

Introduction

Problem formation is the step in problem definition that is used to understand and decide a course of action that needs to be considered to achieve a goal.

Need for Problem formulation

- Every problem should be properly formulated in artificial intelligence.
- Problem formulation is very important before applying any search algorithm.
- Every algorithm demands problem is specific form.
- Before problem formulation it is very important to know components of problem.

Problem Solving Components

In AI one must identify components of problems, which are:-

- Problem Statement
 - Definition
 - Limitation or Constraints or Restrictions
- Problem Solution
- Solution Space
- Operators

Definition of Problem

- The information about **what** is to be done?
- **Why** it is important to build AI system?
- **What** will be the advantages of proposed system?
- For example “**I want to predict the price of house using AI system**”.

Problem Limitation

- There always some limitations while solving problems.
- All these limitations or constraints must be fulfil while creating system.
- For example **“I have only few features, some records are missing. System must be 90% accurate otherwise will be useless”**.

Goal or Solution

- What is expected from system?
- The Goal state or final state or the solution of problem is defined here.
- This will help us to proposed appropriate solution for problem.
- For example **“we can use some machine learning technique to solve this problem”**.

Solution Space

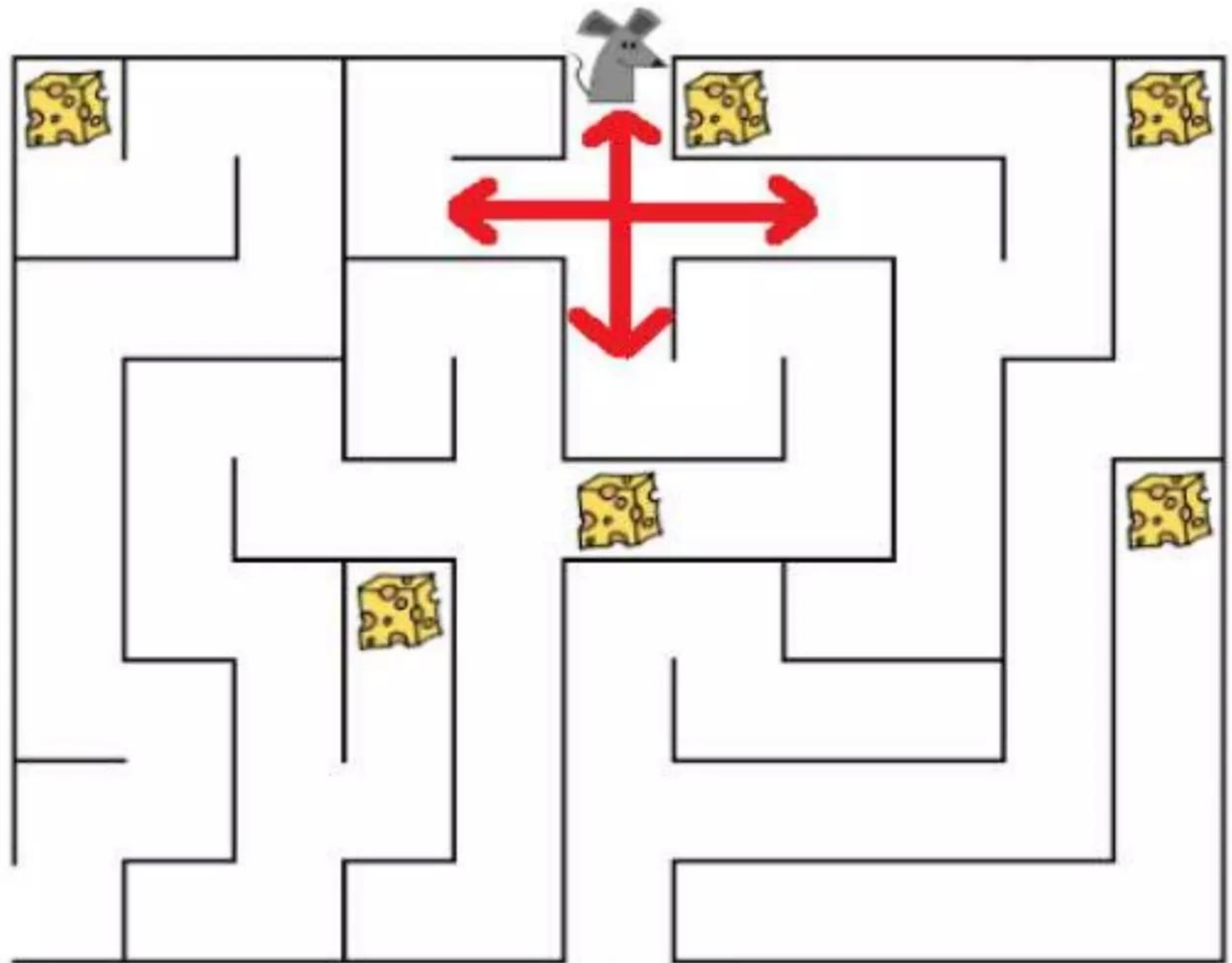
- Problem can be solve in many ways. Some solution will be efficient than others.
- Some will consume less resources, some will be simple etc.
- There are always alternatives exists.
- Many possible ways with which we can solve problem is known as Solution Space.
- For example “**price of house can be predict using many machine learning algorithms**”.

Operators

- Operators are the actions taken during solving problem.
- Complete problem is solved using tiny steps or actions and all these consecutive actions leads to solution of problem.

Examples of Problem Formulation Mouse Path Problem

- **Problem Statement**
 - **Problem Definition:** Mouse is hungry, mouse is in a puzzle where there are some cheese. Mouse will only be satisfied if mouse eat cheese
 - **Problem Limitation:** Some paths are close i-e dead end, mouse can only travel through open paths
- **Problem Solution:** Reach location where is cheese and eat minimum one cheese. There are possible solutions (cheese pieces)
- **Solution Space:** To reach cheese there are multiple paths possible
- **Operators:** Mouse can move in four possible directions, these directions are operators or actions which are UP, DOWN, LEFT and RIGHT



Water Jug Problem

- **Problem Statement**

- **Problem Definition:** You have to measure 4 liter (L) water by using three buckets 8L, 5L and 3L.
- **Problem Limitation:** You can only use these (8L, 5L and 3L) buckets

Measure 4L Using 3 Buckets



Problem Solution: Measure exactly 4L water

Solution Space: There are multiple ways doing this.

Operators: Possible actions are fill water in any bucket and remove water from any bucket.

Path Finding Problem

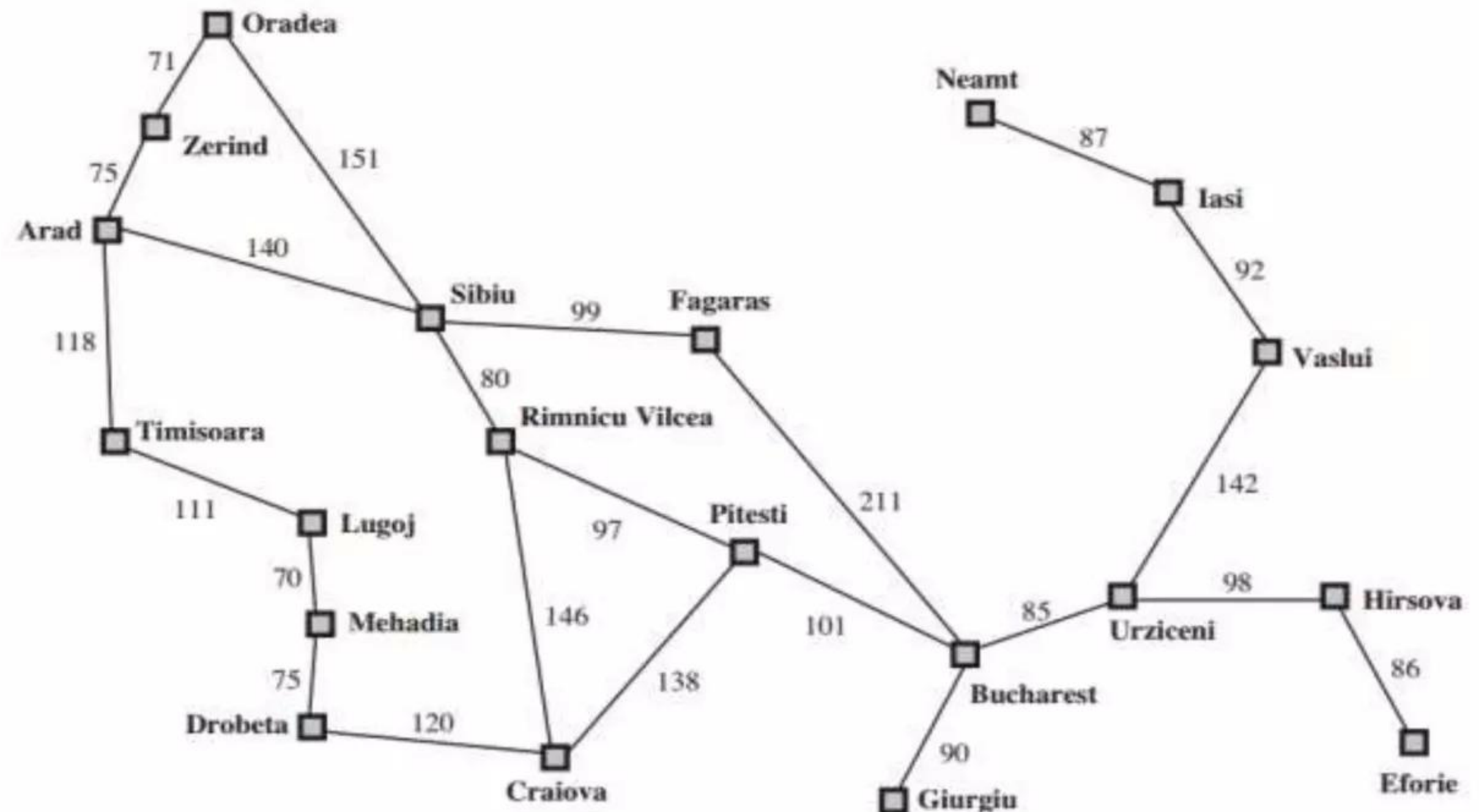
- **Problem Statement**

- **Definition:** Going from Arad to Bucharest in given map
- **Limitation:** Must travel from location to other if there is path

Problem Solution: Reach Bucharest

Solution Space: There are multiple paths to reach Bucharest.

Operators: Move to other locations



Well-defined Problems and Solution

Problem solving components discussed above are applicable to any problem. For AI system implementation, problem must be well defined. A well-defined problem must have five components:-

- **Initial State:** Start point of problem
- **Final State:** The finish point of problem. Aka Goal or solution state
- **States:** Total states in problem
- **Transition Model:** How one can shift from one state to another
- **Actions:** Actions set, used to move from one state to another
- **Path Cost:** What is total effort (cost) from initial state to final state

Examples of Well-Defined Problems

8 Puzzle or Slide Puzzle

- **States:** A state description specifies the location of each of the eight tiles and the blank in one of the nine squares.
- **Initial state:** Any random shuffled state can be designated as initial state

- **Actions:**

- Slide Left
- or Slide Right
- or Slide Up
- And Slide Down

7	2	4
5		6
8	3	1

Start State

	1	2
3	4	5
6	7	8

Goal State

- **Transition model:** Given a state and action, this returns the resulting state
- **Goal test:** This checks whether the state matches the goal
- **Path cost:** Each step costs 1

8 Queens Problem

- **States:** Any arrangement of 0 to 8 queens on the chess board is a state.
- **Initial state:** No queens on the board or randomly shuffled 8 queens on board
- **Actions:** Add a queen to any empty square or move queens one by one
- **Transition model:** Returns the board with a queen added to the specified square.
- **Goal test:** 8 queens are on the board, none attacked.

