Part 2: Intelligent Agents

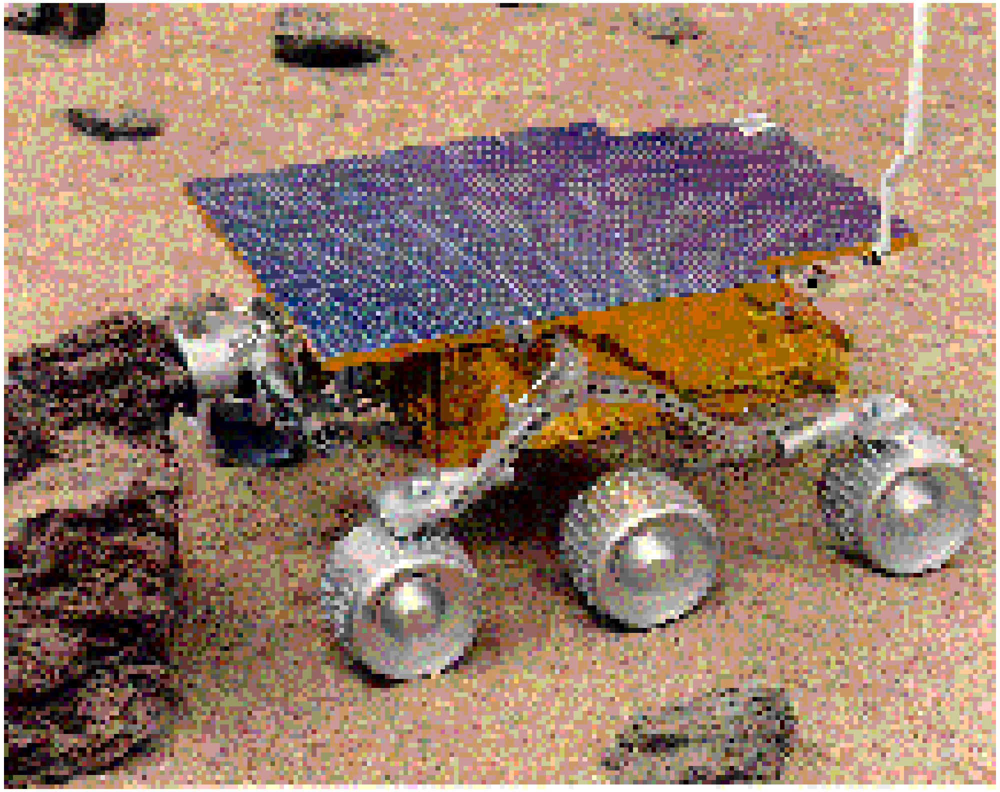
- Intelligent Agents (IA) - Concept
- IA Types
- Environment types
- IA Behaviour
- IA Structure

Mission

- To design/create computer programs that have some intelligence/ can do some intelligent tasks/ or can do tasks that require some intelligence.

Mars Rover

- Autonomous device:
  - Exploring Mars, sending pictures to earth, camera, obstacle sensor, wheels, steering, turning,..

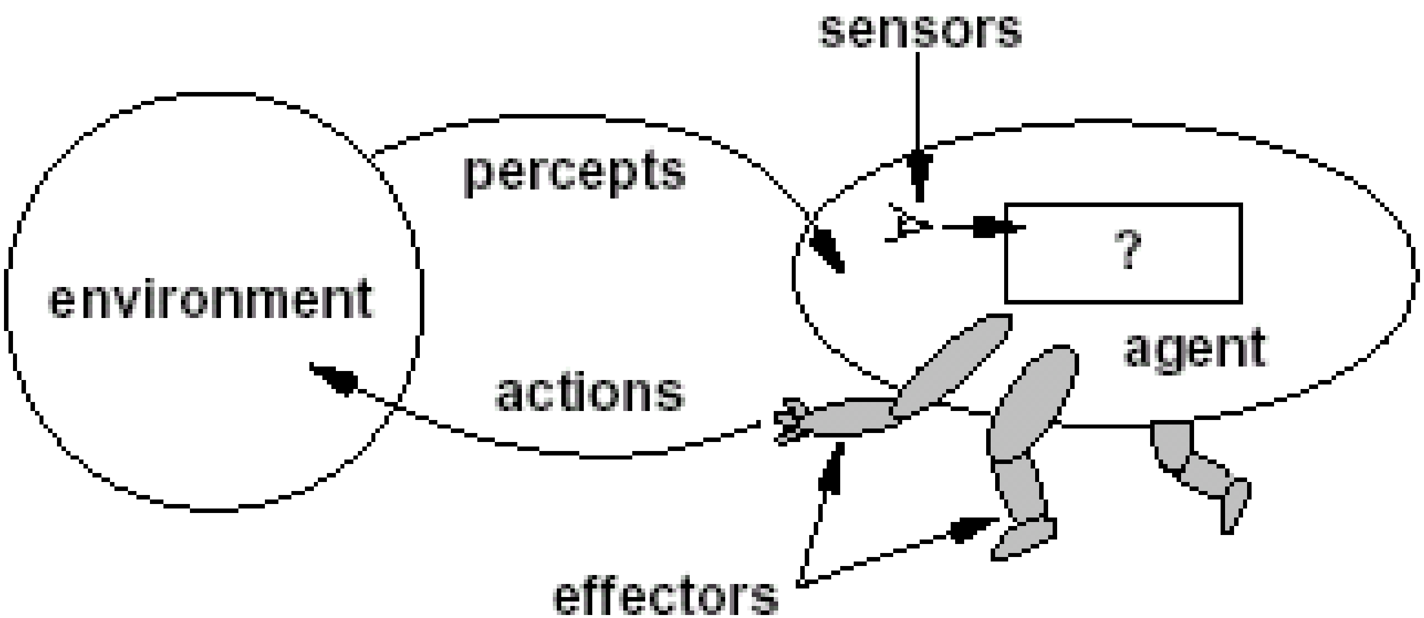


What is an (Intelligent) Agent?

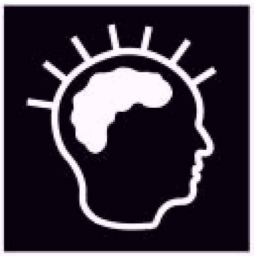
- An over-used, over-loaded, and misused term.
- Anything that can be *viewed as* **perceiving** its **environment** through **sensors** and **acting** upon that environment through its **effectors** to maximize progress towards its **goals**.
- **PAGE** (Percepts, Actions, Goals, Environment)
- Task-specific & specialized: well-defined goals and environment
- The notion of an agent is meant to be **a tool for analyzing systems**, not an absolute characterization that divides the world into agents and non-agents. Much like, e.g., object-oriented vs. imperative program design approaches.

Intelligent Agents

- Agents interact with environments through sensors and effectors



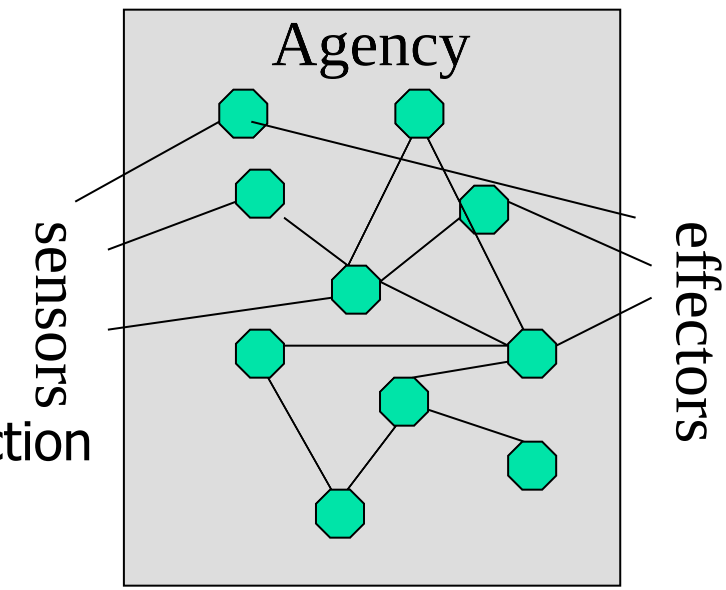
Intelligent Agents and Artificial Intelligence



- Human mind as network of thousands or millions of agents all working in parallel. To produce real artificial intelligence, this school holds, we should build computer systems that also contain many agents and systems for arbitrating among the agents' competing results.

- Distributed decision-making and control

- Challenges:
  - Action selection: What next action to choose
  - Conflict resolution



Agent Research Areas

We can split agent research into two main strands:

- Distributed Artificial Intelligence (DAI) –
  Multi-Agent Systems (MAS) (1980 – 1990)

- Much broader notion of "agent" (1990's – present)
  - interface, reactive, mobile, information

A Windscreen Agent

How do we design a agent that can wipe the windscreens when needed?

- Goals?
- Percepts ?
- Sensors?
- Effectors ?
- Actions ?
- Environment ?

A Windshield Wiper Agent (Cont'd)

- Goals: To keep windscreens clean and maintain good visibility
- Percepts: Raining, Dirty, Clear
- Sensors: Camera (moist sensor)
- Effectors: Wipers (left, right, back)
- Actions: Off, Slow, Medium, Fast
- Environment: Kigali city, highways, weather …

Towards Autonomous Vehicles

Interacting Agents

Collision Avoidance Agent (CAA)

- Goals: Avoid running into obstacles
- Percepts ?
- Sensors?
- Effectors ?
- Actions ?
- Environment: River Road, Nairobi

Lane Keeping Agent (LKA)

- Goals: Stay in current lane
- Percepts ?
- Sensors?
- Effectors ?
- Actions ?
- Environment: Highway

Interacting Agents

Collision Avoidance Agent (CAA)

- Goals: Avoid running into obstacles
- Percepts: Obstacle distance, velocity, trajectory
- Sensors: Vision, proximity sensing
- Effectors: Steering Wheel, Accelerator, Brakes, Horn, Headlights
- Actions: Steer, speed up, brake, blow horn, signal (headlights)
- Environment: River Road, Nairobi

Lane Keeping Agent (LKA)

- Goals: Stay in current lane
- Percepts: Lane center, lane boundaries
- Sensors: Vision
- Effectors: Steering Wheel, Accelerator, Brakes
- Actions: Steer, speed up, brake
- Environment: Highway

The Right Thing = The Rational Action

- **Rational Action:** The action that maximizes the expected value of the performance measure given the percept sequence to date

  - Rational = Best ?
  - Rational = Optimal ?
  - Rational = Omniscience ?
  - Rational = Successful ?

The Right Thing = The Rational Action

- **Rational Action:** The action that maximizes the expected value of the performance measure given the percept sequence to date
  - Rational = Best — Yes, to the best of its knowledge
  - Rational = Optimal (incl. its constraints) — Yes, to the best of its abilities
  - Rational ≠ Omniscience
  - Rational ≠ Successful

Behavior and performance of IAs

- **Perception** (sequence) to **Action Mapping:** $f: \mathcal{P}^* \rightarrow \mathcal{A}$
  - **Ideal mapping:** specifies which actions an agent ought to take at any point in time
  - **Description:** Look-Up-Table,..

- **Performance measure:** a *subjective* measure to characterize how successful an agent is (e.g., speed, power usage, accuracy, money, etc.)

- (degree of) **Autonomy:** to what extent is the agent able to make decisions and actions on its own?

How is an Agent different from other software?

- Agents are **autonomous**, that is they act on behalf of the user
- Agents contain some level of **intelligence**, from fixed rules to learning engines that allow them to adapt to changes in the environment
- Agents don't only act **reactively**, but sometimes also **proactively**
- Agents have **social ability**, that is they communicate with the user, the system, and other agents as required
- Agents may also **cooperate** with other agents to carry out more complex tasks than they themselves can handle
- Agents may **migrate** from one system to another to access remote resources or even to meet other agents

Environment Types

- Characteristics
  - Accessible vs. inaccessible
    - An environment is accessible if the sensors detect all aspects that are relevant to the choice of action.
  - Deterministic vs. non-deterministic
    - If the next state of the environment is completely determined by the current state and the actions selected by the agents, then we say the environment is deterministic.
  - Episodic vs. non-episodic
    - In an episodic environment, the agent's experience is divided into "episodes." Each episode consists of the agent perceiving and then acting.
  - Static vs. dynamic
    - If the environment can change while an agent is deliberating, then we say the environment is dynamic for that agent; otherwise it is static.

Environment Types

- Characteristics
  - Discrete vs. continuous
    - If there are a limited number of distinct, clearly defined percepts and actions we say that the environment is discrete.
  - Hostile vs. friendly
    - This depends on the agent perception.

Environment types

Environment	Accessible	Deterministic	Episodic	Static	Discrete
Operating System					
Virtual Reality					
Office Environment					
Mars					

Environment types

Environment	Accessible	Deterministic	Episodic	Static	Discrete
Operating System	Yes	Yes	No	No	Yes
Virtual Reality	Yes	Yes	Yes/No	No	Yes/No
Office Environment	No	No	No	No	No
Mars	No	Semi	No	Semi	No

- The environment types largely determine the agent design.

Structure of Intelligent Agents

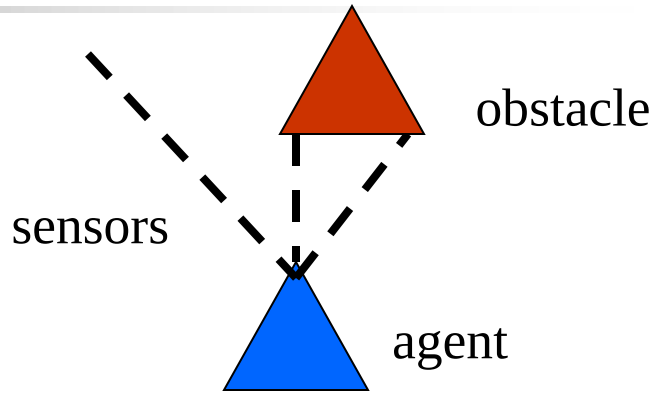
- Agent = architecture + program
- **Agent program:** the implementation of $f: \mathcal{P}^* \rightarrow \mathcal{A}$, the agent's perception-action mapping

function: Skeleton-Agent(*Percept*) **returns** *Action*
memory $\leftarrow$ UpdateMemory(memory, *Percept*)
Action $\leftarrow$ ChooseBestAction(memory)
memory $\leftarrow$ UpdateMemory(memory, *Action*)
return *Action*

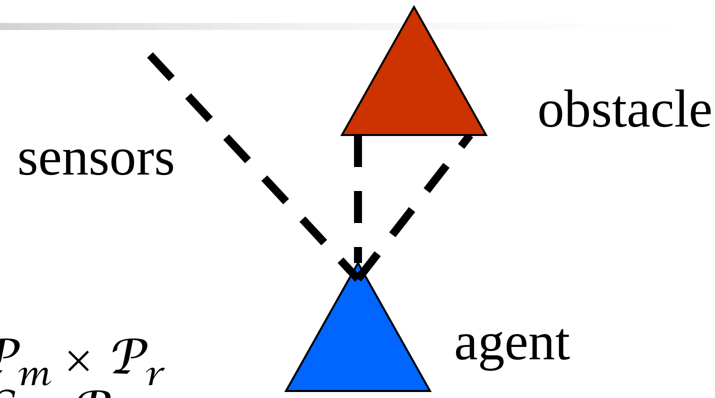
- **Architecture:** a device that can execute the agent program (e.g., general-purpose computer, specialized device, specialized, hardware/software, beobot, etc.)

Using a look-up-table to encode $f: \mathcal{P}^* \rightarrow \mathcal{A}$

- **Example:** Collision Avoidance
  - Sensors: 3 proximity sensors
  - Effectors: Steering wheel, Brakes
- How to generate?
- How large?
- How to select action?



Using a look-up-table to encode $f: \mathcal{P}^* \rightarrow \mathcal{A}$



- Example: Collision Avoidance
  - Sensors: 3 proximity sensors
  - Effectors: Steering wheel, Brakes

- How to generate: for each $p \in \mathcal{P}_\ell \times \mathcal{P}_m \times \mathcal{P}_r$ generate an appropriate action, $a \in \mathcal{S} \times \mathcal{B}$

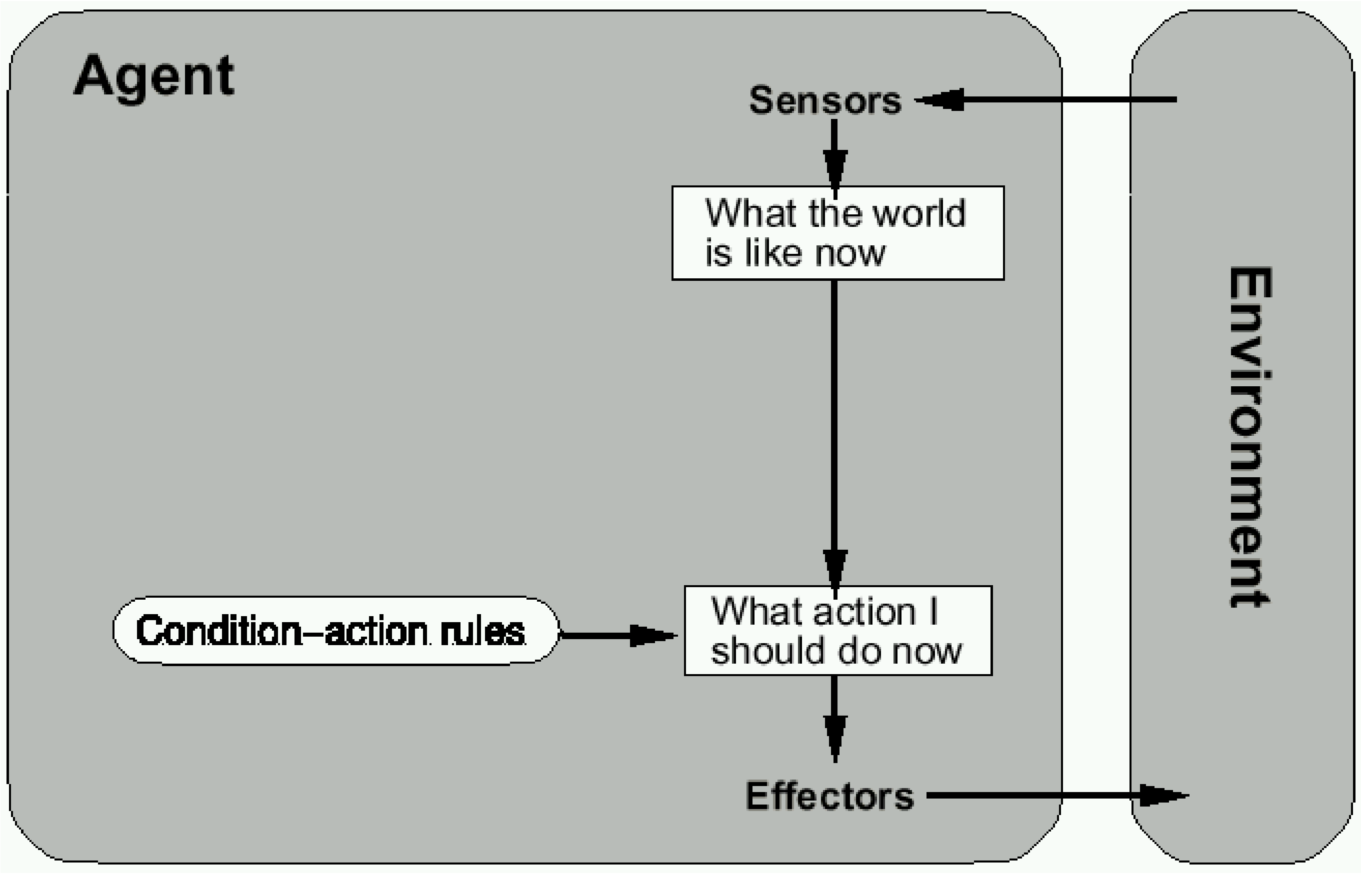
- How large: size of table = #possible percepts times # possible actions = $|\mathcal{P}_\ell|\ |\mathcal{P}_m|\ |\mathcal{P}_r|\ |\mathcal{S}|\ |\mathcal{B}|$
  E.g., P = {close, medium, far}^{3}
  A = {left, straight, right} $\times$ {on, off}
  then size of table = 27*3*2 = 162

- How to select action? Search.

Agent types

- Reflex agents
- Reflex agents with internal states
- Goal-based agents
- Utility-based agents

Reflex agents

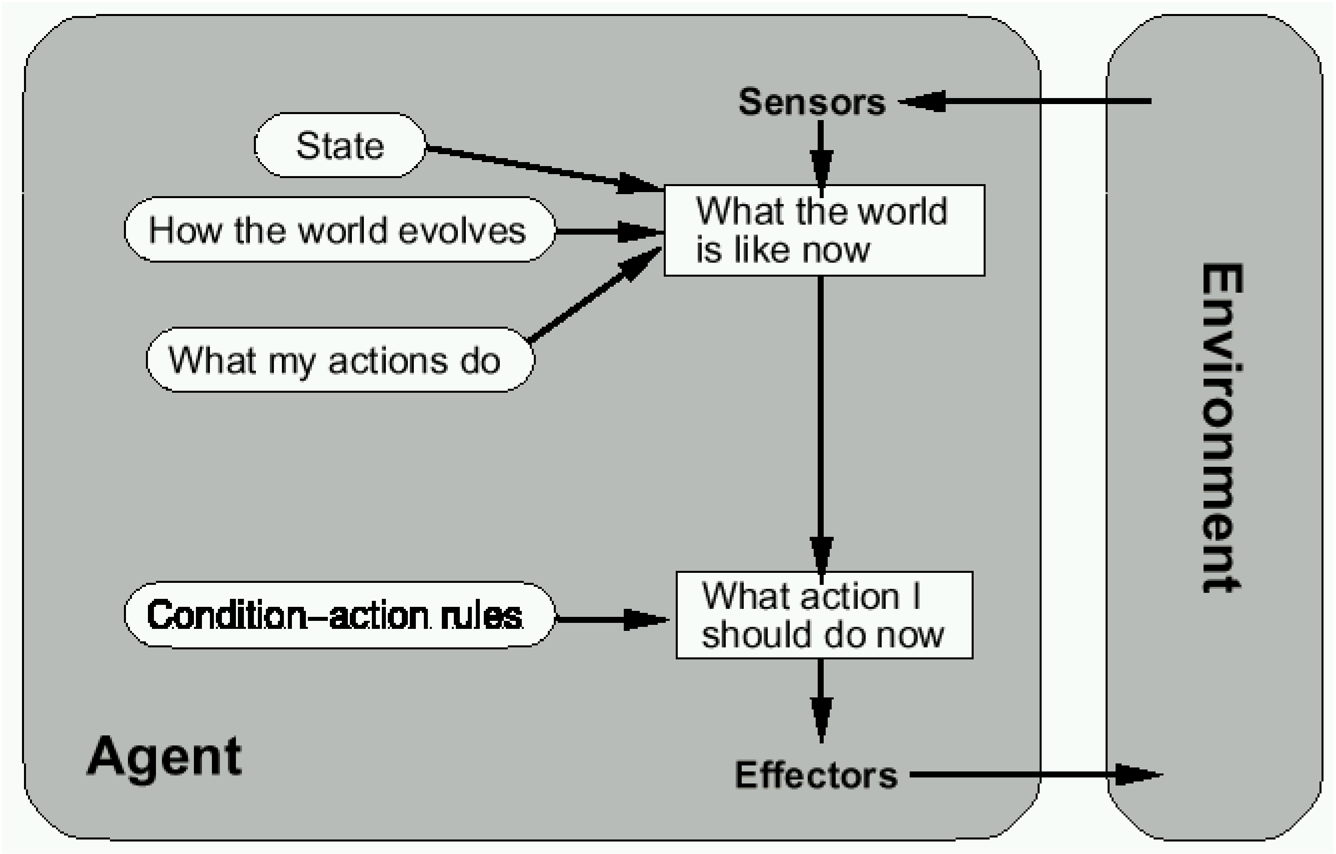


Reactive agents

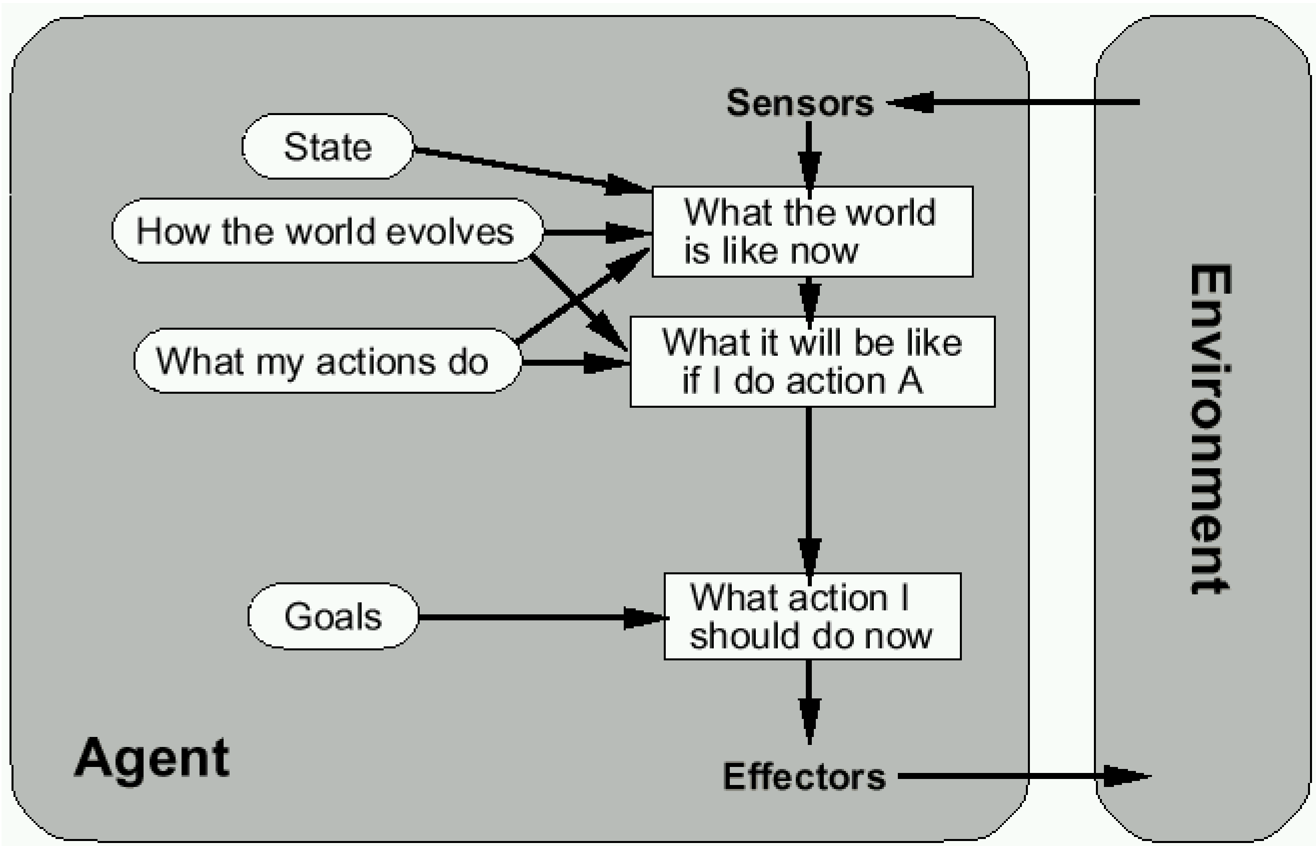
- Reactive agents do not have internal symbolic models.
- Act by stimulus-response to the current state of the environment.
- Each reactive agent is simple and interacts with others in a basic way.
- Complex patterns of behavior emerge from their interaction.

- **Benefits:** robustness, fast response time
- **Challenges:** scalability, how intelligent?
  and how do you debug them?

Reflex agents with state



Goal-based agents

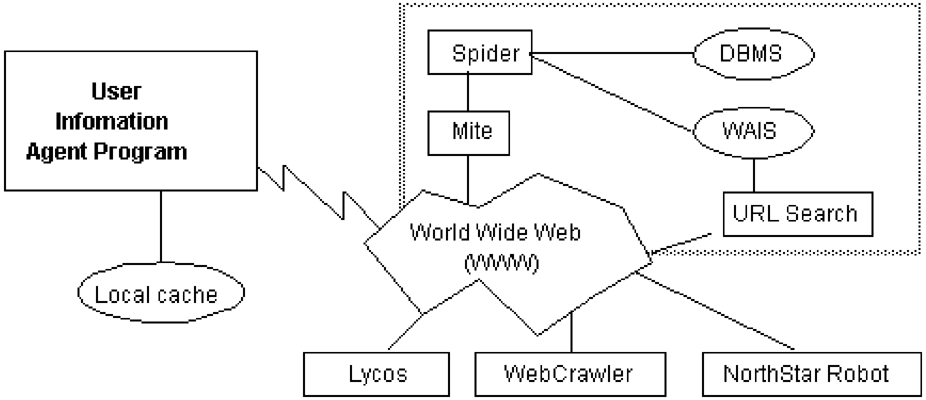


Mobile agents

- Programs that can migrate from one machine to another.
- Execute in a platform-independent execution environment.
- Require agent execution environment (places).
- Mobility not necessary or sufficient condition for agenthood.
- Practical but non-functional advantages:
  - Reduced communication cost (e.g., from PDA)
  - Asynchronous computing (when you are not connected)
- Two types:
  - One-hop mobile agents (migrate to one other place)
  - Multi-hop mobile agents (roam the network from place to place)
- Applications:
  - Distributed information retrieval.
  - Telecommunication network routing.

Information agents

- Manage the explosive growth of information.
- Manipulate or collate information from many distributed sources.
- Information agents can be mobile or static.
- Examples:
  - BargainFinder comparison shops among Internet stores for CDs
  - FIDO the Shopping Doggie (out of service)
  - Internet Softbot infers which internet facilities (finger, ftp, gopher) to use and when from high-level search requests.
- Challenge: ontologies for annotating Web pages (e.g., SHOE).



Summary

- **Intelligent Agents:**
  - Anything that can be *viewed as* **perceiving** its **environment** through **sensors** and **acting** upon that environment through its **effectors** to maximize progress towards its **goals**.
  - PAGE (Percepts, Actions, Goals, Environment)
  - Described as a Perception (sequence) to Action Mapping: $f : \mathcal{P}^* \rightarrow \mathcal{A}$
  - Using look-up-table, closed form, etc.

- **Agent Types:** Reflex, state-based, goal-based, utility-based

- **Rational Action:** The action that maximizes the expected value of the performance measure <u>given the percept sequence to date</u>