Introduction to Rational Agents

- Reading: Russell and Norvig, ch. 2
  - The material here is based on Russell's slides
- Agents and environments
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

Agents

- Can be robots, but also humans, software, devices like thermostats
  - Maps percept histories to actions
    - $f : P^* \rightarrow A$ is their representation of the mapping
  - Percept includes data from sensors, other inputs
  - “histories” – not just current percepts
  - “actions” – must be able to do something
    - Actuators are what the agent uses to perform the actions
    - Ex: thermostat turns on heat and/or A/C if temperature setting is reached

Vacuum cleaner robot example

- Agent = robot
- Environment = world with positions A and B
- Percepts = location (GPS?) and whether the position is dirty or not
  - Ex: [B, Dirty]
  - Percept history is a list of these pairs
- Actions = Left, Right, Suck, NoOp
- How does a Roomba compare? (ex: http://store.irobot.com/default/roomba-vacuuming-robot-vacuum-irobot-roomba-980/R980020.html)

Vacuum cleaner function

- [A, Clean] → Right
- [B, Clean] → Left
- [A, Dirty] → Suck
- [A, Dirty], [A, Clean] → Right
  - Last percept is most recent
  - For basic case, only most recent percept used to determine action
  - How might we change this if we want to minimize energy used?
  - “A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date”

Vacuum cleaner function

- May not be successful
  - Percept histories may not give a complete picture
  - Actions may not always succeed
- “Rational” includes
  - Exploration
  - Learning
    - Should be able to evaluate result of action
  - Autonomy
    - Actions not imposed from external source

PEAS

- Performance measure, Environment, Actuators, Sensors
- Ex: Thermostat
  - Possible performance measures?
  - Environment: the building/room where thermostat is installed
  - Actuators: controls for heating and/or cooling
  - Sensors: thermometer, maybe calendar/clock (if allowed to set different temperature for different time of day, day of the week)
- Ex: PEAS for Internet shopping agent?

Environment characteristics

- Observable
  - Can the agent perceive all aspects of the environment relevant to its task?
  - Can be fully or partially observable
    - Chess: board and other possible elements like move clocks are fully observable
    - Surgery: technology can show much of the body, but not everything, and patient may have unknown issues
- Deterministic
  - From any state, will the same action always produce the same result?
  - State includes environment and agent
  - Ex: anything mechanical has some chance of failure, not completely deterministic

Environment characteristics

- Episodic
  - Do previous actions affect next decision?
  - Episodic – decision does not need to examine previous actions
  - Wikibooks example: examining radiology image is not affected by previous images (unless for same person?)
- Static
  - If the environment does not change while the agent is deciding on actions
  - Ex: Driving on a real road would not be static

Environment characteristics

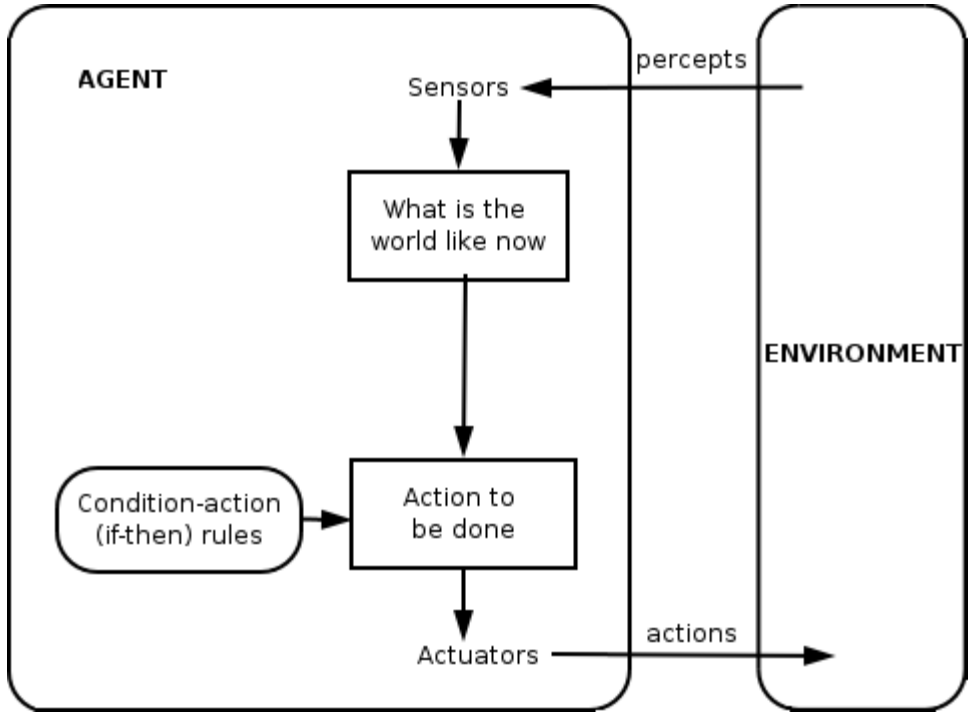
- Discrete
  - Environment/time divided into discrete elements
  - Ex: Board games usually have a fixed number of positions and a turn-by-turn measure of time
- Single-agent
  - Multi-agent if any other agent in environment
    - Agents can cooperate, compete, or ignore other agents

Environment characteristics

- Wikibooks page adds 2 more characteristics
- Known/Unknown
  - Whether agent understands rules of environment
  - Ex: if robot is exploring cave, it can make decisions based on understanding things like that wet surfaces are slippery
- Simulated
  - Whether environment, percepts, evaluation of agent performance is provided by a program
  - Simulation is important for testing (ex: robot sent to explore Mars)

Agent types

- Simple reflex agent (diagram based on text, from Wikipedia):



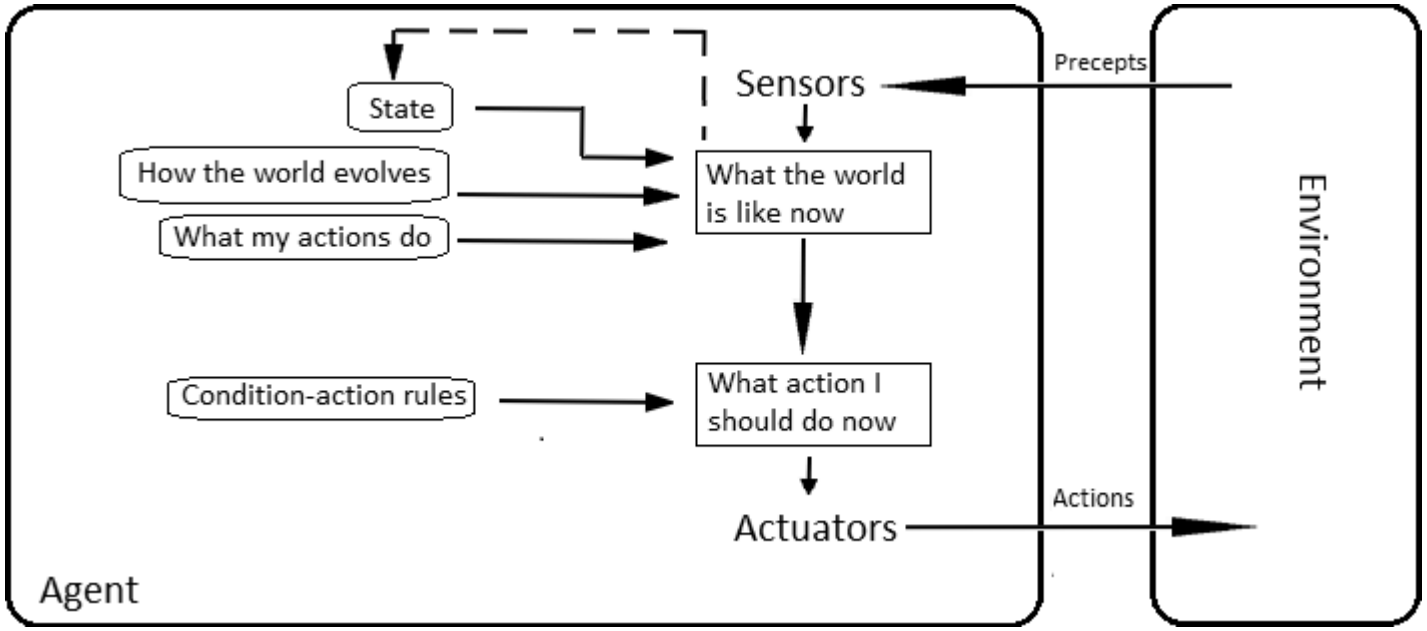
By Utkarshraj Atmaram - Author, Public Domain, https://commons.wikimedia.org/w/index.php?curid=519978

f : P* → A for vacuum agent

```
// C++-ish
string f(char location, bool dirty) {
  if (dirty) return "suck"
  if ('A' == location) return "right"
  return "left" // on clean B
}
```

Reflex agents with state

- By DDSniper - Originally from Stuart J. Russell and Peter Norvig, Artificial Intelligence: A Modern Approach p.51; with additions by me, CC0, https://commons.wikimedia.org/w/index.php?curid=14666524

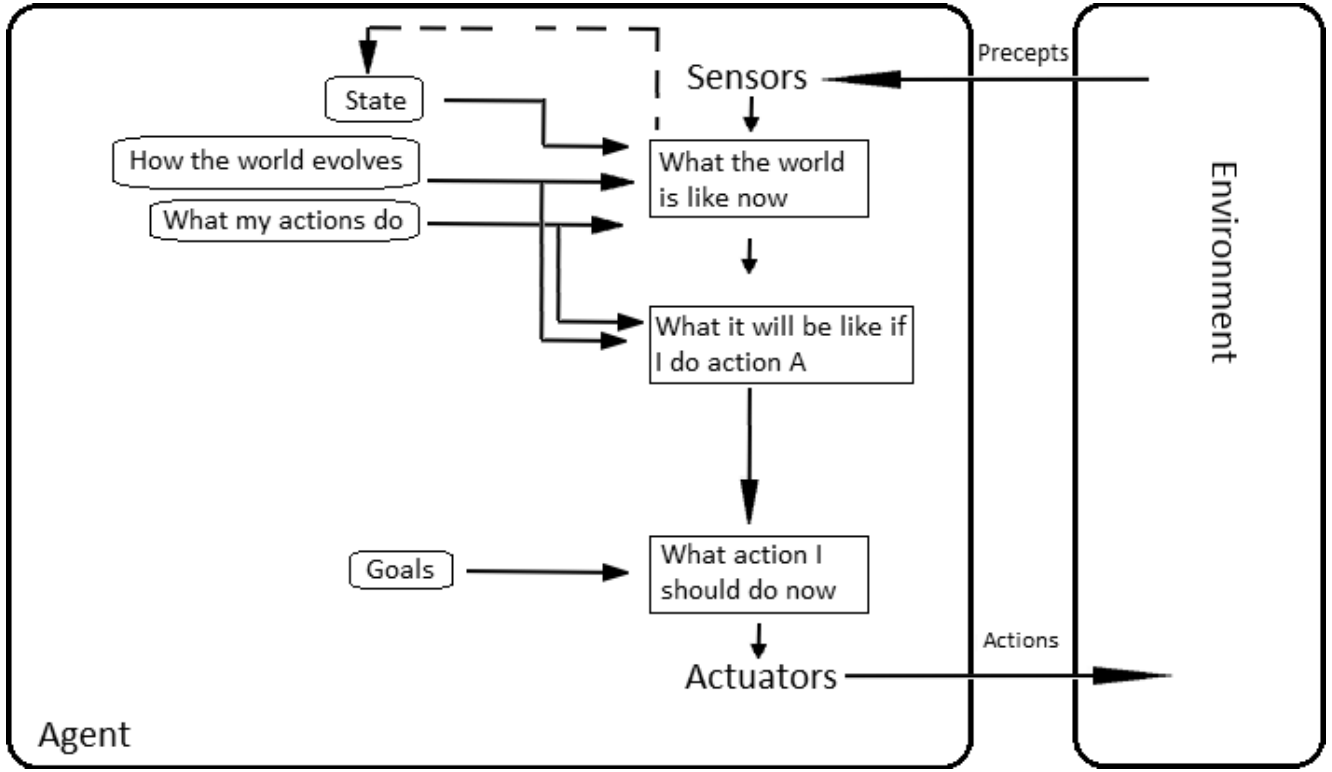


f : P* → A for vacuum agent with state

```
// delays moving if recently cleaned
string f(char location, bool dirty) {
  static int lastA = ∞, lastB = ∞
  lastA++, lastB++
  if (dirty)
    if ('A' == location) lastA = 0
    else lastB = 0
    return "suck"
  if ('A' == location)
    if (lastB > 3) return "right" else return "noop"
  if (lastA > 3) return "left" else return "noop"
}
```

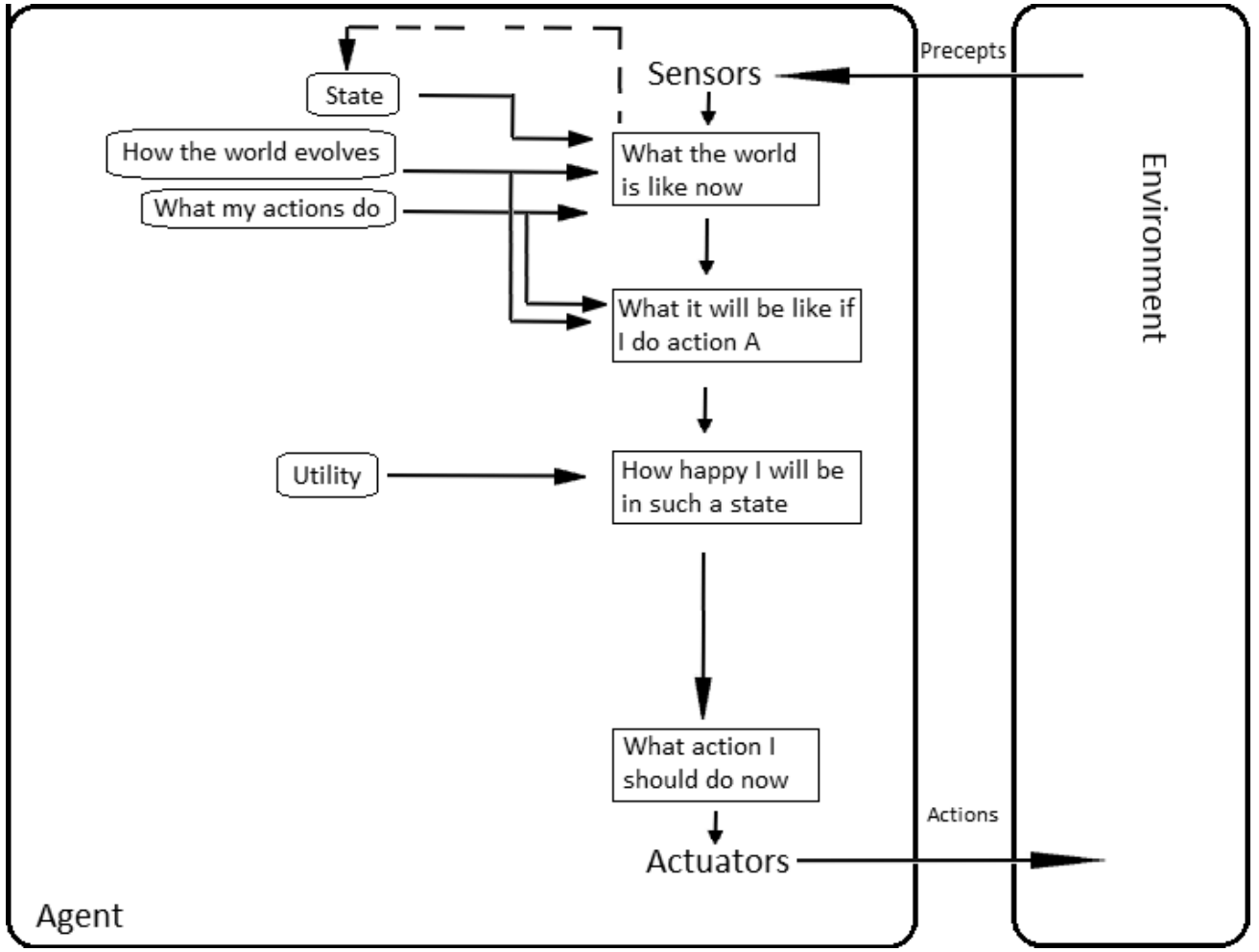
Goal-based agent

- By DDSniper - Originally from Stuart J. Russell and Peter Norvig, Artificial Intelligence: A Modern Approach p.52; with additions by me, CC0, https://commons.wikimedia.org/w/index.php?curid=14666540



Utility-based agent

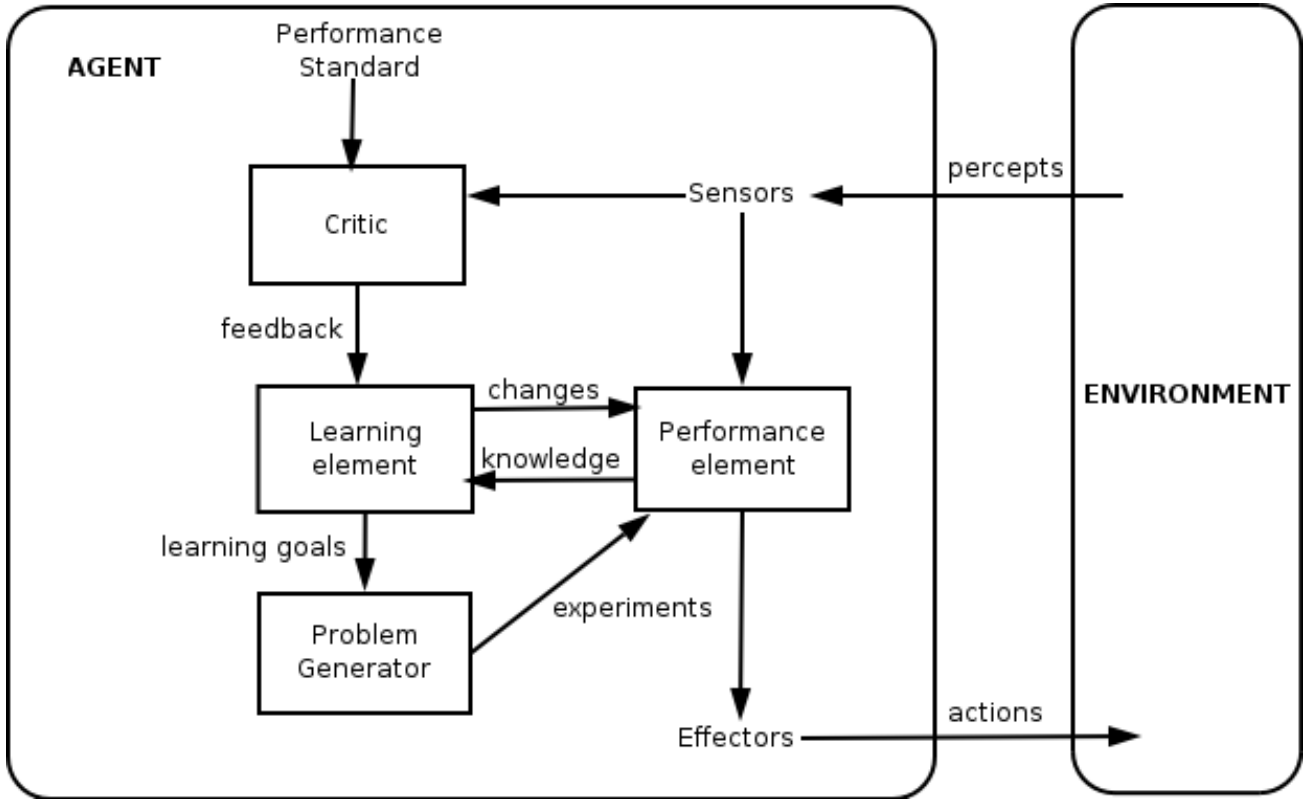
By DDSniper - Originally from Stuart J. Russell and Peter Norvig, Artificial Intelligence: A Modern Approach p.54; with additions by me, CC0, https://commons.wikimedia.org/w/index.php?curid=14666544



Learning agent

By Utkarshraj Atmaram - Author, Public Domain, https://commons.wikimedia.org/w/index.php?curid=519973

Any of the above agent types can add this component



Adding learning to vacuum agent with state

```
// increase delay if not dirty
string f(char location, bool dirty) {
  static int waitB = 3
  static bool justMoved = false
  …
  if ('A' == location)
    if (lastB > waitB) {
      justMoved = true
      return "right"
    } else return "noop"
  if (justMoved) // to B, but B is not dirty
    waitB++
  …
```