- Programming assignment 1: Send me an email if you have doubts.
- Python tutorial: 31/01/21 (Sunday), 5:30 PM to 7 PM.
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  - Aditya Suraj Krishnan
  - Piyush Maheshwari

Simulated Annealing

Simulated Annealing

function SIMULATED-ANNEALING(*problem*, *schedule*)
  inputs: *problem*, a problem
    schedule, a mapping from time to "temperature"

  current ← MAKE-NODE(*problem*.INITIAL-STATE)
  for $t = 1$ **to** ∞ **do**
    $T \leftarrow schedule(t)$
    if $T = 0$ **then return** *current*
    next ← a randomly selected successor of *current*
    $\Delta E \leftarrow next.\text{VALUE} - current.\text{VALUE}$
    if $\Delta E > 0$ **then** *current* ← *next*
    else *current* ← *next* only with probability $e^{\Delta E/T}$

$$p = \frac{1}{e^{|\Delta E|/T}}$$

Simulated Annealing

Q. Suppose we are at state A initially and $f(\cdot)$ is the fitness function. There are two successor states B and C such that:

1. $f(B) - f(A) \leq 0$ and $f(C) - f(A) \leq 0$.
2. $|f(B) - f(A)| \ll |f(C) - f(A)|$.

ΔE

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c. When T becomes close to zero and current state is A, which state becomes more likely to be the next state: B or C?

- Chapter 4: Only section 4.1

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- Problem solving agents (Chapter 3)
  - Path from initial state to goal state is important.

Problem Solving Agents

- Focus on problems that have a **fixed sequence of actions** as their solutions.
- We have a problem solving agent that has to find the shortest path between two cities in Romania.

State Space

- The agent has knowledge about the environment in the form of state space.
- State space: initial state, actions, transition model.
- Goal test

State Space Graph

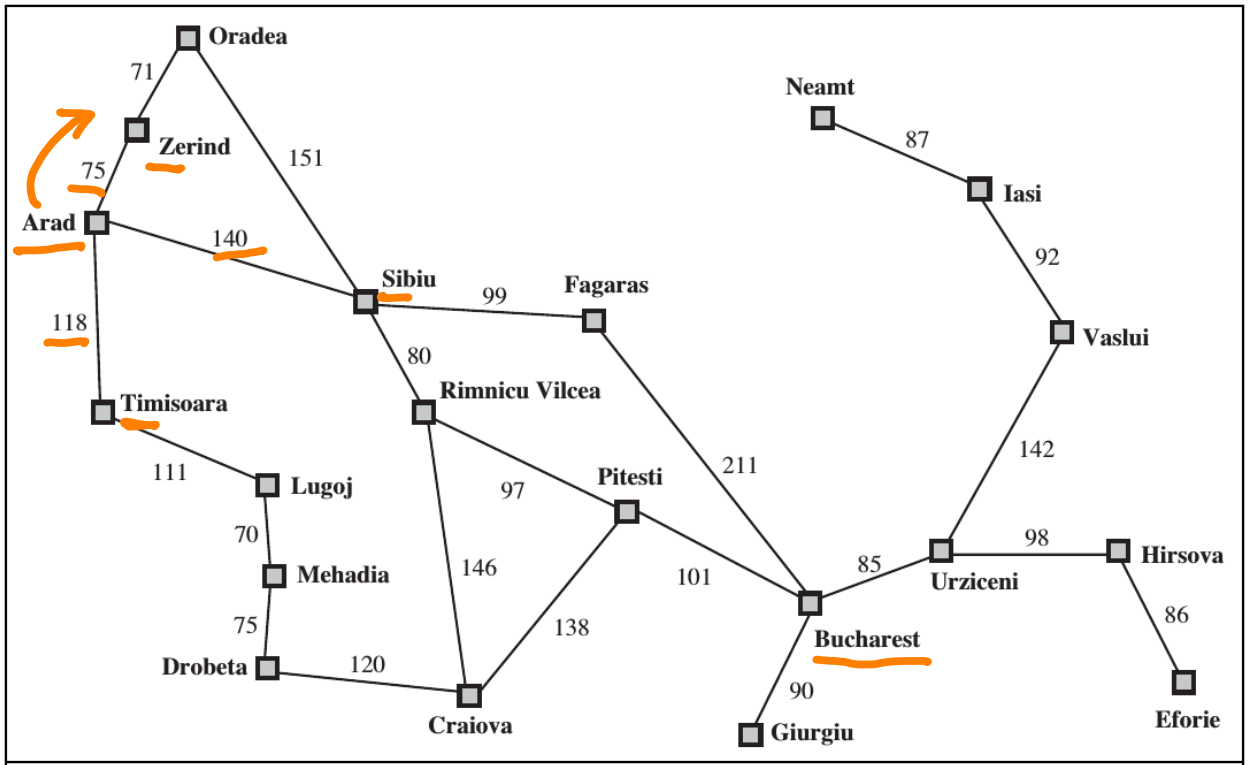
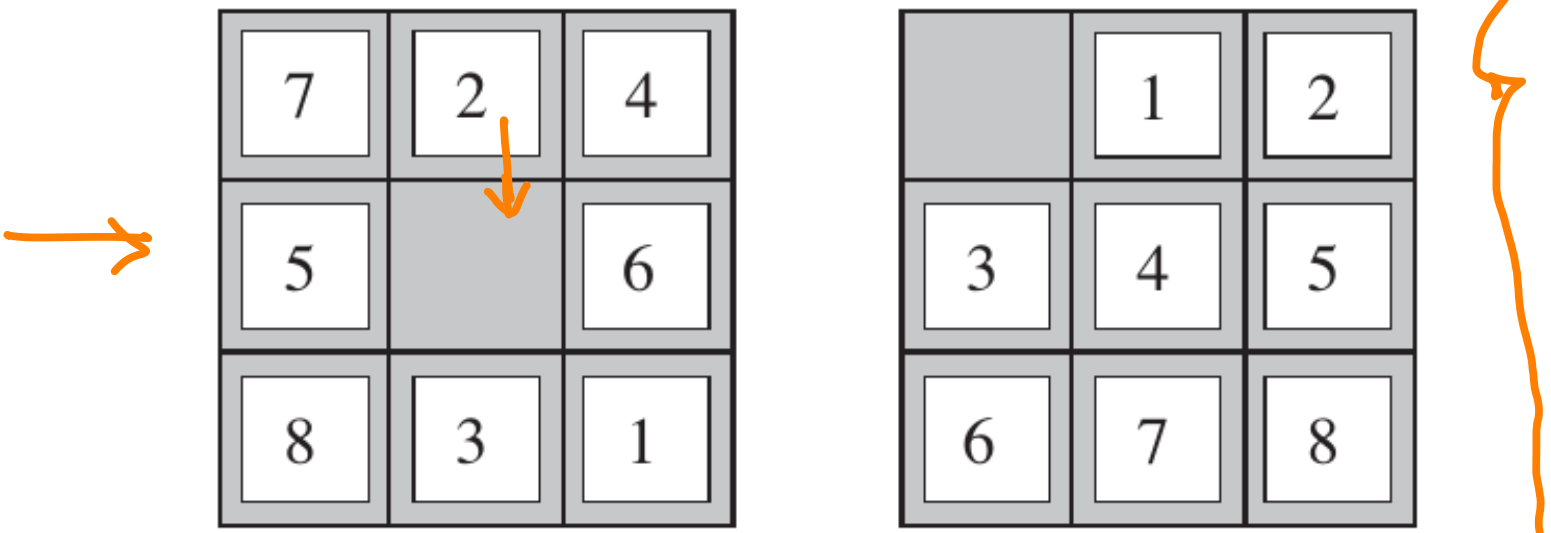


Figure 3.2 A simplified road map of part of Romania.

- Initial state $= In(Arad)$
- Actions $= \{\ go(Sibiu), go(Timisoara), go(Zerind)\ \}$
- Goal state $= \{\ In(Bucharest)\ \}$

- Step cost $= c(s, a, s')$
- Step costs are nonnegative.
- Path cost = sum of step costs
- **Solution** to a problem is an action sequence that leads from the initial state to a goal state.
- Performance measure = Path cost
- **Optimal solution** has the lowest path cost among all solutions.

Eight puzzle problem



Start State

Goal State

Transition

How many states?

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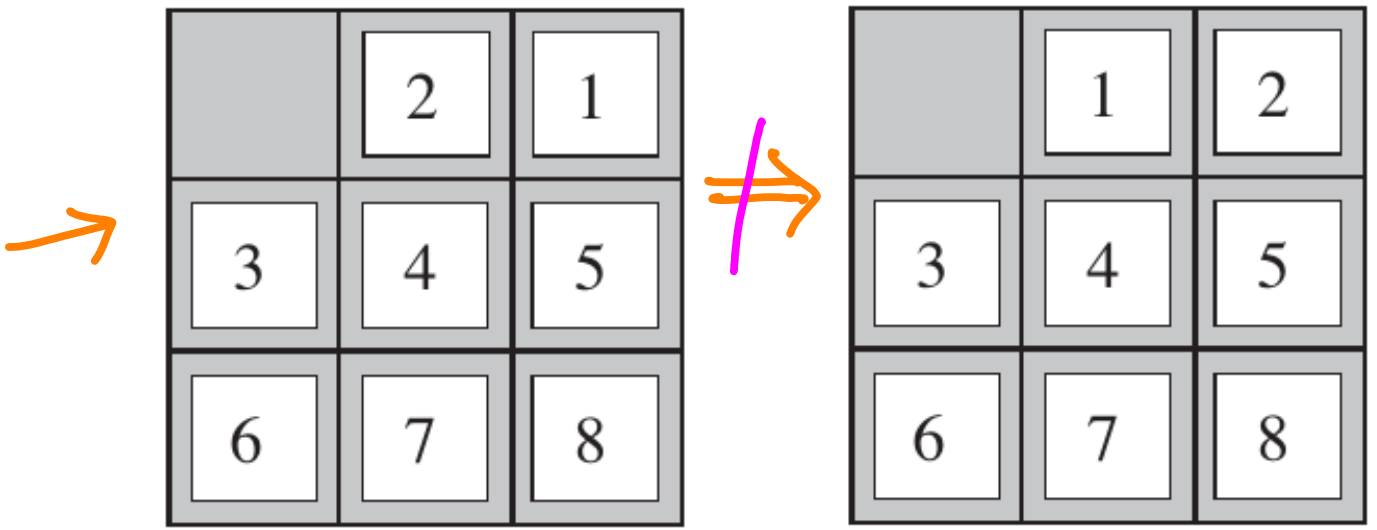

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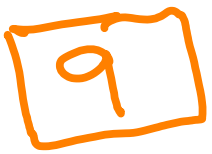

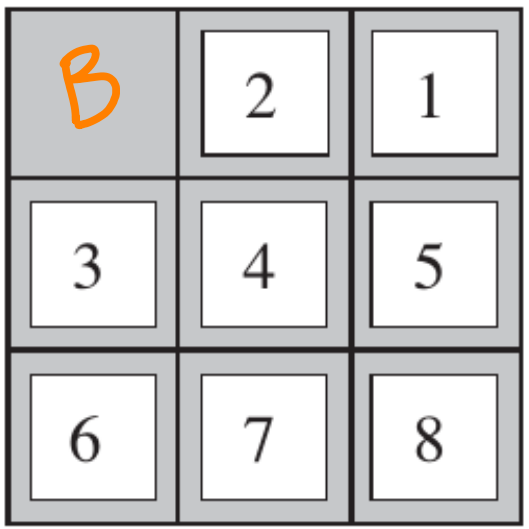

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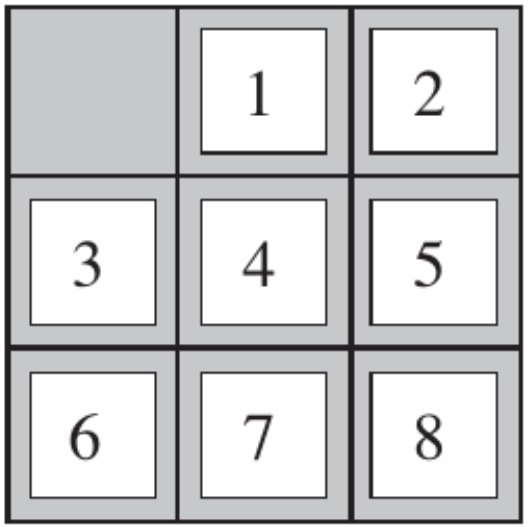

Goal State

- Number of states in state space $= 9!/2$

State Space for Eight puzzle problem

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$20! = 2.433 \times 10^{18}$

State Space for Eight puzzle problem

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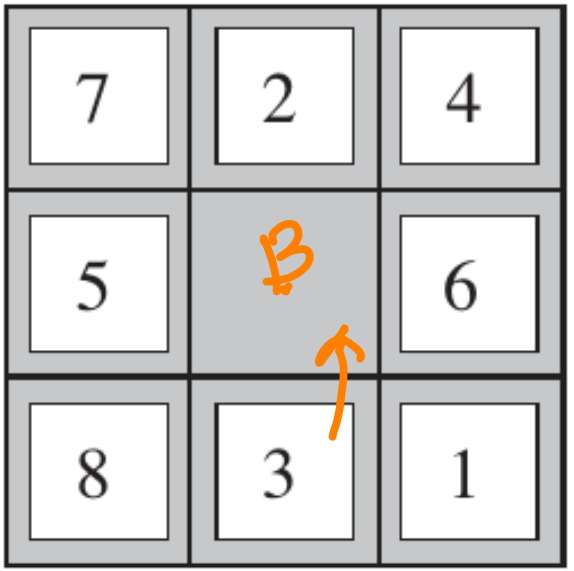

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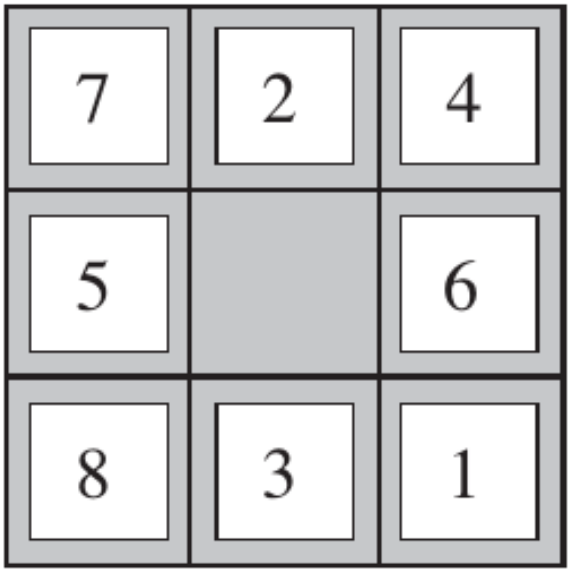
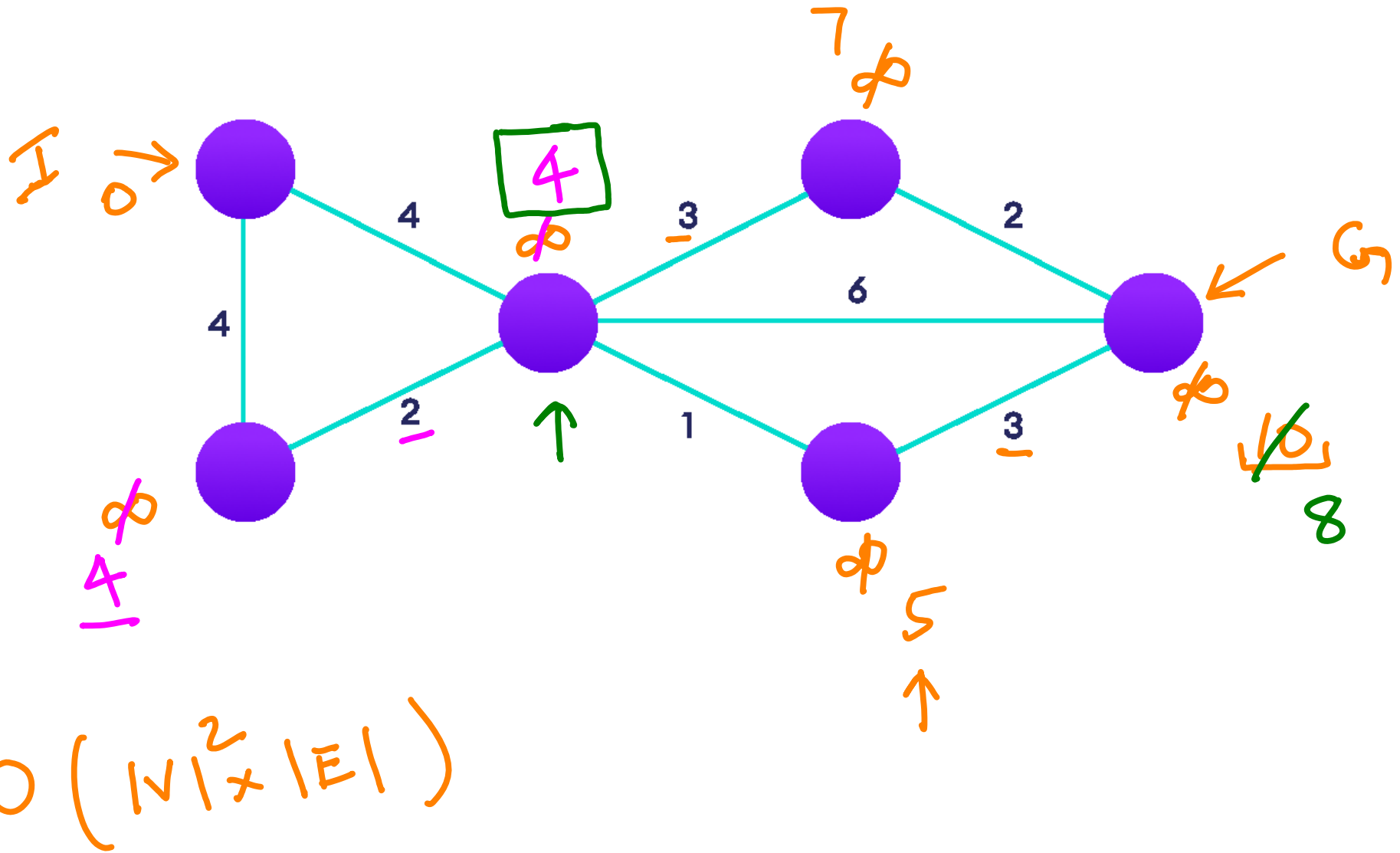


Start State

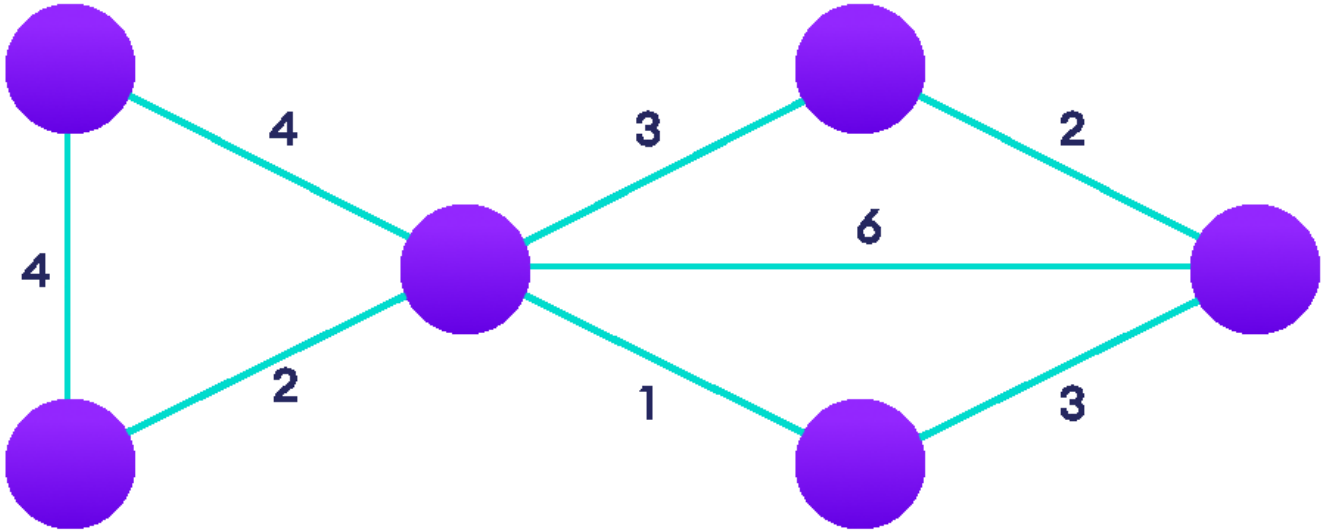
- Each step costs 1, and path cost is the number of steps from initial state to the goal state.

Dijkstra's algorithm



$O(|V|^2 \times |E|)$

Dijkstra's algorithm



- Can we use Dijkstra's algorithm to solve the problems that we have discussed? Will the algorithm run in polynomial time?