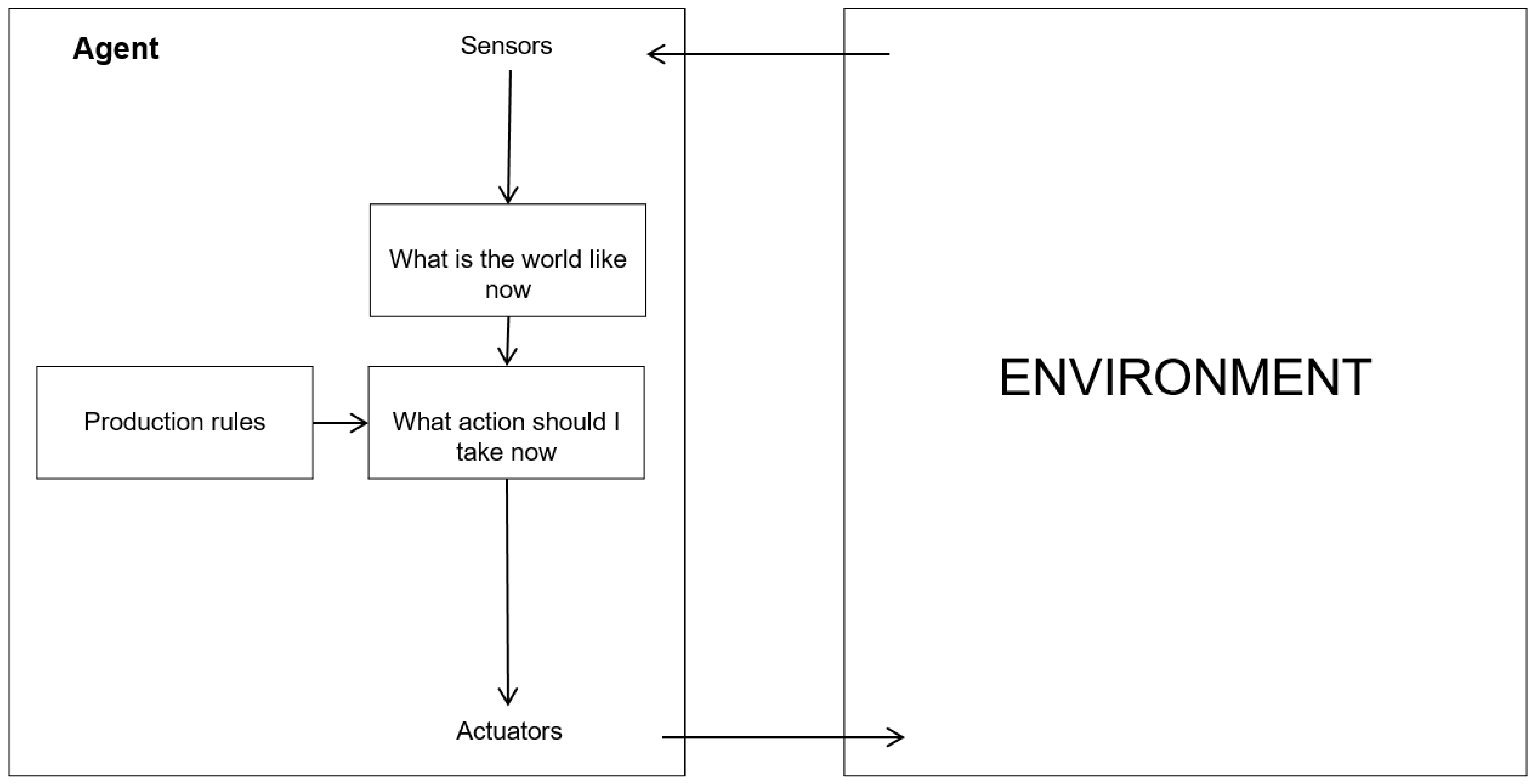
Simple reflex agents



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Model-based reflex agents

In order to overcome partial visibility, the agent has **to keep track of the part of the world he can not see at the moment.**

In order to update the information about the inner state, two types of knowledge are required:

- how the world develops, regardless of the agent;
- how the actions of the agent influence the world.

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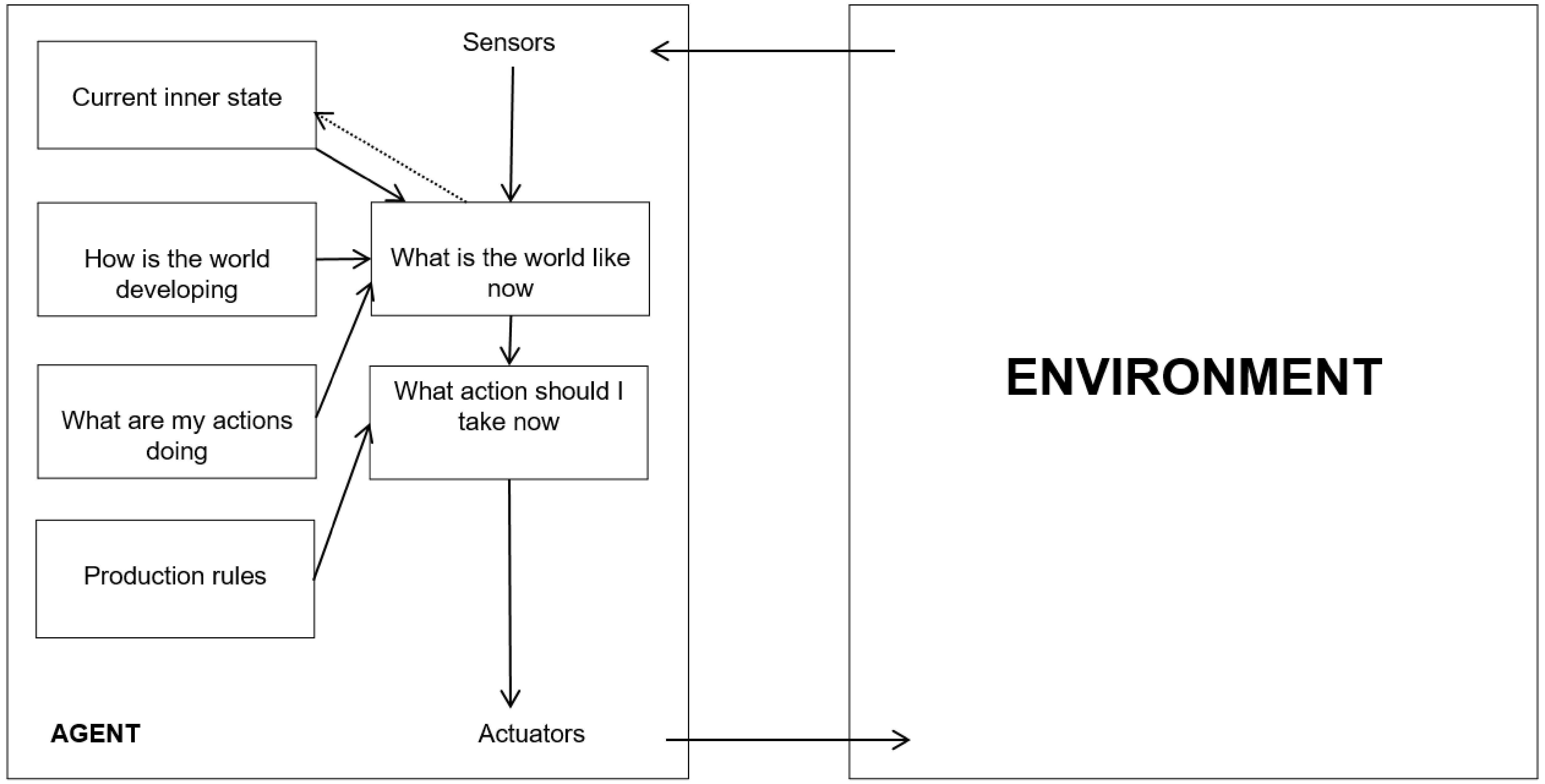
Model-based reflex agents



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Goal-based agents

Knowledge of the current state of the environment is not always sufficient to decide what to do.

Example: at an intersection, the car can turn left, right or continue straight.

i.e. **the agent also needs information about the goal it wants to achieve**.

IS can combine this with information about the results of possible actions (the same information used to update the internal state of the reflected agent). The choice becomes more complex when the agent must perform a sequence of actions and search for a path to achieve the goal.

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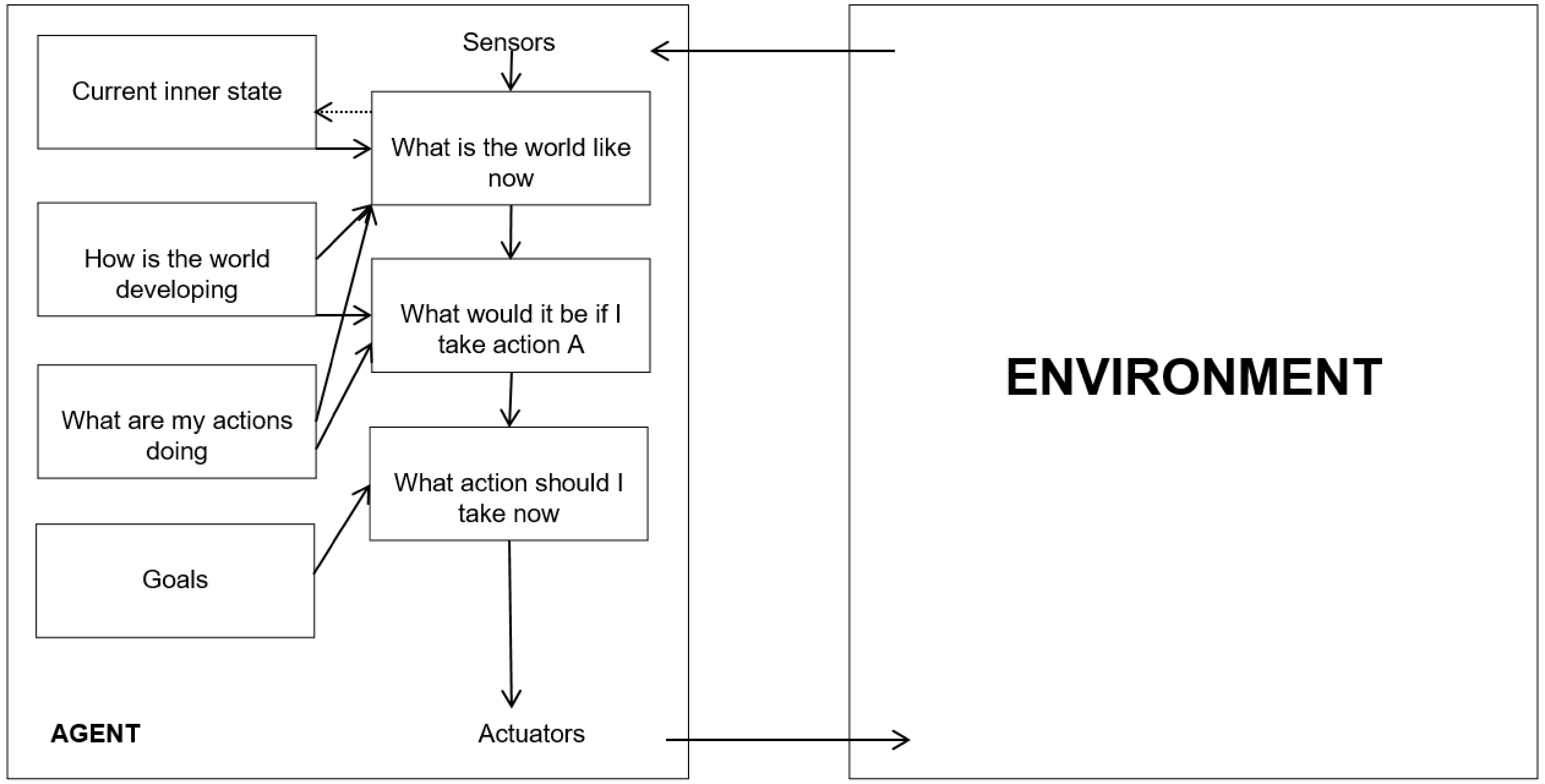
Goal-based agents



Utility-based agents

Example: there are different sequences of actions that would get the car to the goal, but some are faster, safer or cheaper than others.

The goal provides an awareness of the difference between "happy" and "unhappy" states, whereas a more basic measure of performance would allow a comparison between different states according to exactly how happy they would make the agent.

A utility function may map to a state or sequence of states a number that describes the **associative degree of happiness**.

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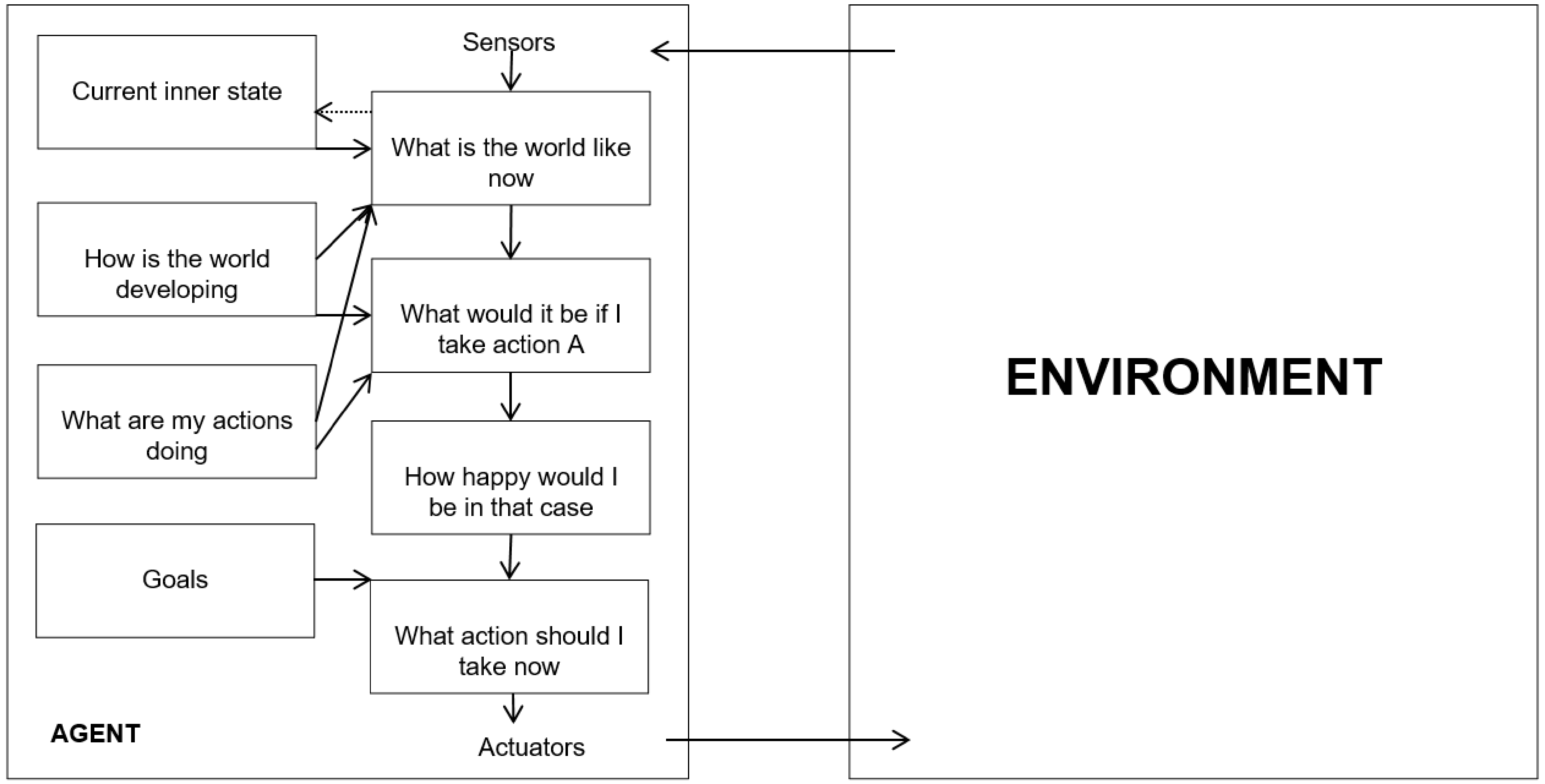
Utility-based agents



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Problem solving agents

To solve problems we need sensible agents, which are usually **utility-based**.

Example: agent, going on holiday.

The performance measure could contain many factors:

- to get a tan,
- to enjoy the nightlife,
- to visit landmarks, etc.

If the agent has a flight delay, then he needs to transform his goal.

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