State

State: The status s_i (like location) of the agent with respect to the environment.

State Space: Set of all possible states $\mathcal{S} = \{s_i\}$.

Action

Action: Possible operations a_i of agent for each state.

Action space: Set of all possible actions $\mathcal{A}(s_i) = \{a_i\}$.

State transition

Agent moves from one state to another, the process is called state transition.

Denoted as $s_1 \xrightarrow{a_1} s_2$.

Forbidden area:

- Case 1: Accessible but with penalty.
- Case 2: Inaccessible.

State transition probability: At state s_i, and choose action a_k, with probability p to transit to s_j, denoted as $p(s_2|s_1, a_1) = p$.

Policy

Policy tells agent what actions to take at a state.

Math: $\pi(a|s) = p$.

Reward

Reward: The real number we receive as a result of taking an action, which represents encouragement or punishment.

Math: $\pi(r = C|a, s) = p$.

Trajectory and return

Trajectory: A state-action-reward chain:

$$s_1 \xrightarrow[r=C_1]{a_1} s2 \xrightarrow[r=C_2]{a_2} s3$$

Return: Sum of all rewards collected along the trajectory.

Discounted return

A trajectory may be infinite. So we introduce a discount rate $\gamma \in [0, 1)$.

- If γ close to 0, return is dominated by the rewards obtained in the near future.
- If γ close to 1, return is dominated by the rewards obtained in the far future.

Episode

Agent may stop at some terminal states. The resulting trajectory is called an **episode** (or a trial).

An episode is usually assumed to be a **finite** trajectory. Tasks with episodes are called **episodic tasks**. Some tasks without terminal states (where interaction with the environment never ends) are called **continuing tasks**.

Two options to unify episodic and continuing tasks:

- Treat the target state as a special absorbing state. Once the agent reaches these states, it will never leave, and subsequent rewards are 0.
- Treat the target state as a normal state. The agent can still leave the target state.

Markov decision process (MDP)

Key elements:

- Sets:
  - State
  - Action
  - Reward
- Probability distribution:
  - State transition probability: $p(s'|s, a)$

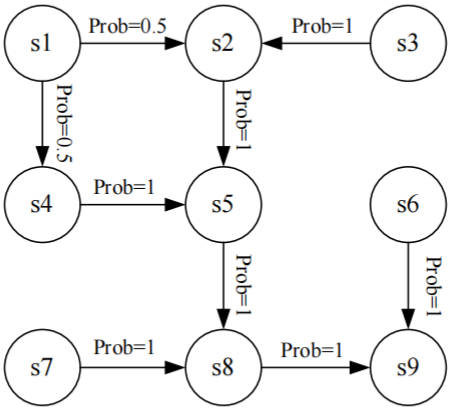
    - Reward probability: $p(r|s,a)$
- Policy
- Markov property:

  Memoryless property.

$$p(s_{t+1}|a_{t+1},s_t,\ldots,a_1,s_0) = p(s_{t+1}|a_{t+1},s_t)$$
$$p(r_{t+1}|a_{t+1},s_t,\ldots,a_1,s_0) = p(r_{t+1}|a_{t+1},s_t)$$

Markov process:

e.g.



Markov decision process becomes Markov process once the policy is given.