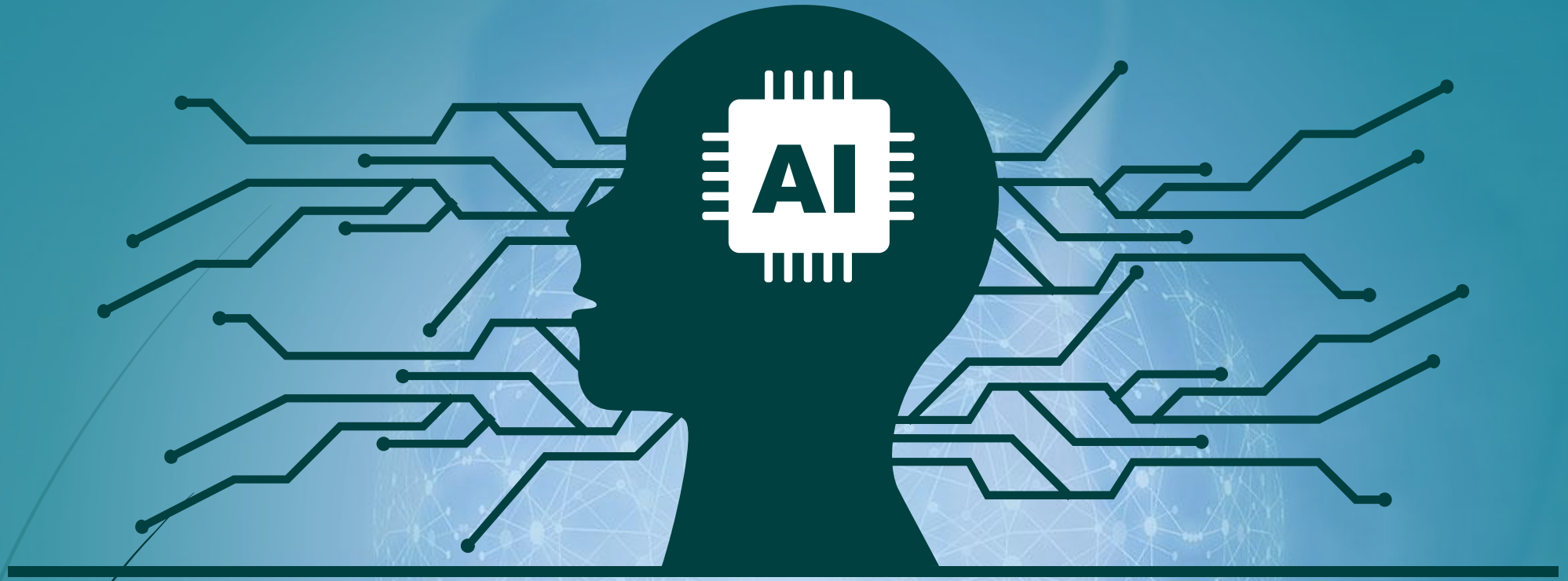

Advanced Artificial Intelligence

Week #2-1

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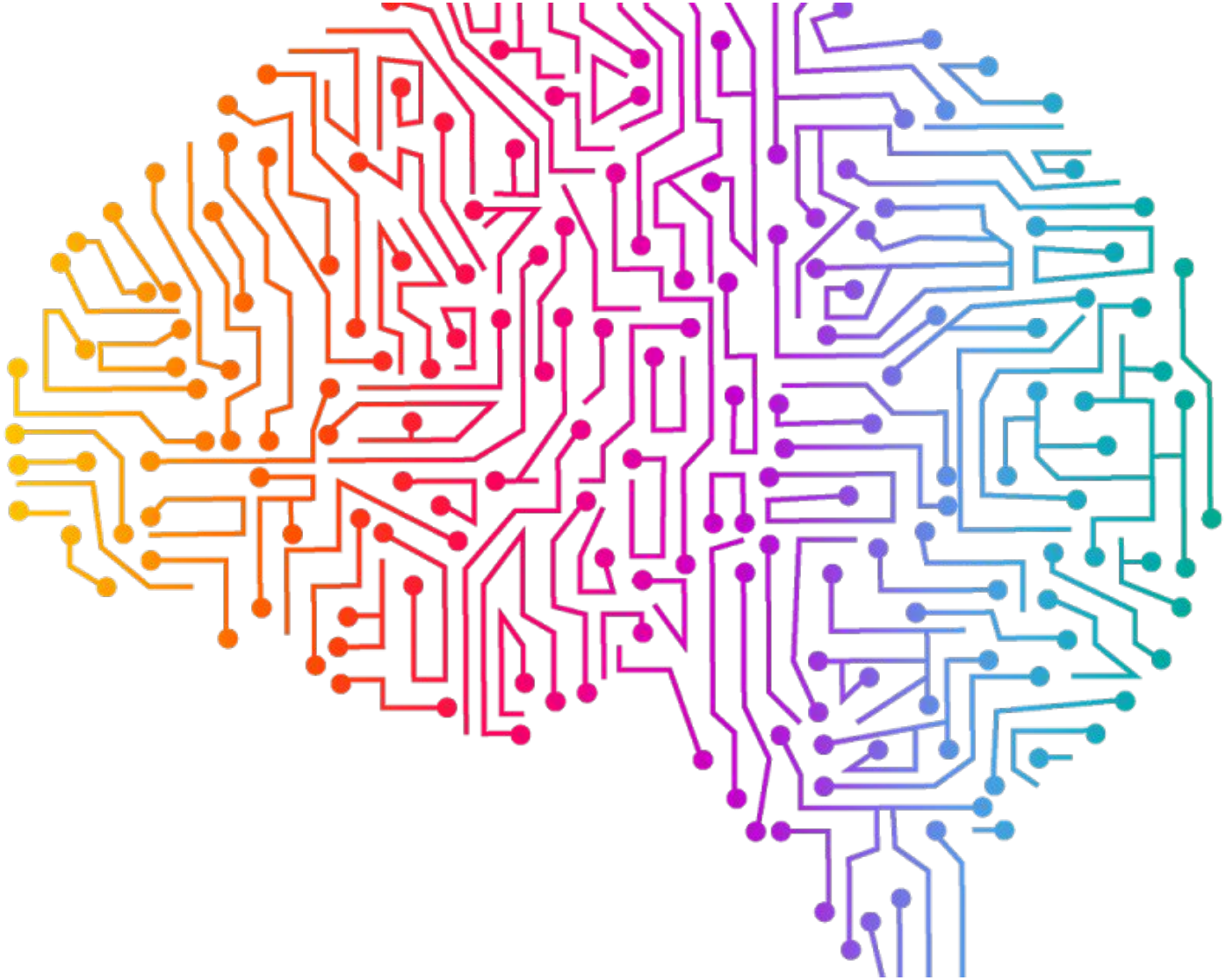
PROBLEM-SOLVING
in AI

Learning Objective of this Topic

- What is Problem Solving?
- Problem-Solving Agent
  - Goal Formulation
  - Problem Formulation
    - Problem Definition
  - Searching Solution
  - Executing Solution

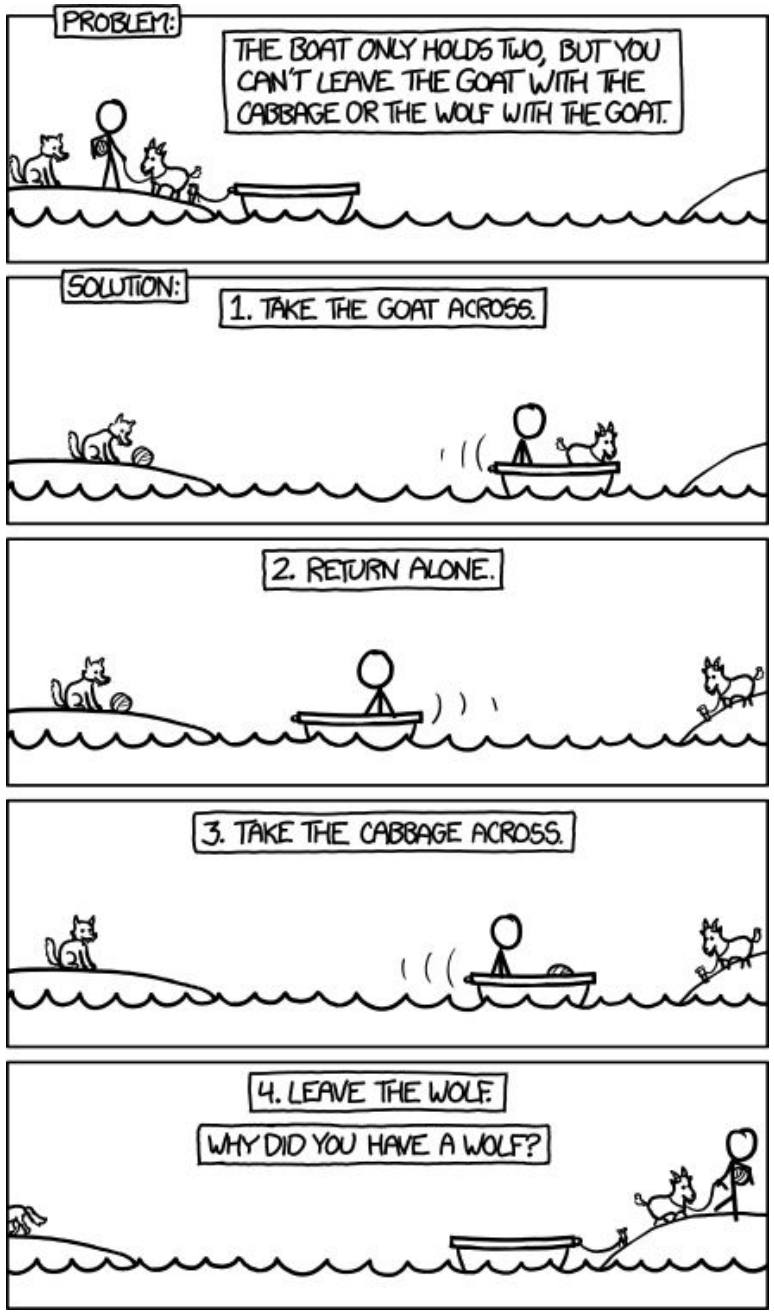
PROBLEM SOLVING



Question

A **farmer** wants to get his **cabbage**, **goat**, and **wolf** across a river. He has a boat that only holds two. He cannot leave the cabbage and goat alone or the goat and wolf alone. How many river crossings does he need?

- 4
- 5
- 6
- 7
- no solution

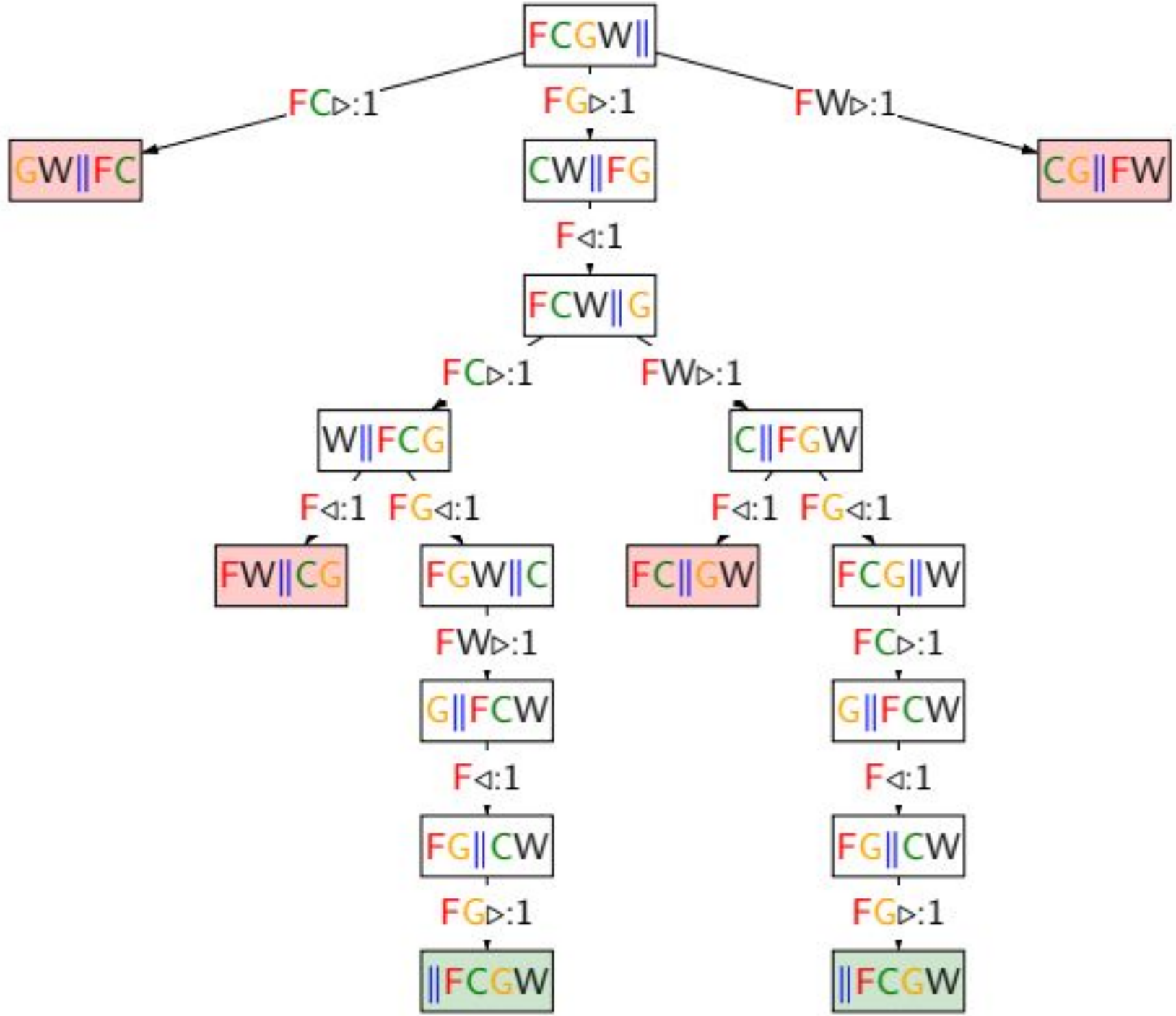

PROBLEM:
THE BOAT ONLY HOLDS TWO, BUT YOU CAN'T LEAVE THE GOAT WITH THE CABBAGE OR THE WOLF WITH THE GOAT.
SOLUTION:
1. TAKE THE GOAT ACROSS.
2. RETURN ALONE.
3. TAKE THE CABBAGE ACROSS.
4. LEAVE THE WOLF.
WHY DID YOU HAVE A WOLF?

Farmer Cabbage Goat Wolf

Actions:

F▷	F◁
FC▷	FC◁
FG▷	FG◁
FW▷	FW◁

Approach: build a **search tree** ("what if?")

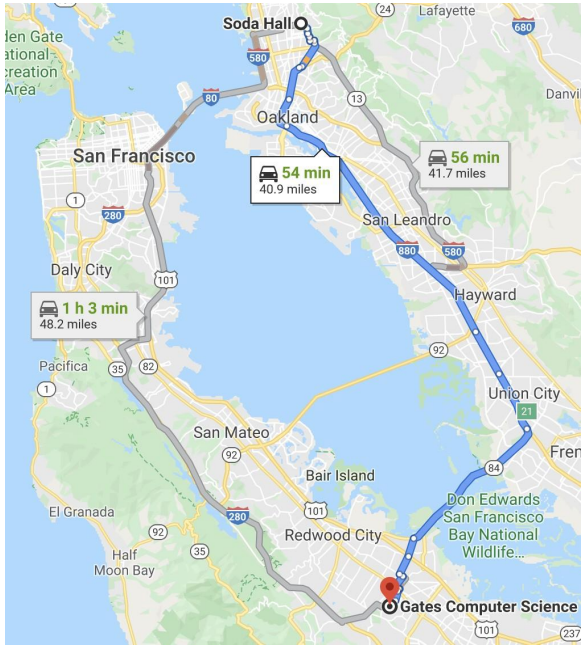

FCGW||
FC▷:1
FG▷:1
FW▷:1
GW||FC
CW||FG
CG||FW
F◁:1
FCW||G
FC▷:1
FW▷:1
W||FCG
C||FGW
F◁:1
FG◁:1
F◁:1
FG◁:1
FW||CG
FGW||C
FC||GW
FCG||W
FW▷:1
FC▷:1
G||FCW
G||FCW
F◁:1
F◁:1
FG||CW
FG||CW
FG▷:1
FG▷:1
||FCGW
||FCGW

Problem Solving

- It is the process in which one perceives and tries to arrive at the desired solution from a present situation by taking some path, which is blocked by known or unknown hurdles.

- Problem solving also includes **decision-making**, which is the process of selecting the best suitable alternative out of multiple alternatives to reach the desired goal.

Application: Route finding



Objective: shortest? fastest? most scenic? Actions: go straight, turn left, turn right

Application: Robot motion planning

Objective: fastest path

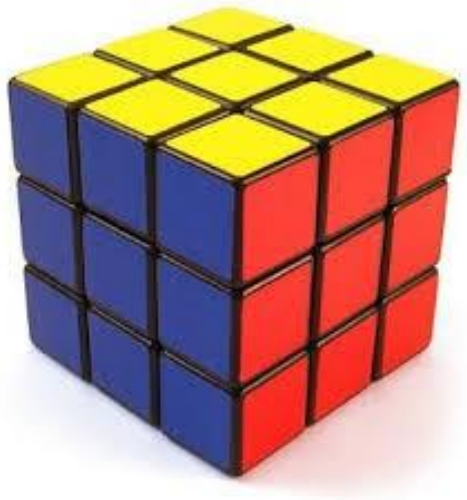
Actions: acceleration and throttle

Application: Robot motion planning

Objective: fastest? most energy efficient? safest? most expressive?

Actions: translate and rotate joints

Application:Solving puzzles

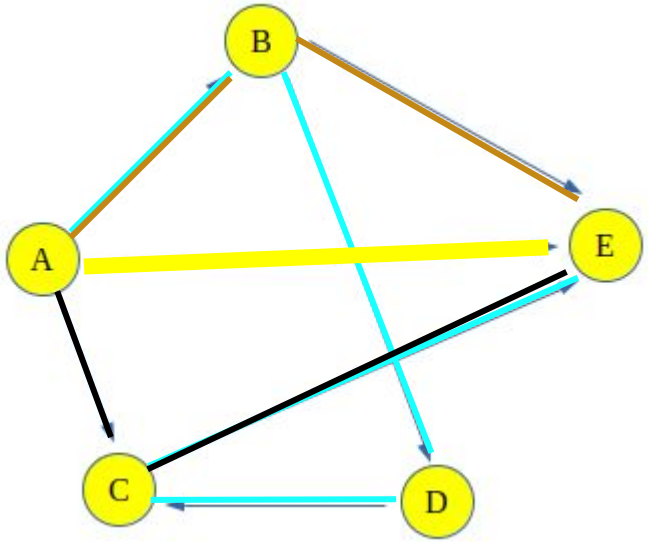


Objective: reach a certain configuration

Actions: move pieces (e.g., Move12Down)

Simple Example

For the following Graph: there are how many ways to reach from vertex A to E. What's the shortest way?



Problem Solving Agent

1) Goal Formulation
2) Problem Formulation
3) Searching Solution
   - Problem Definition
4) Executing Solution

1- Goal Formulation

- **Goal formulation**, based on the current situation/state and the agent's performance measure, is the first step in problem-solving.
- **Performance Measure:** Visit as many cities as possible, spend as low as possible on fuel.
- **Current State:** In Arad
- **Possible Goal:** In Bucharest → A set of states in which goal is satisfied

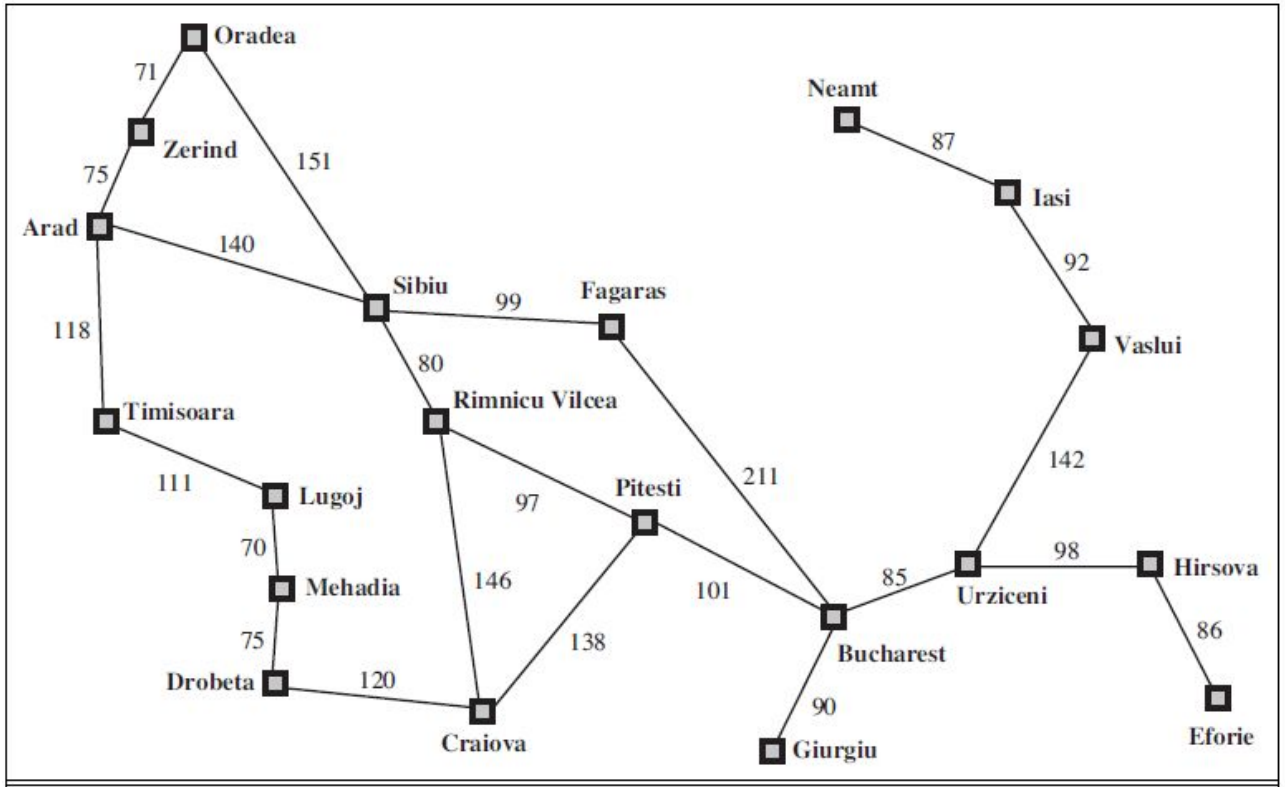


Figure 3.2 A simplified road map of part of Romania.

2- Problem Formulation

- **Problem formulation** is the process of deciding what actions and states to consider, given a goal.
- The agent will consider actions at the level of driving from one major town to another. Each state therefore corresponds to being in a particular town.

- **Go Left, Go Right, Go forward, Go reverse**. If these 4 actions are considered agent will never go out of the parking lot let alone reaching Bucharest.
- **Possible Action**: Go Cityname

Problem Definition

- A problem consists of five components,
  - Initial State
  - Possible Actions
  - Transition Model
  - Goal Test
  - Path Cost

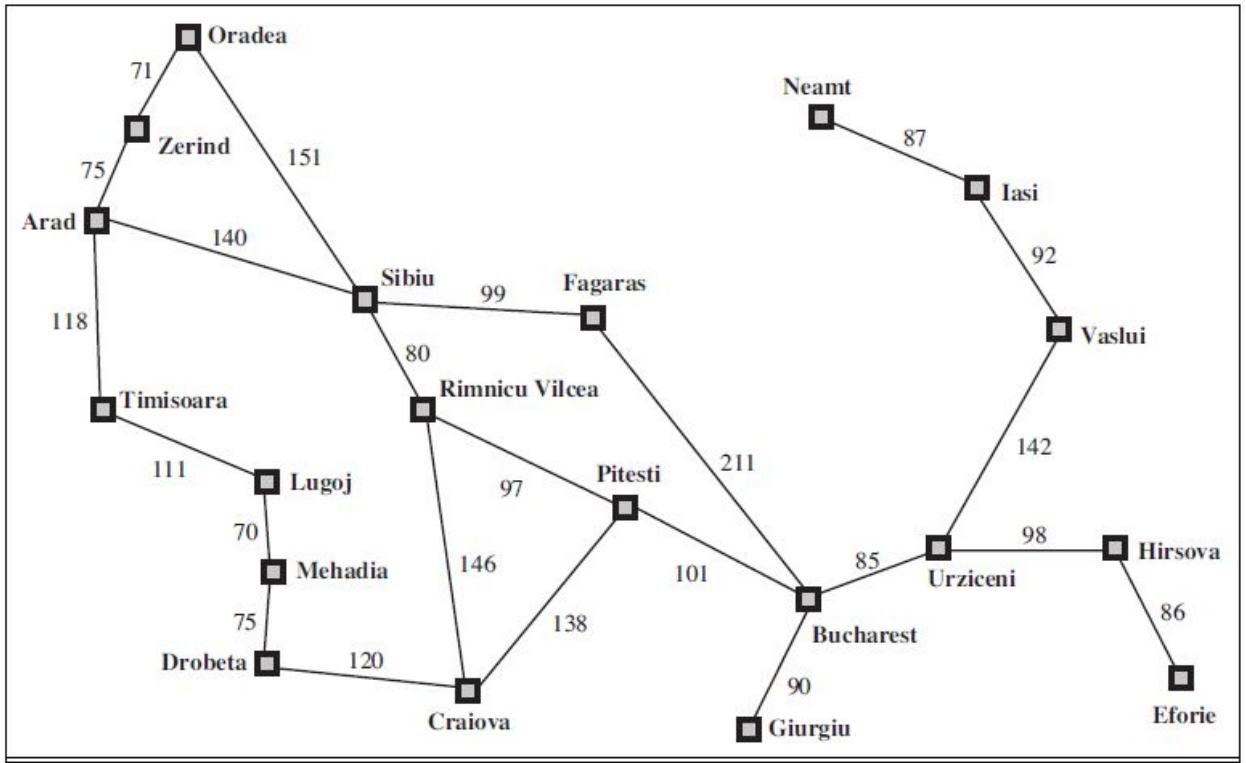


Figure 3.2 A simplified road map of part of Romania.

Problem Definition

- A problem consists of five components,
  - Initial State: in (Arad)
  - Possible Actions (given a state): e.g.,
  - from Arad possible actions are

{Go(Sibiu), Go(Timisoara), Go(Zerind)}.

  - Transition Model: specifies the relationship between a state, a possible action and the resulting successor state e.g.,

RESULT(In(Arad),Go(Zerind)) = In(Zerind)

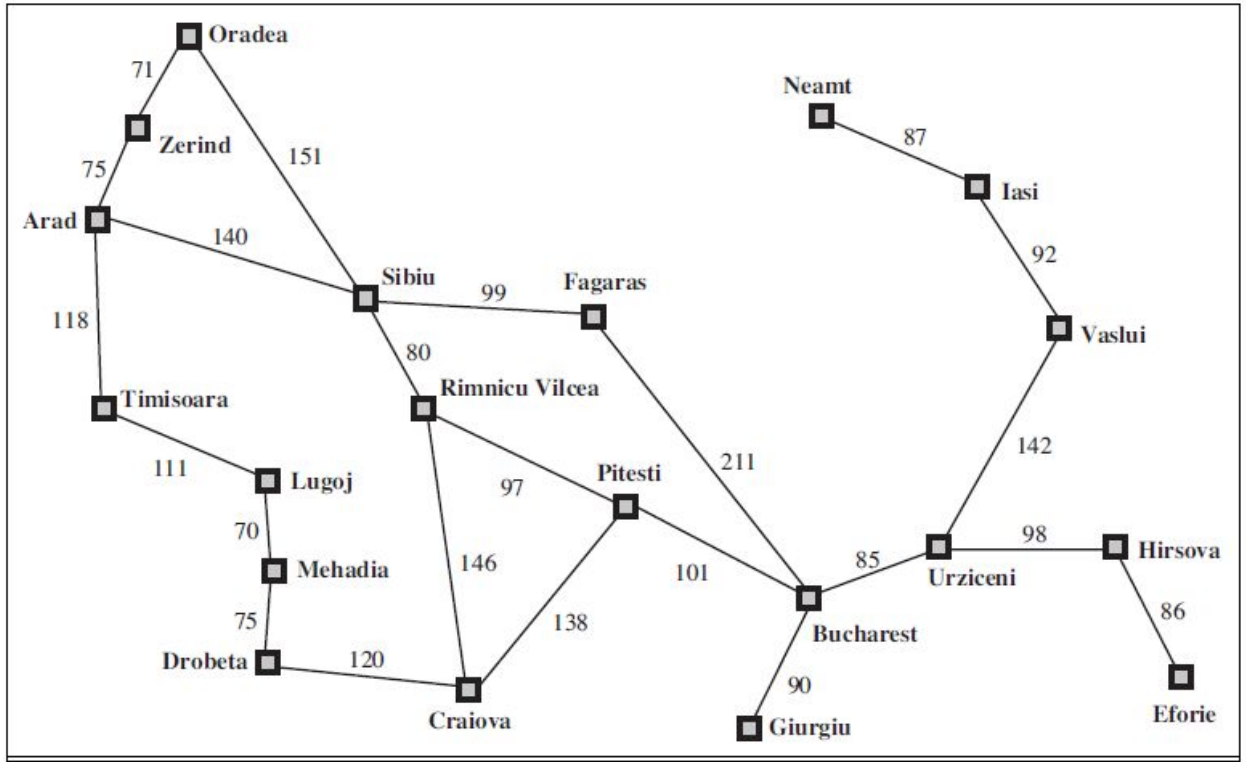


Figure 3.2 A simplified road map of part of Romania.

Problem Definition

- A problem consists of five components,
  - Initial State
  - Possible Actions
  - Transition Model
  - Goal Test (whether a given state is a goal state) e.g. {In(Bucharest)}.
  - Path Cost (based upon agent's performance measure). Two paths shown on the right. Step cost (the cost of a single action within a path)

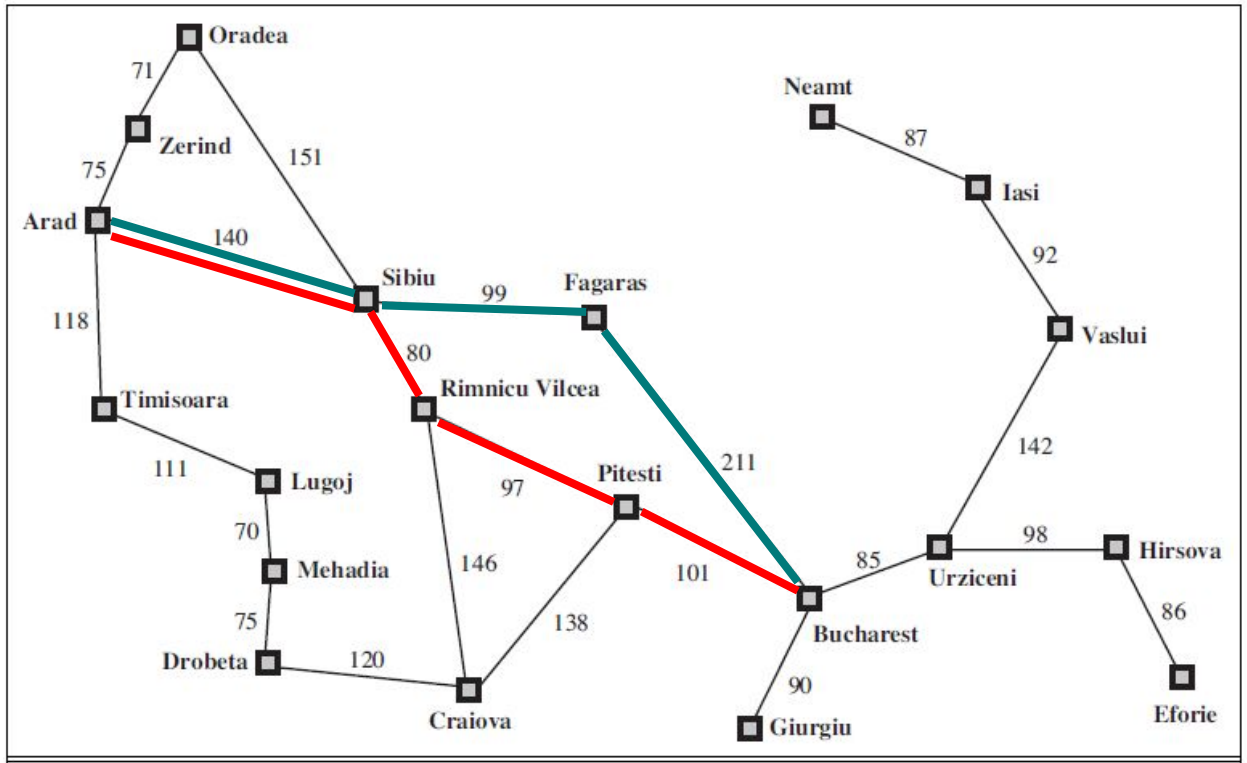


Figure 3.2 A simplified road map of part of Romania.

3- Searching Solution (Search Space Graph)

- On the right is the state space graph of our problem
- State Space - the set of all states reachable from the initial state by any sequence of actions.
- A **path** in the state space is a sequence of states connected by a sequence of actions.

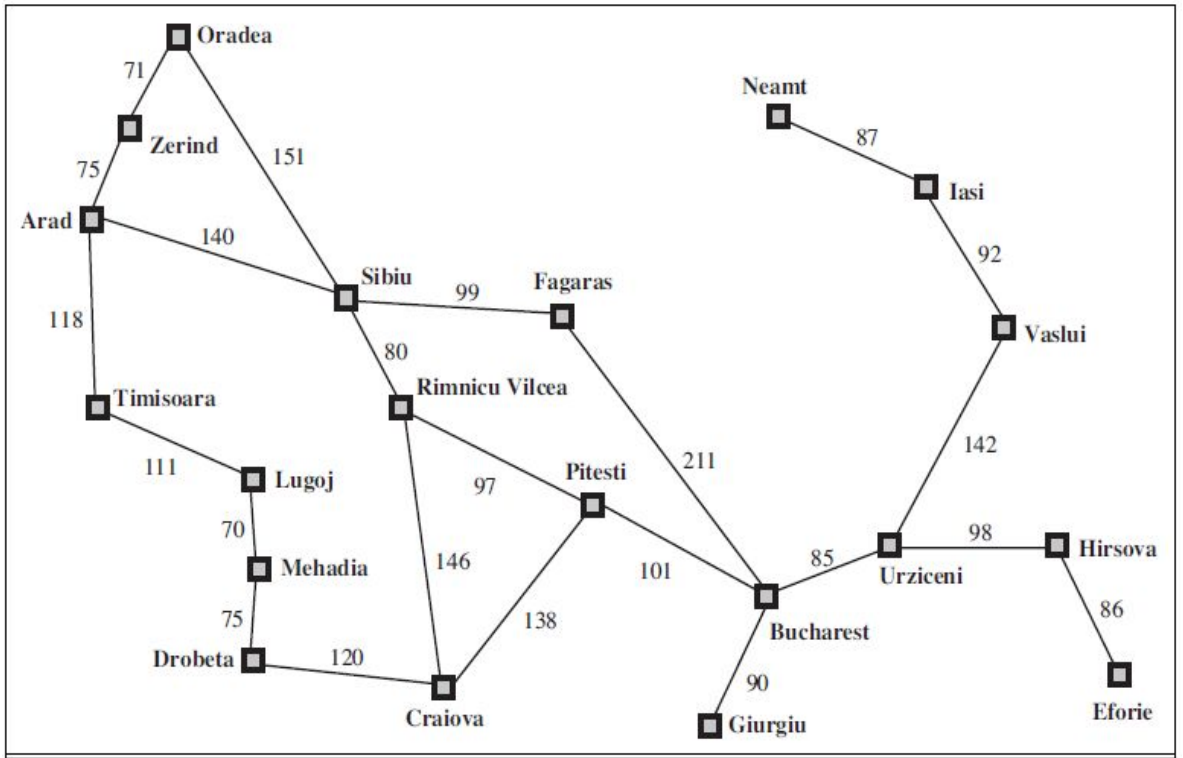


Figure 3.2 A simplified road map of part of Romania.

4- Executing Solution

- A **solution** to a problem is an action sequence that leads from the initial state to a goal state.
- Solution quality is measured by the path cost function, and an **optimal solution** has the lowest path cost among all solutions.

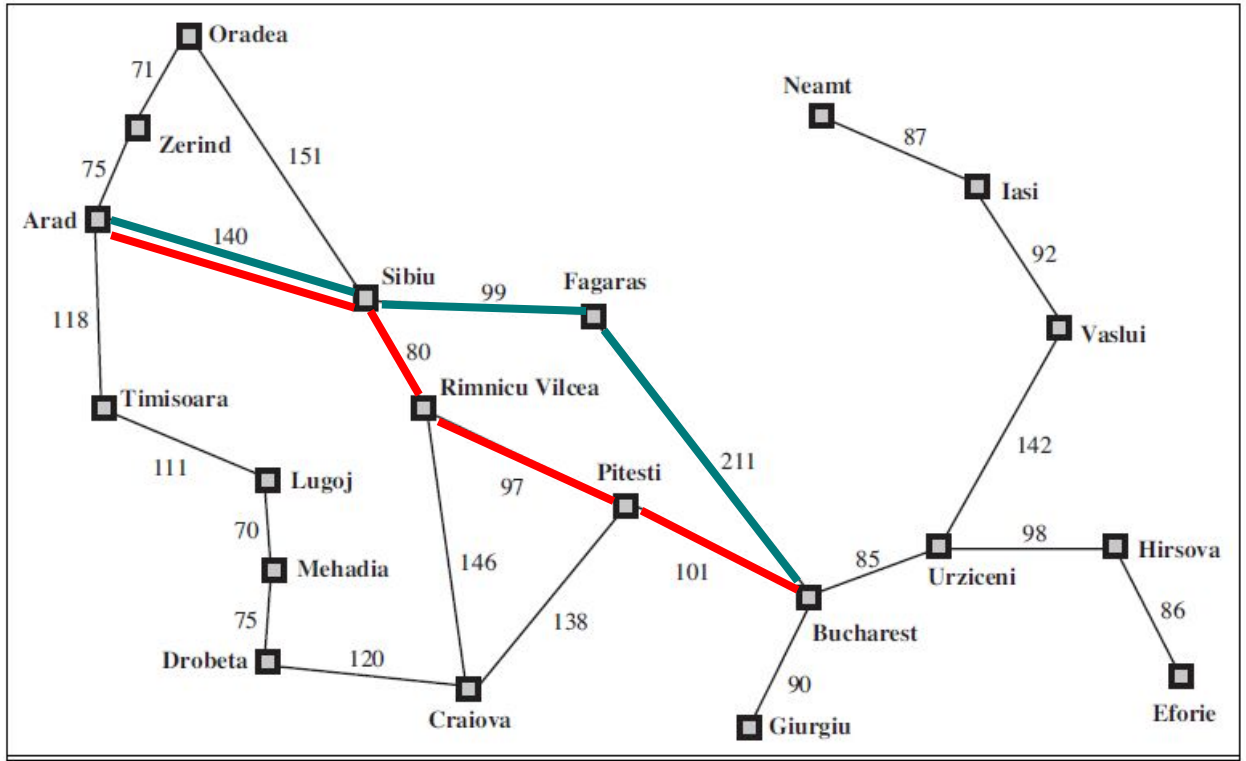


Figure 3.2 A simplified road map of part of Romania.

Tree Search

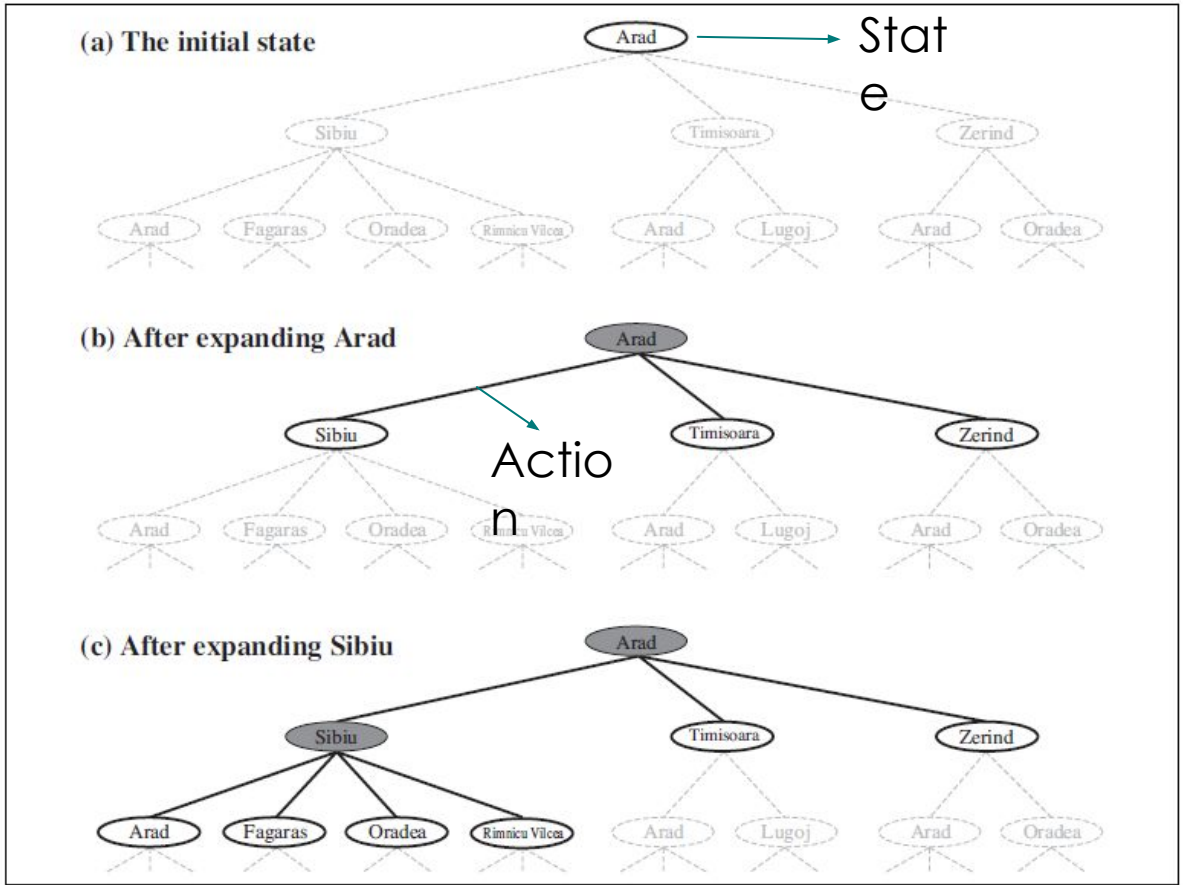


Figure 3.6 Partial search trees for finding a route from Arad to Bucharest. Nodes that have been expanded are shaded; nodes that have been generated but not yet expanded are outlined in bold; nodes that have not yet been generated are shown in faint dashed lines.

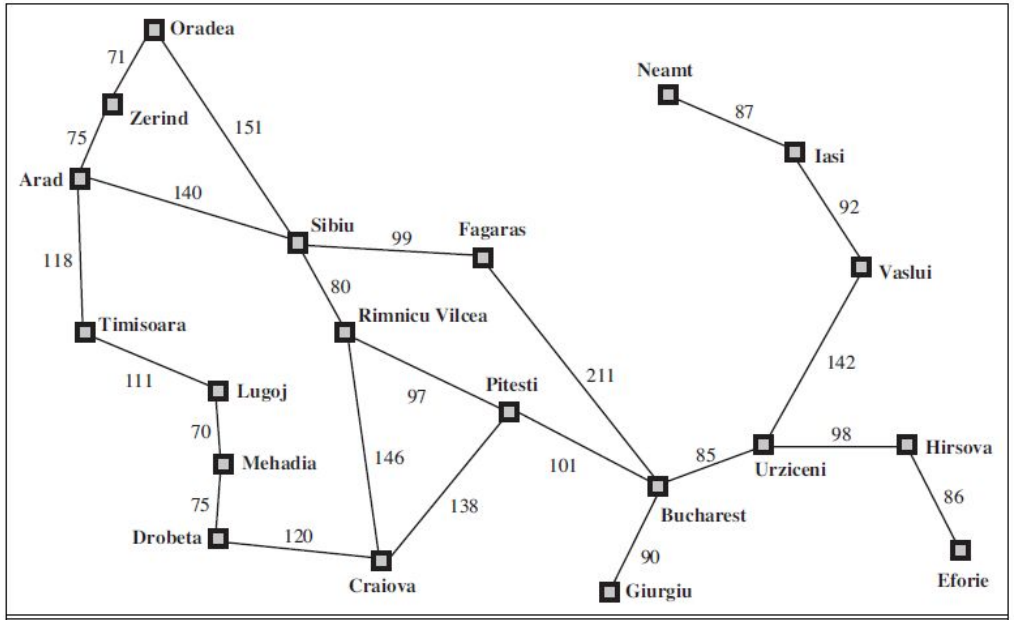
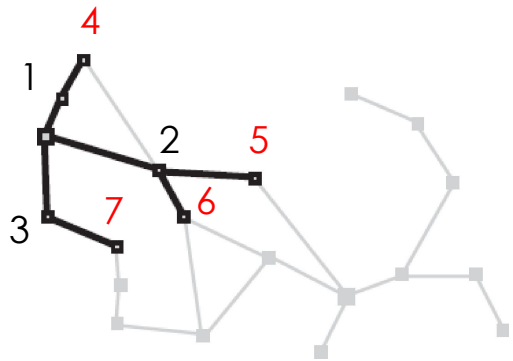


Figure 3.2 A simplified road map of part of Romania.

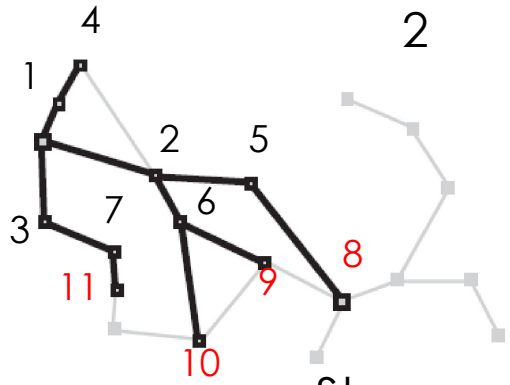
Graph Search

- Use an explore set / closed list / frontier to remember the states already visited

Step 1



Step 2



Step 3

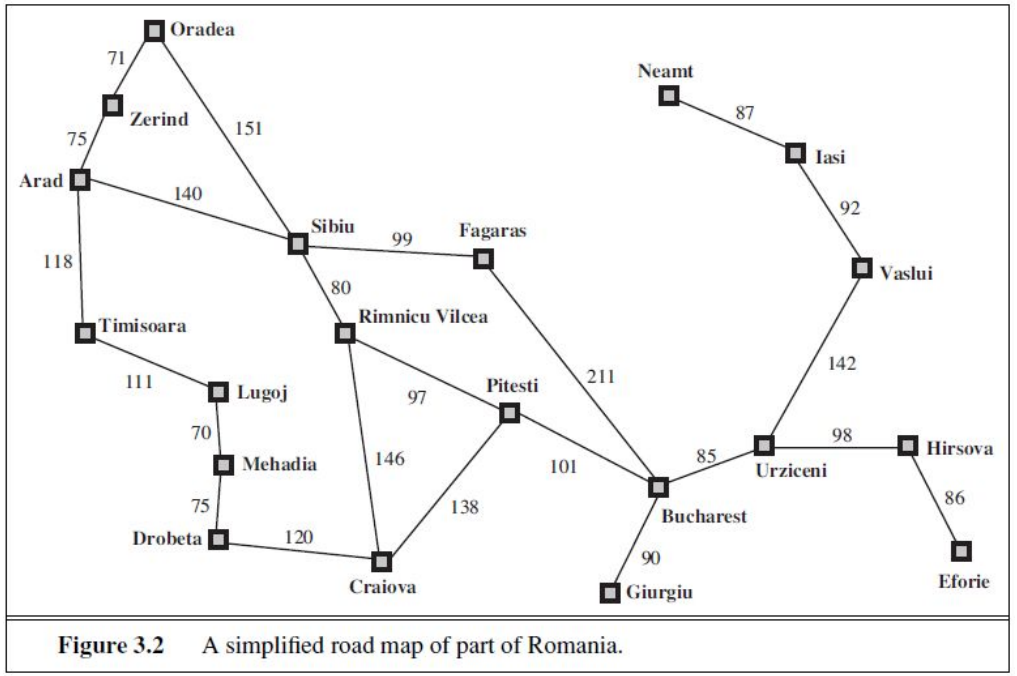


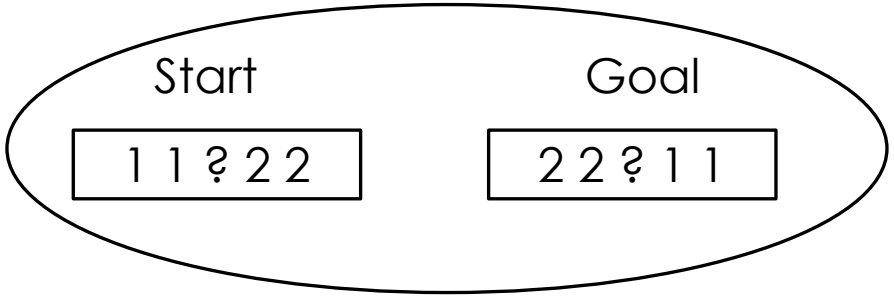
Figure 3.2 A simplified road map of part of Romania.

Problem-Solving Agent

- *In which we look at how an agent can decide what to do by systematically considering the outcomes of various sequences of actions that it might take.*

- Stuart Russell & Peter Norvig

Two – One Problem

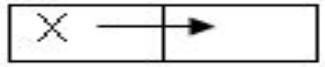


Rules:

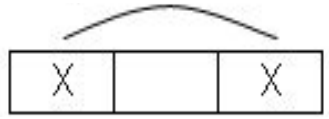
- 1s' move right
- 2s' move left
- Only one move at a time
- No backing up

Legal Moves:

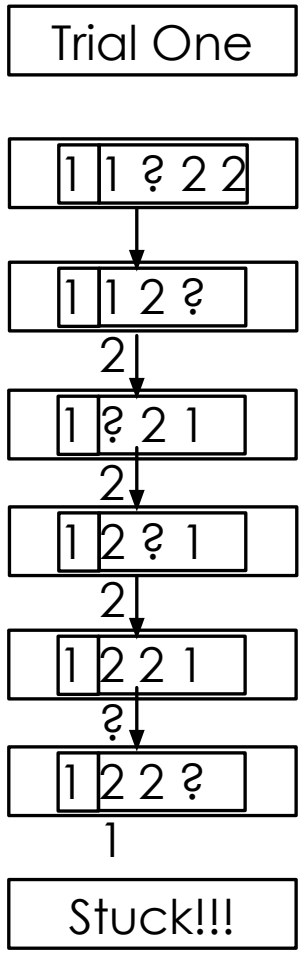
- Slide

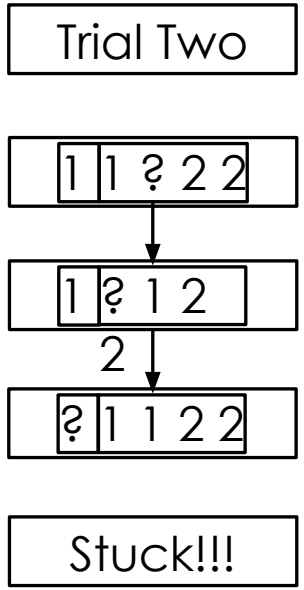


- Hop

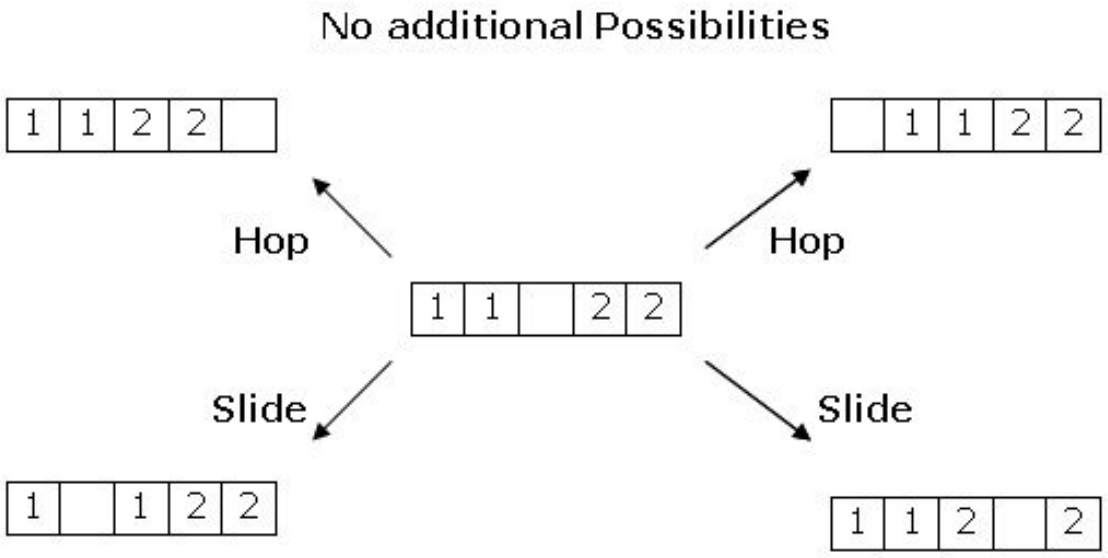


Two – One Problem
Trials to solve the problem



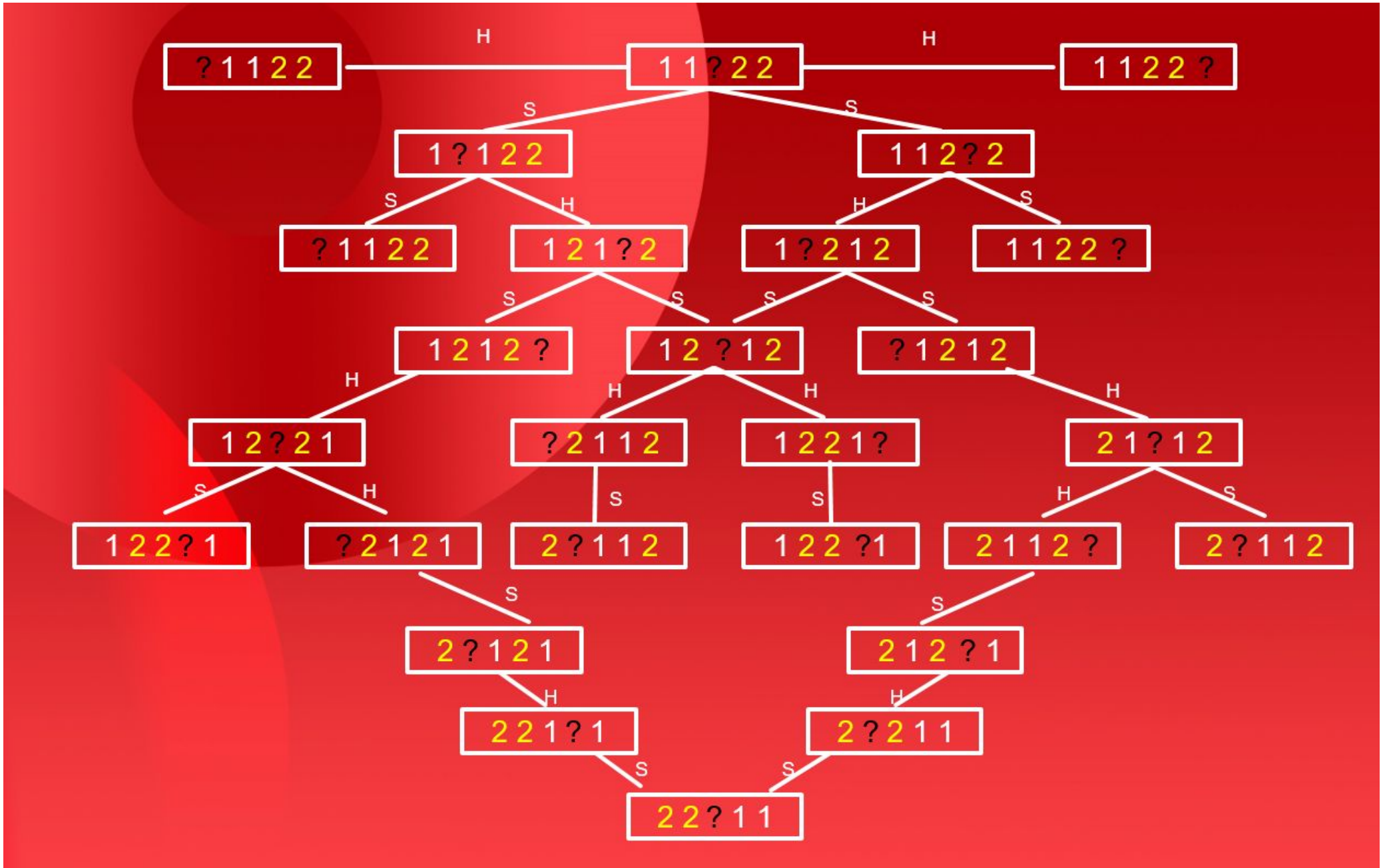


Two – One Problem
Five States



- Both hopping and sliding can still be applied

Two – One Problem-Solution Space




Questions
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Answers
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