Search

- Search permeates all of AI
- What choices are we searching through?
  - Problem solving
    Action combinations (move 1, then move 3, then move 2...)
  - Natural language
    Ways to map words to parts of speech
  - Computer vision
    Ways to map features to object model
  - Machine learning
    Possible concepts that fit examples seen so far
  - Motion planning
    Sequence of moves to reach goal destination
- An intelligent agent is trying to find a set or sequence of actions to achieve a goal

Assumptions

- Static or dynamic?

Environment is static

Assumptions

- Static or dynamic?
- Fully or partially observable?

Environment is fully observable

Assumptions

- Static or dynamic?
- Fully or partially observable?
- Discrete or continuous?

Environment is discrete

Assumptions

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- Discrete or continuous?
- Deterministic or stochastic?

Environment is deterministic

Assumptions

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- Discrete or continuous?
- Deterministic or stochastic?
- Episodic or sequential?

Environment is sequential

Assumptions

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- Single agent or multiple agent?

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Search Space Definitions

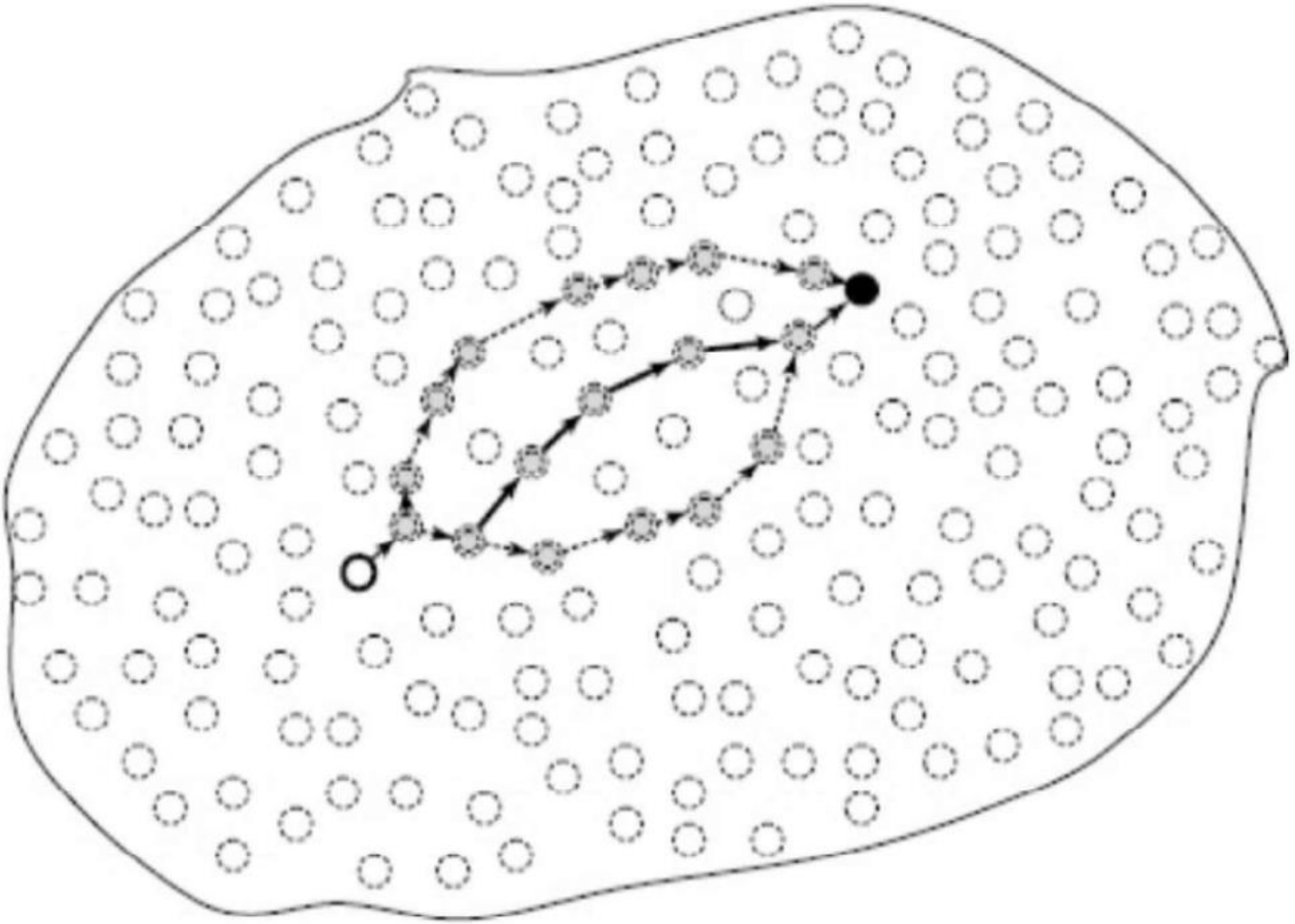
- State
  - A description of a possible state of the world
  - Includes all features of the world that are pertinent to the problem
- Initial state
  - Description of all pertinent aspects of the state in which the agent starts the search
- Goal test
  - Conditions the agent is trying to meet
- Goal state
  - Any state which meets the goal condition
- Action
  - Function that maps (transitions) from one state to another

Search Space Definitions

- Problem formulation
  - Describe a general problem as a search problem
- Solution
  - Sequence of actions that transitions the world from the initial state to a goal state
- Solution cost (additive)
  - Sum of the cost of operators
  - Alternative: sum of distances, number of steps, etc.
- Search
  - Process of looking for a solution
  - Search algorithm takes problem as input and returns solution
  - We are searching through a space of possible states
- Execution
  - Process of executing sequence of actions (solution)

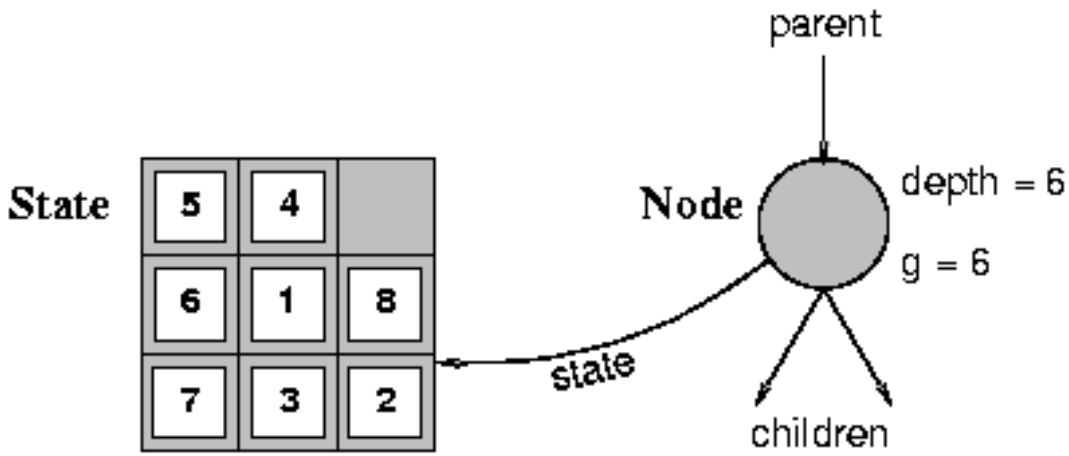
Problem Formulation

We model the problem solving process as traversing a *state space*. The state space is a space in which each element is a state. A state is a description of the world in which the problem solver operates. The given situation is described by a state called the *START* state. The desired or the goal situation is described by one or more *GOAL* states. In any given state, an action or a decision by the agent changes something and the agent makes a *move* to a new state. The task is to make a sequence of moves, such that the agent ends up being in a goal state.

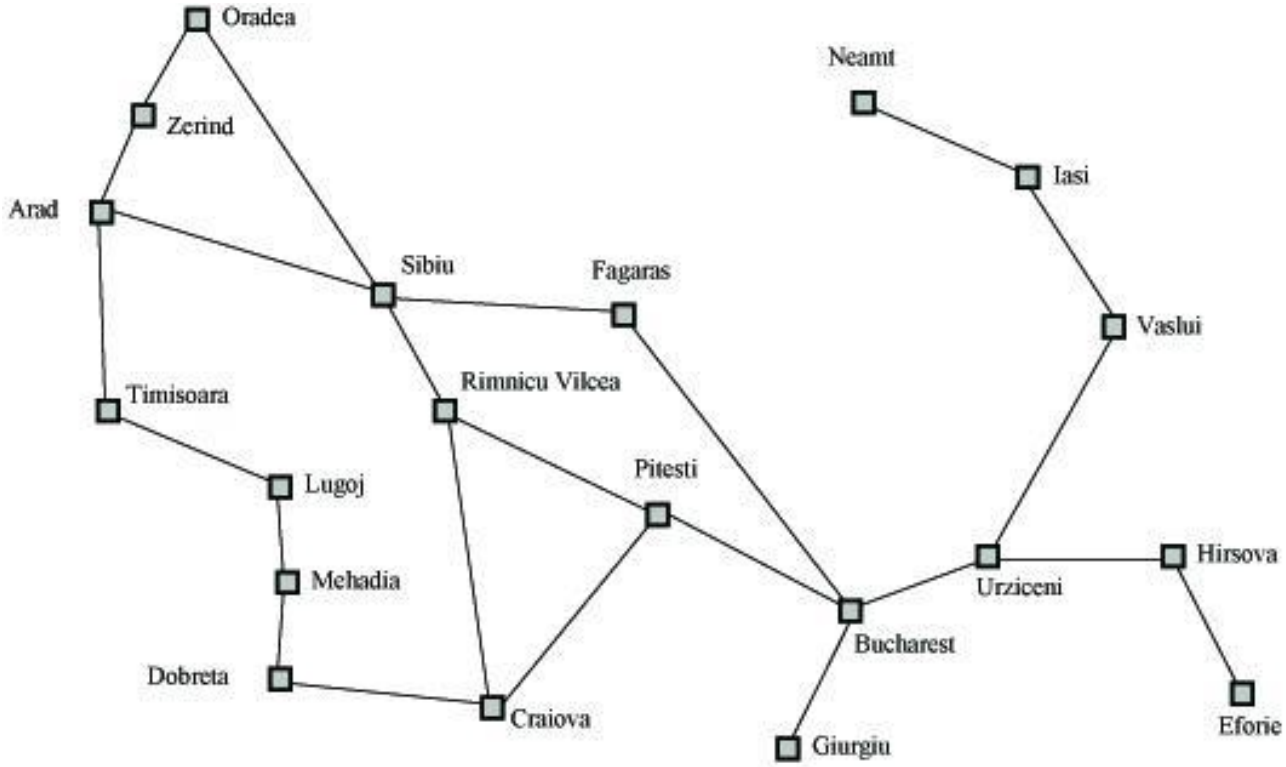


Visualize Search Space as a Tree

- States are nodes
- Actions are edges
- Initial state is root
- Solution is path from root to goal node
- Edges sometimes have associated costs
- States resulting from operator are children



Search Example



Formulate goal: Be in Bucharest.

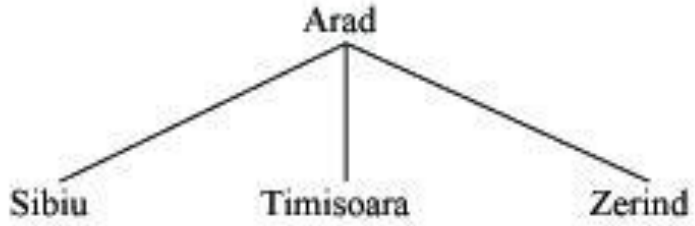
Formulate problem: states are cities, operators drive between pairs of cities

Find solution: Find a sequence of cities (e.g., Arad, Sibiu, Fagaras, Bucharest) that leads from the current state to a state meeting the goal condition

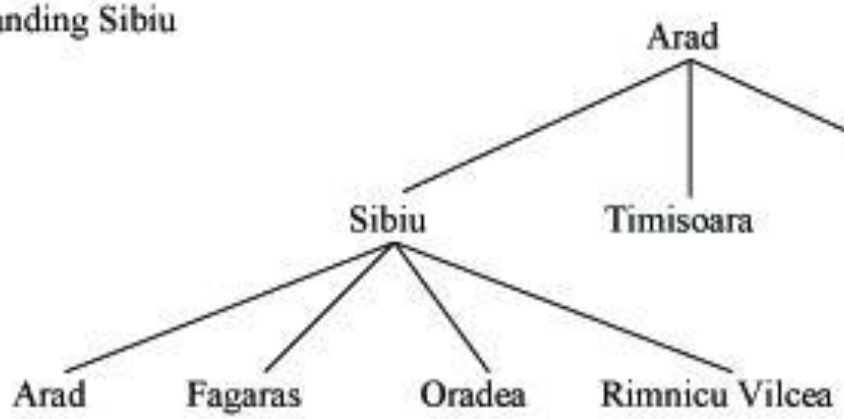
Search Problem Example (as a tree)

(a) The initial state

(b) After expanding Arad



(c) After expanding Sibiu



Example Problems – Missionaries and Cannibals

*On one bank of a river are **3** missionaries and **3** cannibals. There is **1** boat available that can carry at most **2** people and that they would like to use to cross the river. If the cannibals ever outnumber the missionaries on either of the river's banks or on the boat, the missionaries will get eaten. How can the boat be used to carry all the missionaries and cannibals across the river safely? The boat cannot cross the river by itself with no people on board and there is no island in the middle of the river.*

States: number of missionaries, cannibals, and boat

Initial state: all on near river bank

Operators: move boat with 3 missionaries and 3 cannibals to other side of river
- no more cannibals than missionaries on either river bank or in boat
- boat holds at most 2 occupants

Goal: all on far river bank

Path cost: 1 per river crossing

Obtain the complete search tree