Intelligent Agents

Chapter 2

Waitlist and auditing

- The class size will not be increased. I do not have the power to change the order of the waitlist.
- If you can't enroll, you are welcome to audit. I will try to make the web page available. You can come to class and office hours; however, we cannot grade your assignments.
- If you want access to the web page, please email me with the subject "Please add me to the CMPT 310 web page" and include your name and SFU ID.

Outline

- Agents and environments
- Rationality
- Task environment:

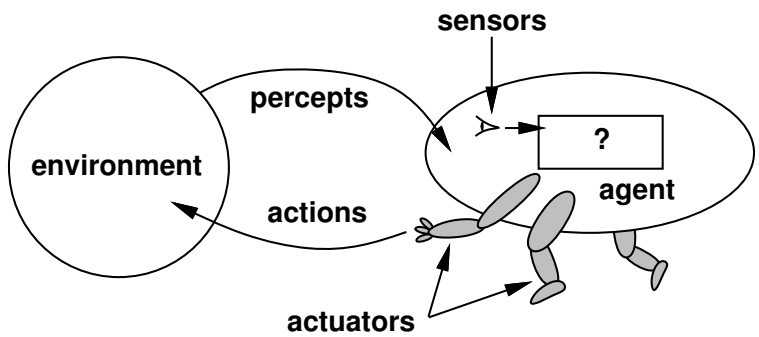
  PEAS:

  - *Performance measure*
  - *Environment*
  - *Actuators*
  - *Sensors*

- Environment types
- Agent types

Agents and Environments

- An *agent* is anything that can be viewed as perceiving its *environment* through *sensors* and acting in that environment through *actuators*.



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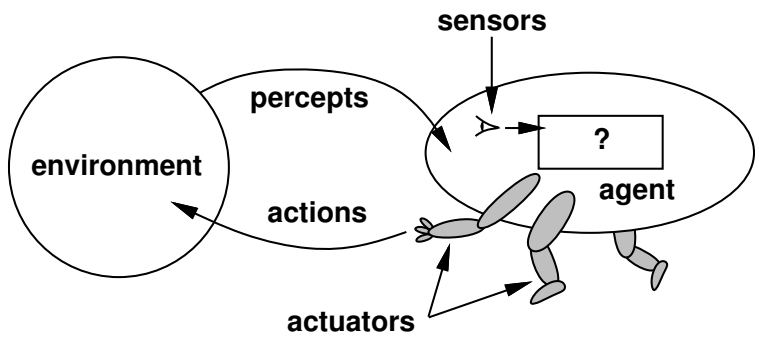
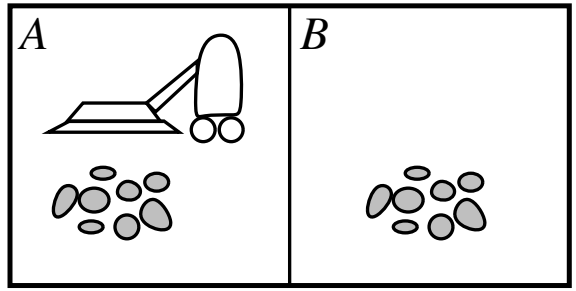


- *Agents* include humans, robots, softbots, thermostats, etc.
- The *agent function* maps from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

- The *agent program* runs on a physical *architecture* to give f

Vacuum-cleaner world



Percepts: location and contents, e.g., $[A, \mathit{Dirty}]$
Actions: *Left*, *Right*, *Suck*, *NoOp*

A vacuum-cleaner agent

Agent function:

Percept sequence	Action
$[A, Clean]$	*Right*
$[A, Dirty]$	*Suck*
$[B, Clean]$	*Left*
$[B, Dirty]$	*Suck*
$[A, Clean], [A, Clean]$	*Right*
$[A, Clean], [A, Dirty]$	*Suck*
...	...

Note: This says *how* the agent should function.

- It says nothing about how this should be implemented.

Rationality

Informally a *rational* agent is one that does the "right thing".

- *How well* an agent does is given by a *performance measure*.
- A fixed *performance measure* evaluates the *environment sequence*

  Examples:

  - one point per square cleaned up in time T?
  - one point per clean square per time step, minus one per move?
  - penalize for $> k$ dirty squares?
- A *rational agent* selects an action which maximizes the expected value of the performance measure given the percept sequence to date and its own knowledge.
- The action selection may range from being hardwired (e.g. in an insect or reflexive agent) to involving substantial reasoning.

Rationality

Notes:

- Rational $\neq$ omniscient
  - percepts may not supply all the relevant information
- Rational $\neq$ clairvoyant
  - action outcomes may not be as expected
- Hence, rational $\neq$ successful
- Full, general rationality requires exploration, learning, autonomy

The Task Environment

- To design a rational agent, we must specify the *task environment*
- The task environment has the following components:
  - Performance measure
  - Environment
  - Actuators
  - Sensors
- Acronym: PEAS

PEAS

Consider, e.g., the task of designing an automated taxi:

Performance measure: safety, destination, profits, legality, comfort, ...

Environment: streets/freeways, traffic, pedestrians, weather, ...

Actuators: steering, accelerator, brake, horn, speaker/display, ...

Sensors: video, accelerometers, gauges, engine sensors, keyboard, GPS, ...

Internet shopping agent

Performance measure: ??

Environment: ??

Actuators: ??

Sensors: ??

Internet shopping agent

Performance measure: price, quality, appropriateness, efficiency

Environment: ??

Actuators: ??

Sensors: ??

Internet shopping agent

Performance measure: price, quality, appropriateness, efficiency

Environment: current and future WWW sites, vendors, shippers

Actuators: ??

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Internet shopping agent

Performance measure: price, quality, appropriateness, efficiency

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Actuators: display to user, follow URL, fill in form

Sensors: ??

Internet shopping agent

Performance measure: price, quality, appropriateness, efficiency

Environment: current and future WWW sites, vendors, shippers

Actuators: display to user, follow URL, fill in form

Sensors: HTML pages (text, graphics, scripts)

Environment Types

- *Fully observable* vs. *partially observable*
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- *Discrete* vs. *continuous*

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- *Discrete* vs. *continuous*
- *Single-agent* vs. *multiagent*

Environment types

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☞ *The environment type largely determines the agent design*

- The real world is:
  - partially observable, stochastic, sequential, dynamic, continuous, and multi-agent

Agent programs

- The *agent function* is a mathematical entity maps from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

- *agent program* runs on a physical architecture. It takes percepts $\mathcal{P}$ as input and returns actions A.
- An agent program implements a given agent function f.

Table-driven agent

Table-driven agent:

percepts = A list, initially empty
table = A table of actions, indexed by a list of percepts
Function Table-Driven-Agent(percept) returns an action
    Append percept to percepts
    action ← Lookup(percepts, table)
    return action

Ask:

- What is the size of table?
- What happens to that size as the agent receives more percepts?

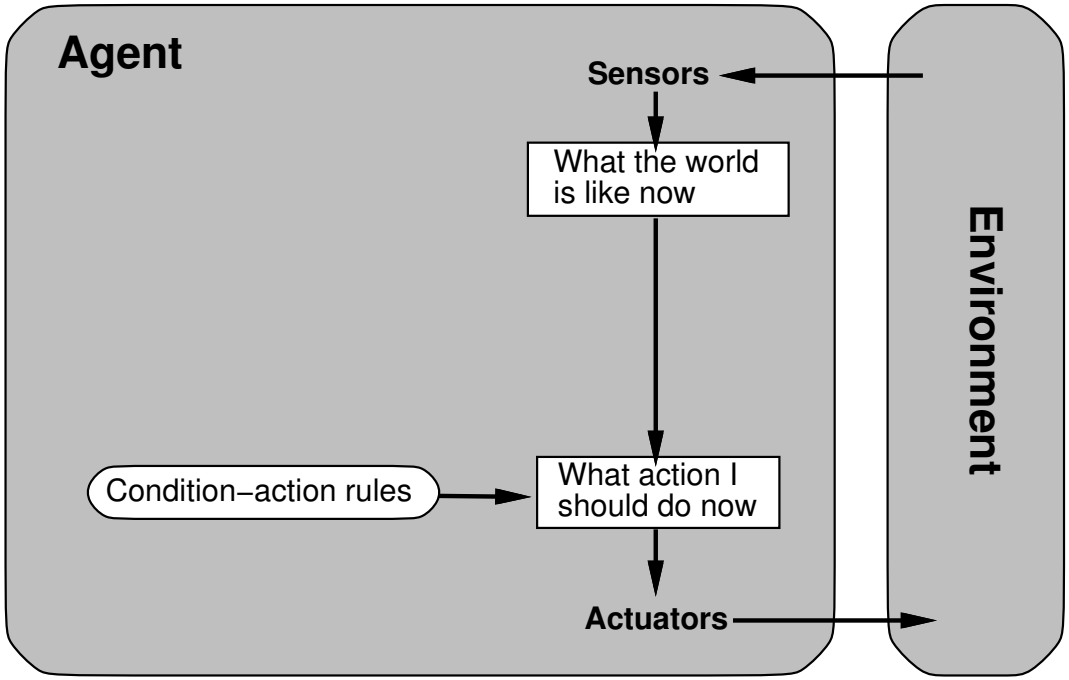
Agent types

There are four basic types in order of increasing generality:

- simple reflex agents
- reflex agents with state
- goal-based agents
- utility-based agents

All these can be turned into learning agents.

Simple reflex agents



- Action is selected according to the current percept
- So, no knowledge of percept history.

A simple reflex agent algorithm

Function Simple-Reflex-Agent(percept) returns an action

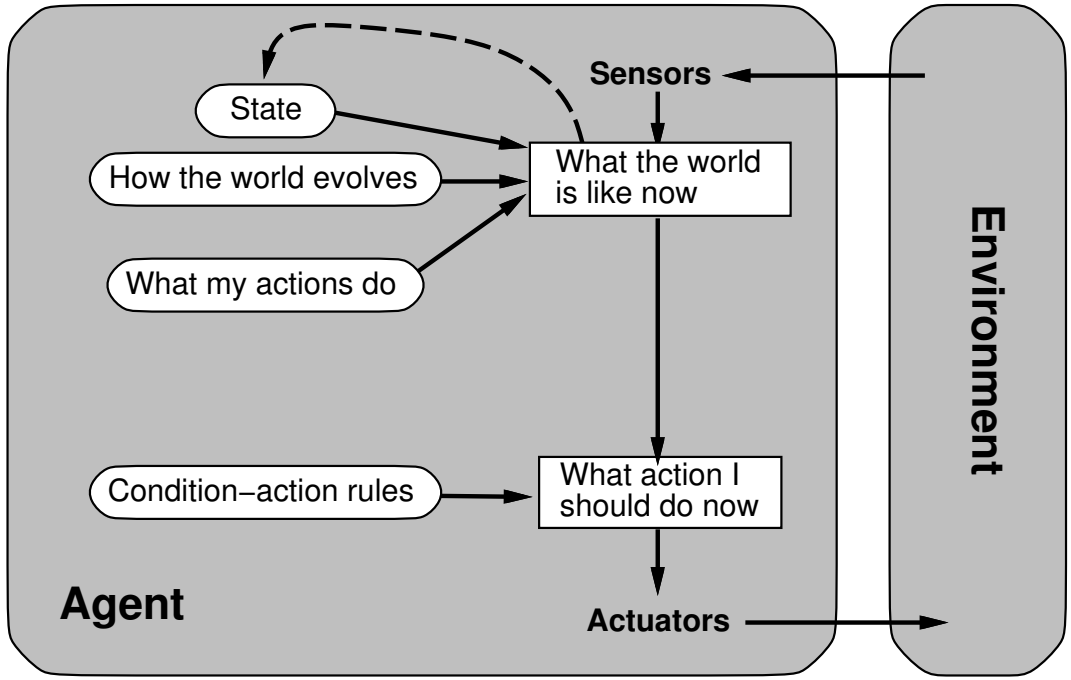
persistent: rules a set of condition-action rules

state $\leftarrow$ Interpret-Input(percept)
rule $\leftarrow$ Rule-Match(state,rules)
action $\leftarrow$ rule.Action
return action

Example

```
Function Reflex-Vacuum-Agent([location,status]) returns an action
if status = Dirty then return Suck
      else if location = A then return Right
      else if location = B then return Left
```

Reflex agents with state



- Also called a "model-based reflex agent"
- Agent keeps track of what it knows about the world.
- Useful for partial observability

A simple reflex agent algorithm

Function Reflex-Agent-With-State(percept) returns an action

persistent: state: the agent's conception of the world state

model: The transition model – how the next state depends on the present state and action

rules: a set of condition-action rules

action: the most recent action (initially none)

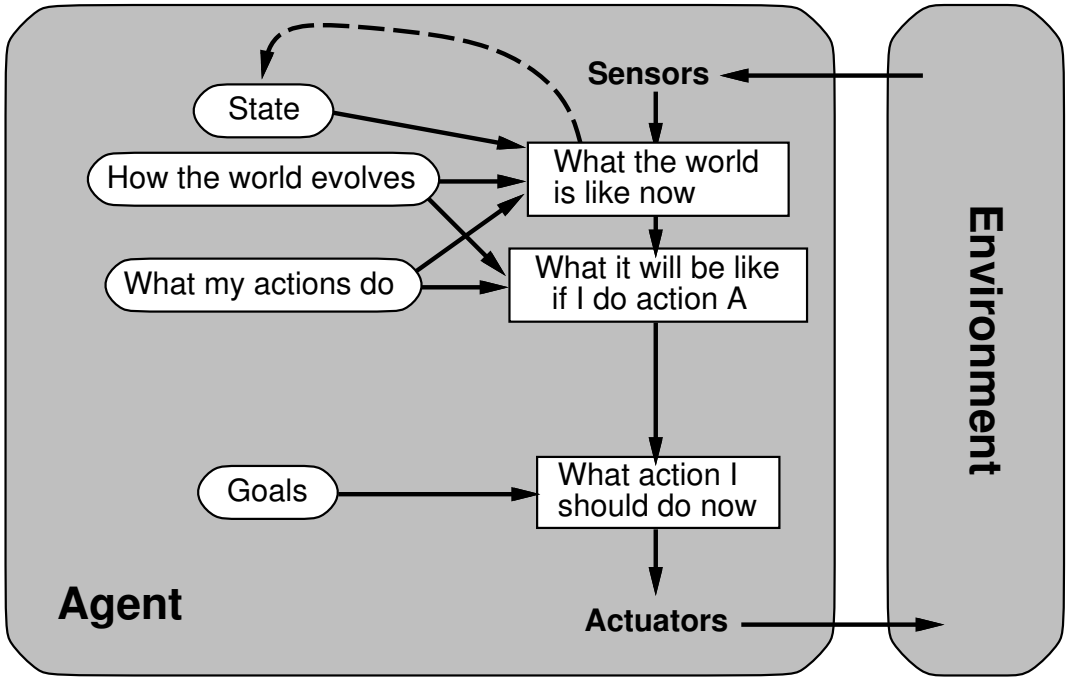
state $\leftarrow$ Update-State(state,action,percept,model)

rule $\leftarrow$ Rule-Match(state,rules)

action $\leftarrow$ rule.Action

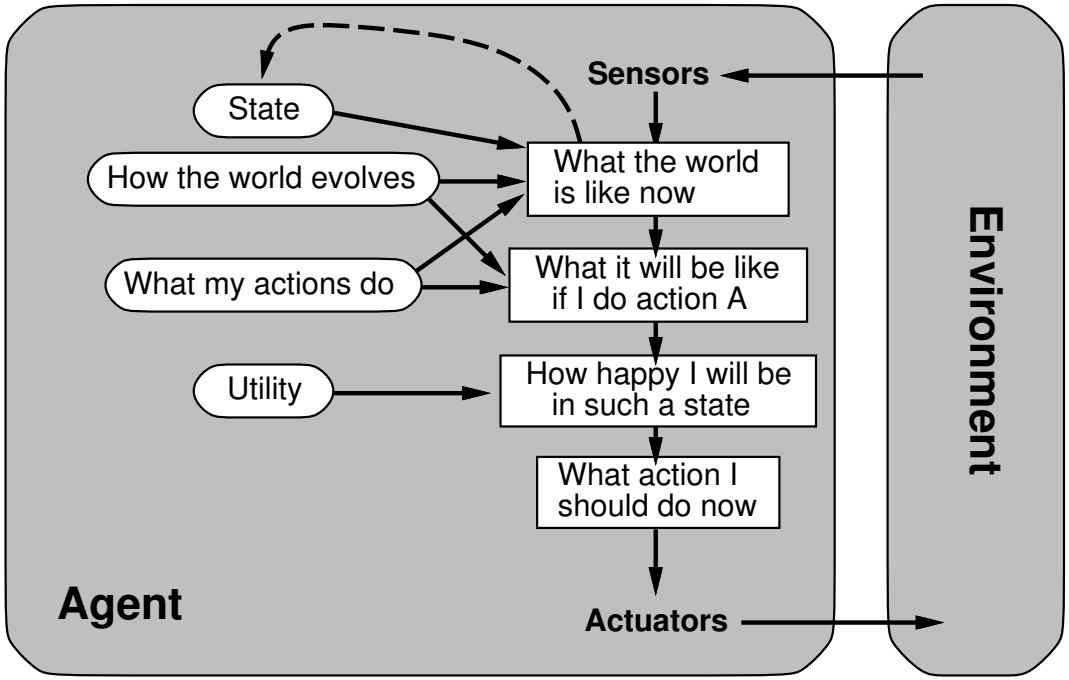
return action

Goal-based agents



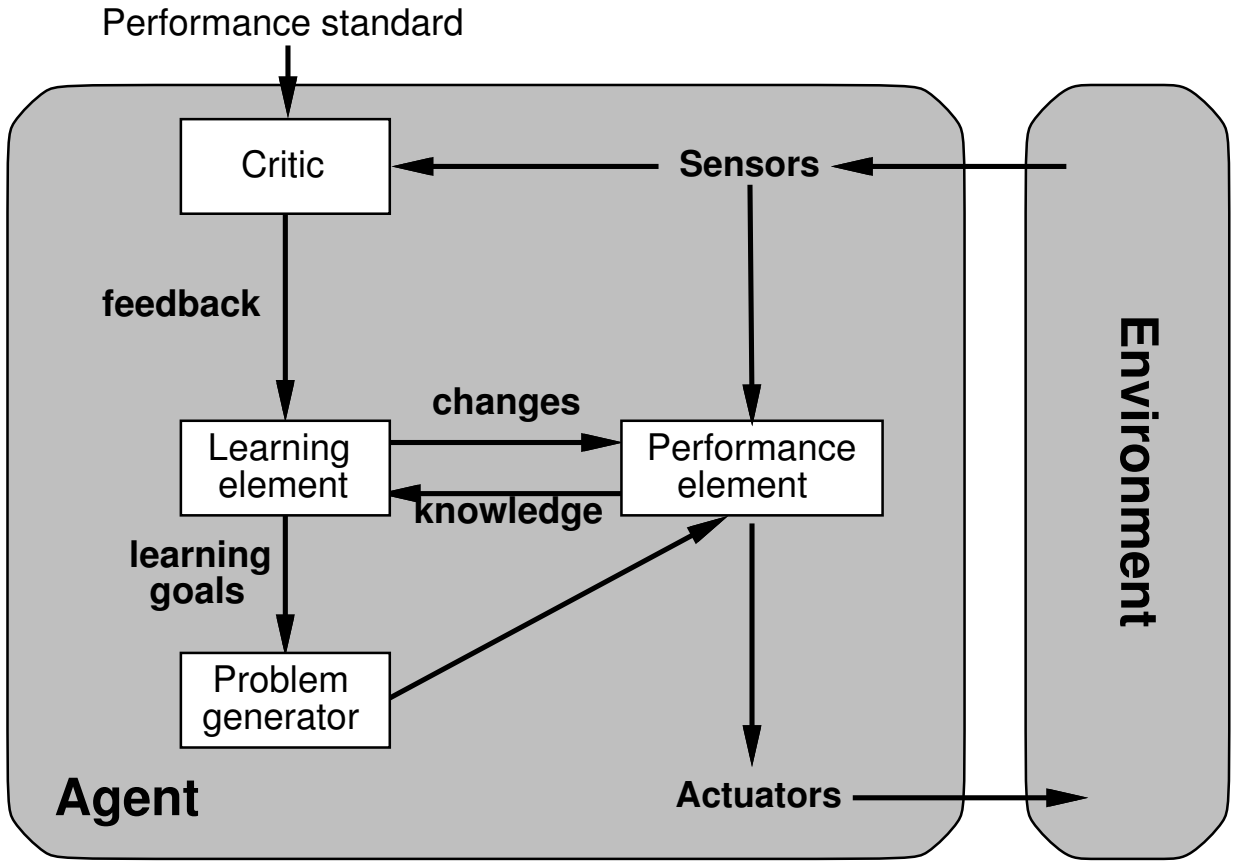
- Agent's actions are determined in part by its *goals*.
- Example: Classical planning.

Utility-based agents



- In addition to goals, use a notion of how "good" an action sequence is.
  - E.g.: Taxi to airport should be safe, efficient, etc.

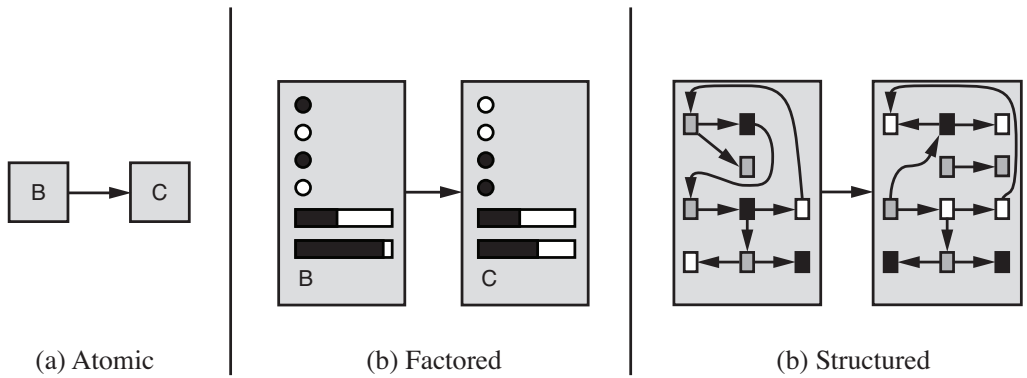
Learning agents



Problem state representation

Three types of representations:

- Atomic: Each state is *indivisible*.
- Factored: A state consists of a *collection* of attributes.
- Structured: States may have arbitrary relationships.



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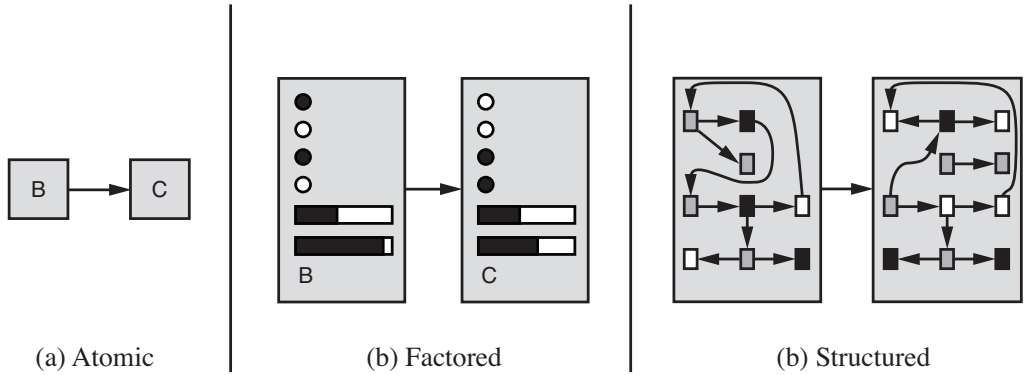
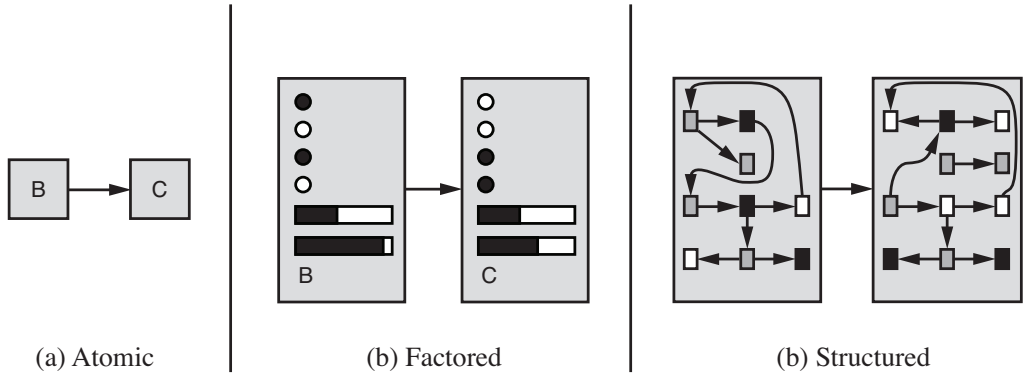


How large is the representation of the rules of chess using a representation that is:

- Atomic:

Problem state representation



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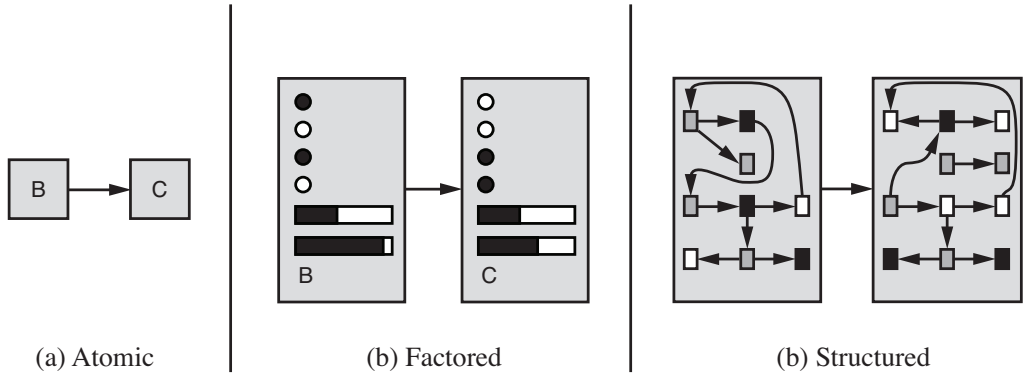
- Atomic: $(64^6)^2$.

Problem state representation



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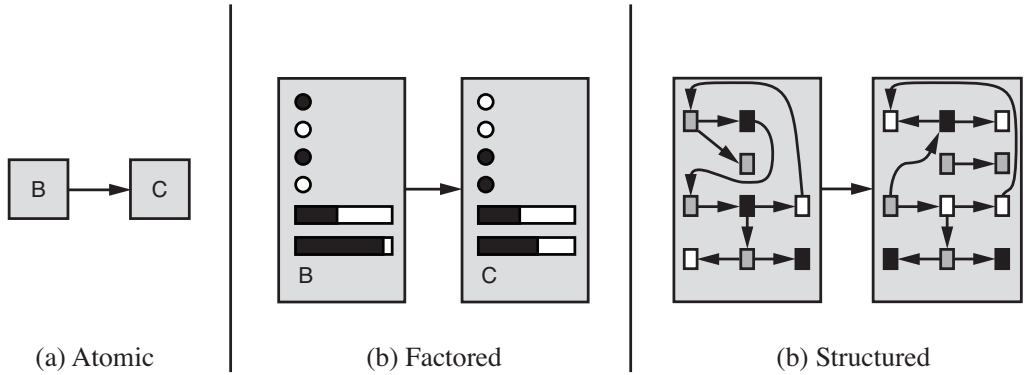

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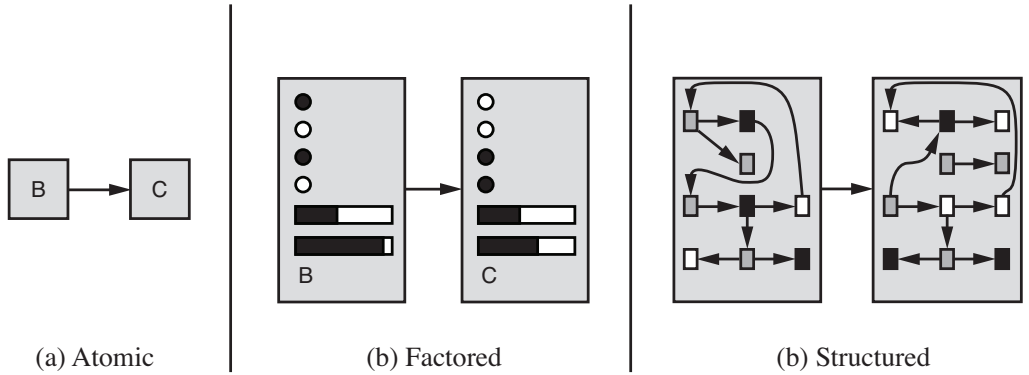

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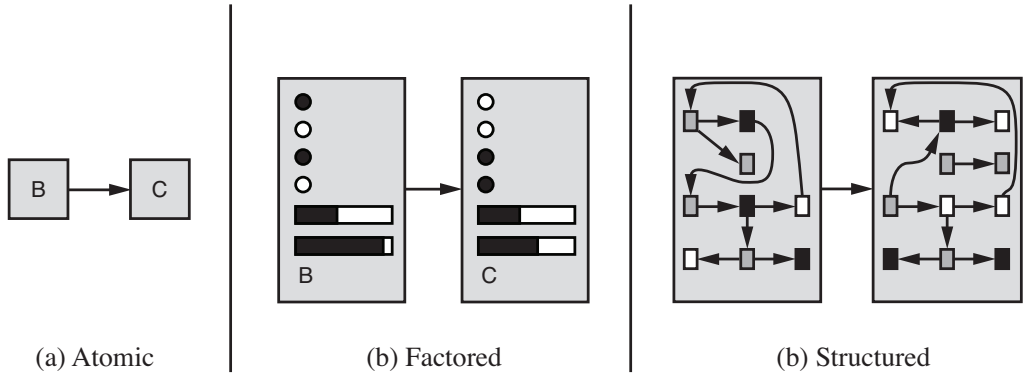

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Summary

- *Agents* interact with *environments* through *actuators* and *sensors*
- The *agent function* describes what the agent does in all circumstances
- The *performance measure* evaluates the environment sequence
- A *rational* agent maximizes expected performance
- *Agent programs* implement agent functions
- *PEAS* descriptions define task environments
- Environments are categorized along several dimensions:
  observable? *deterministic*? *episodic*? *static*? *discrete*? *single-agent*?
- Several basic agent architectures exist:
  reflex, *reflex with state*, *goal-based*, *utility-based*