Artificial and Computational Intelligence

AIMLCZG557

Contributors & Designers of document content : Cluster Course Faculty Team

M2 : : Problem Solving Agent using Search

BITS Pilani
Pilani Campus

Presented by
Faculty Name
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Artificial and Computational Intelligence

Disclaimer and Acknowledgement

- Few content for these slides may have been obtained from prescribed books and various other source on the Internet
- I hereby acknowledge all the contributors for their material and inputs and gratefully acknowledge people others who made their course materials freely available online.
- .I have provided source information wherever necessary
- This is not a full fledged reading materials. Students are requested to refer to the textbook w.r.t detailed content of the presentation deck that is expected to be shared over e-learning portal - taxilla.
- I have added and modified the content to suit the requirements of the class dynamics & live session's lecture delivery flow for presentation

- **Slide Source / Preparation / Review:**
- From BITS Pilani WILP**:** Prof.Raja vadhana, Prof. Indumathi, Prof.Sangeetha
- From BITS Oncampus & External : Mr.Santosh GSK

Course Plan

M1	Introduction to AI
M2	Problem Solving Agent using Search
M3	Game Playing
M4	Knowledge Representation using Logics
M5	Probabilistic Representation and Reasoning
M6	Reasoning over time
M7	Ethics in AI

Learning Objective

At the end of this class , students Should be able to:

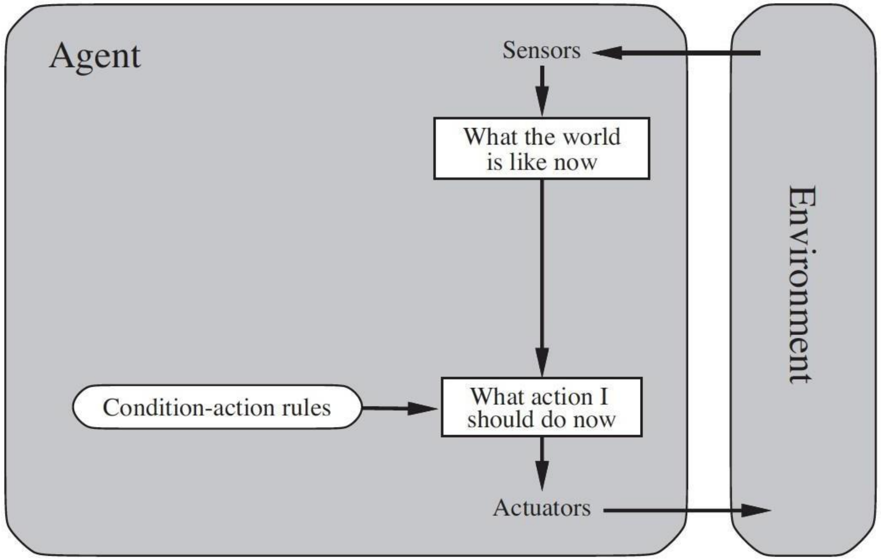
1. Design problem solving agents
2. Create search tree for given problem
3. Apply uninformed search algorithms to the given problem
4. Compare performance of given algorithms in terms of completeness, optimality, time and space complexity
5. Differentiate for which scenario appropriate uninformed search technique is suitable and justify

Agents Architectures

Agent Architectures

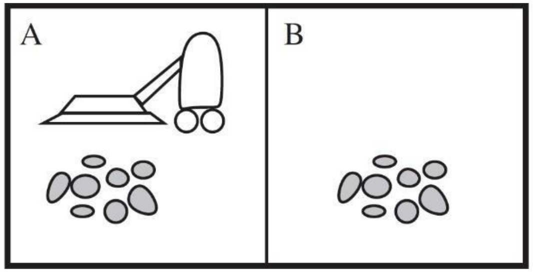
Simple Reflex Agent

function SIMPLE-REFLEX-AGENT(*percept*) returns an action
    persistent: *rules*, a set of condition–action rules
    state←INTERPRET-INPUT(*percept*)
    rule←RULE-MATCH(*state*, *rules*)
    action ←*rule*.ACTION
    return *action*



function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action
    if *status* = *Dirty* **then return** Suck
    else if *location* = *A* **then return** Right
    else if *location* = *B* **then return** Left

Simple Reflex Agents

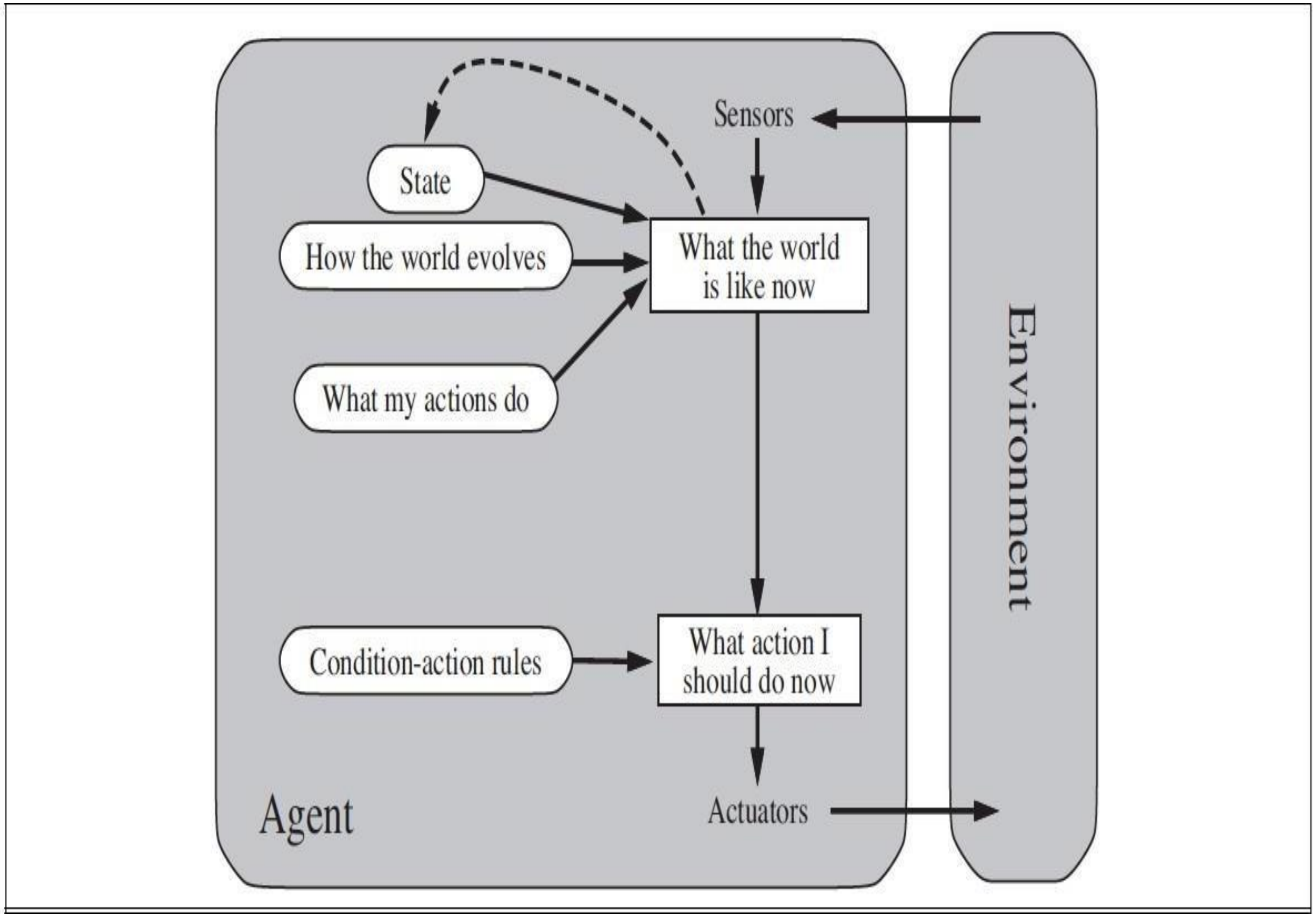


Agent Architectures

Model based Agent

Simple Reflex Agents

Model Based Agents



Model based Agent

function MODEL-BASED-REFLEX-AGENT(*percept*) **returns** an action

persistent: *state*, the agent's current conception of the world state
transition model, a description of how the next state depends on the current state and action
sensor model , a description of how the current world state is reflected in the agent's percepts
rules, a set of condition–action rules
action, the most recent action, initially none

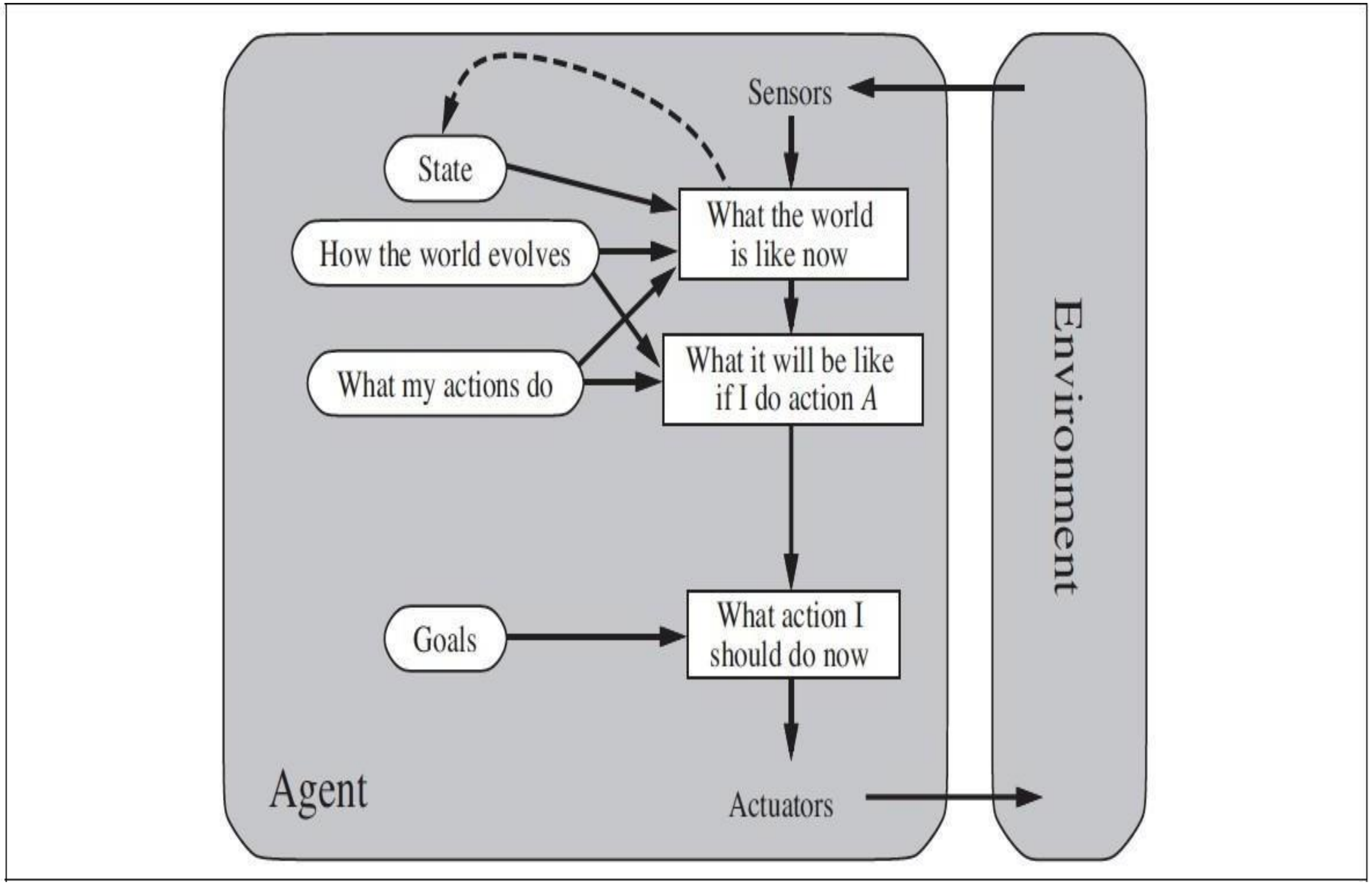
state←UPDATE-STATE(*state, action, percept, transition model, sensor model*)
rule←RULE-MATCH(*state, rules*)
action ←*rule*.ACTION
return *action*

Goal based Agent

Simple Reflex Agents

Model Based Agents

Goal Based Agents



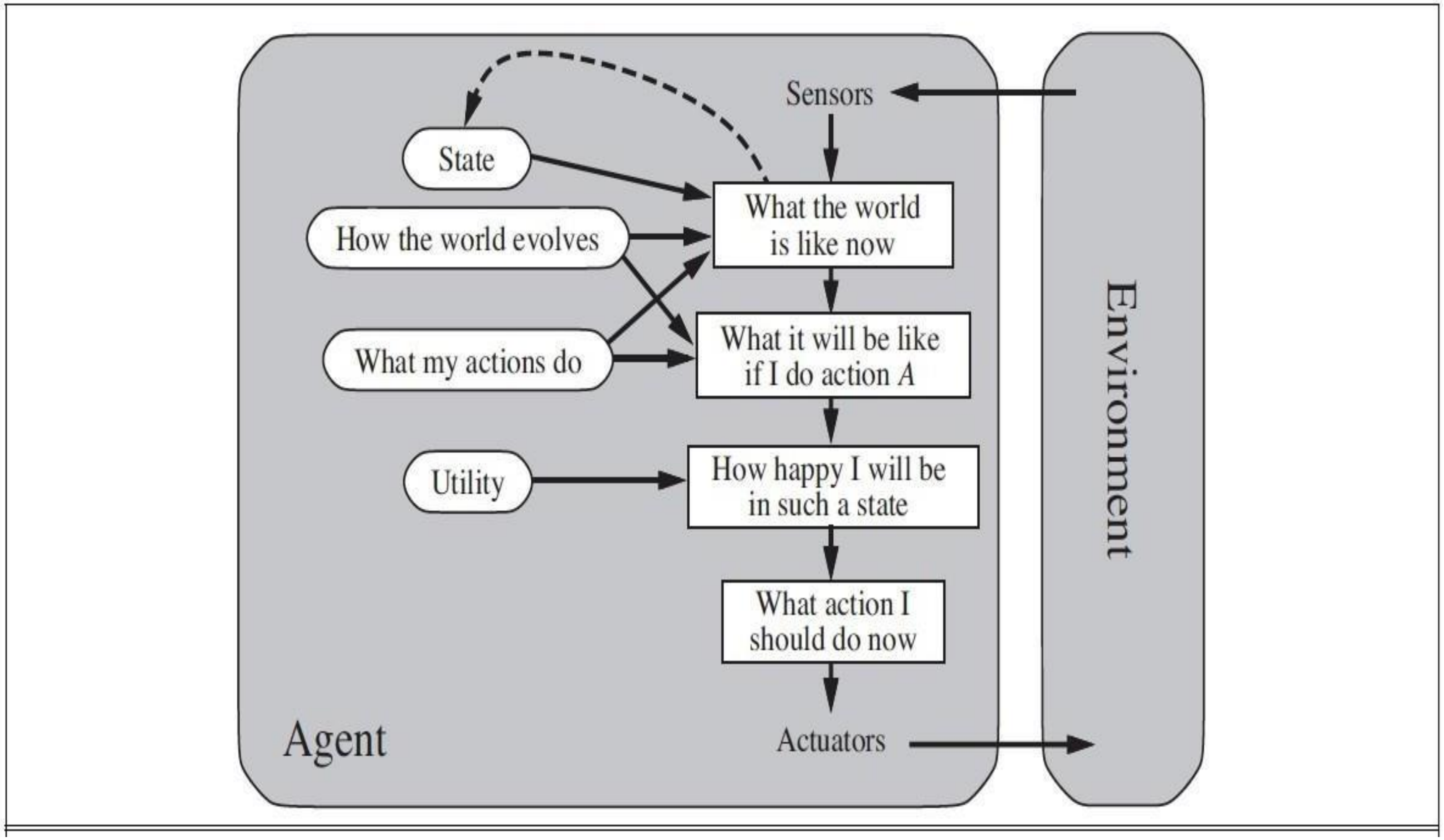
Utility based Agent

Simple Reflex Agents

Model Based Agents

Goal Based Agents

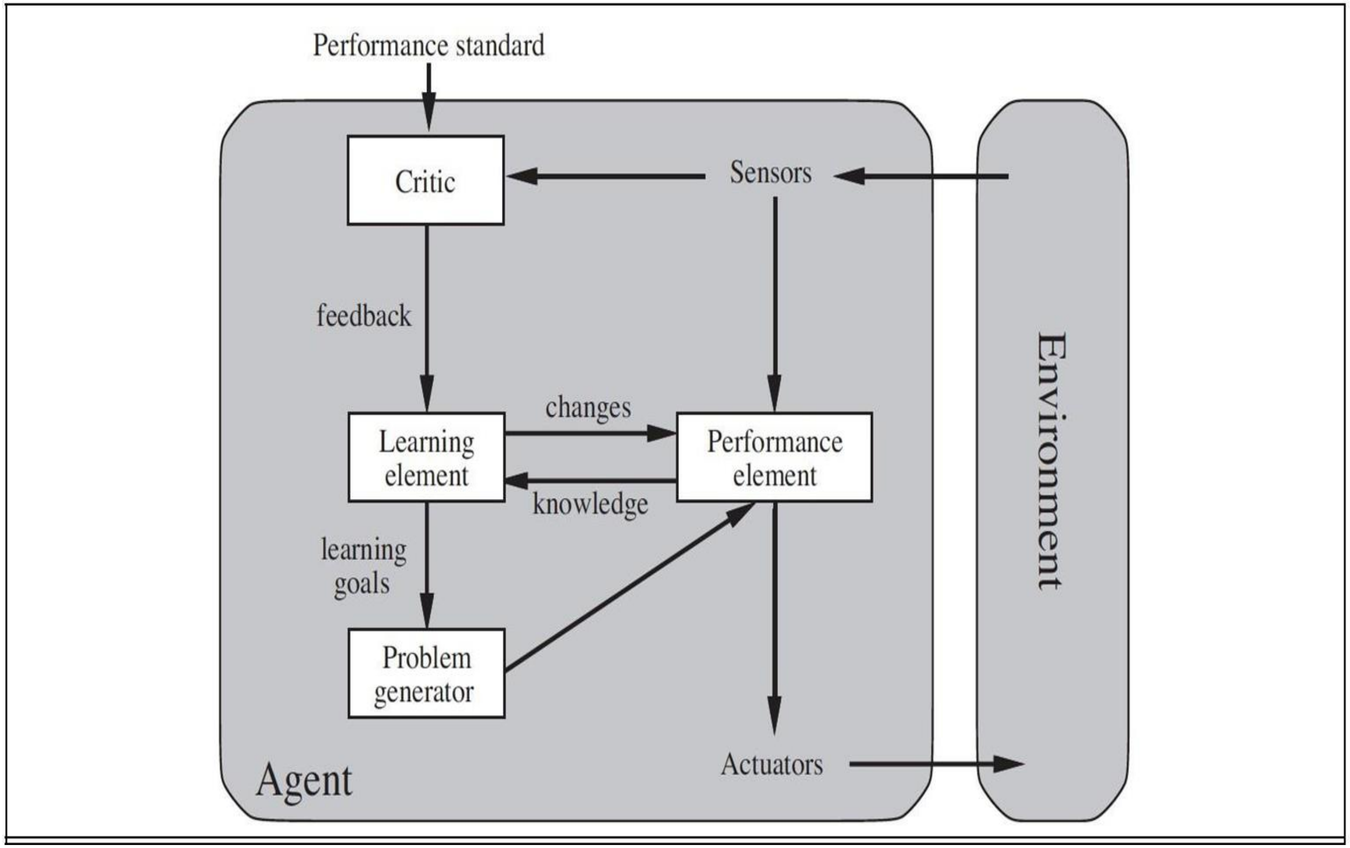
Utility Based Agents



Agent Architectures

Learning Agent

- Simple Reflex Agents
- Model Based Agents
- Goal Based Agents
- Utility Based Agents
- Learning Agents



Role of Learning

Performance Element – taking a decision of action based on percepts

Learning Element – Make the performance element select better actions such that the utility function is optimized

Critic – Provides feedback on the actions taken

Problem Generator – Make the Performance Element select sub-optimal actions such that you would learn from unseen actions

Role of Learning

Agents that improve their performance by learning from their own experiences

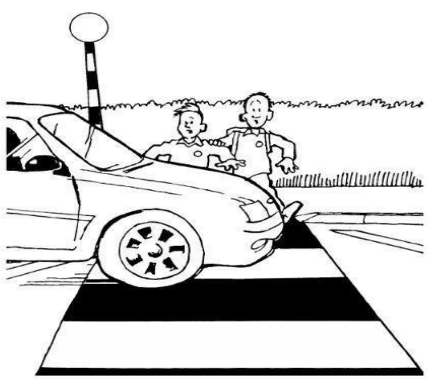
Input Percept

Performance Element

Output Action

APPLY BRAKE

Resulting State



Critic

Feedback

-2

Role of Learning

Input Percept

Possible Actions

Brake
Change Gear to Lower
Change Gear to Higher
Accelerate
Steer left
Steer right

Random

Selected Action

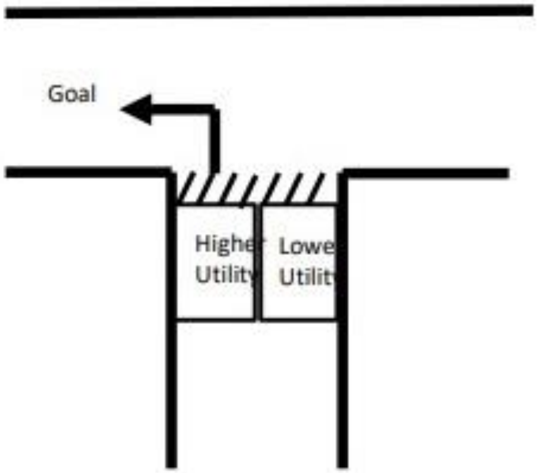
Change Gear to Lower

Role of Learning

Performance Element – Takes decision on action based on percept

$$f(red\ signal, \quad distance) = 15k\ N\ brake$$
$$distance = f'(percept\ sequence)$$
$$f(percepts, distance, raining)$$

- $f(state_0, actionA) = 0.83,$
- $f(state_0, actionB) = 0.45$



Role of Learning

Learning : Supervised Vs Unsupervised Vs Reinforcement

Input Percept

at 50 mts away

Performance Element*

Output Action

APPLY BRAKE

Force of **17k** N

Input Percept

at 50 mts away

Performance Element

Output Action

APPLY BRAKE

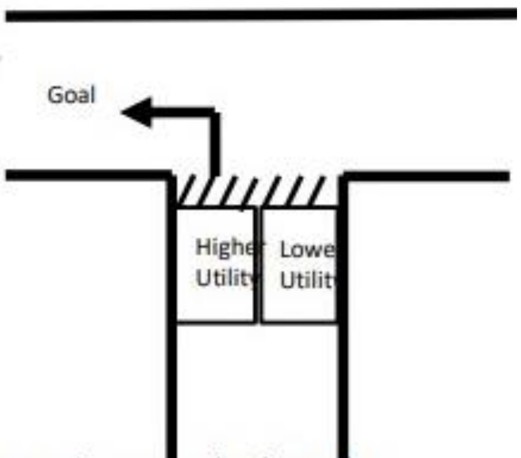
Force of 15k N

+ Critic Feedback -2

Role of Learning

Performance Element – Takes decision on action based on percept

$$f(red\ signal, \quad distance) = 15k\ N\ brake$$
$$distance = f'(percept\ sequence)$$
$$f(percepts, distance, raining)$$



- $f(state_0, actionA) = 0.83,$
- $f(state_0, actionB) = 0.45$

Learning Element – Make the performance element select better actions such that the utility function is optimized

Critic – Provides feedback on the actions taken

Problem Generator – Make the Performance Element select sub-optimal actions such that you would learn from unseen actions

Problem Formulation

Problem Solving Agents

Goal based decision making agents finds sequence of actions that leads to the desirable state.

Phases of Solution Search by PSA

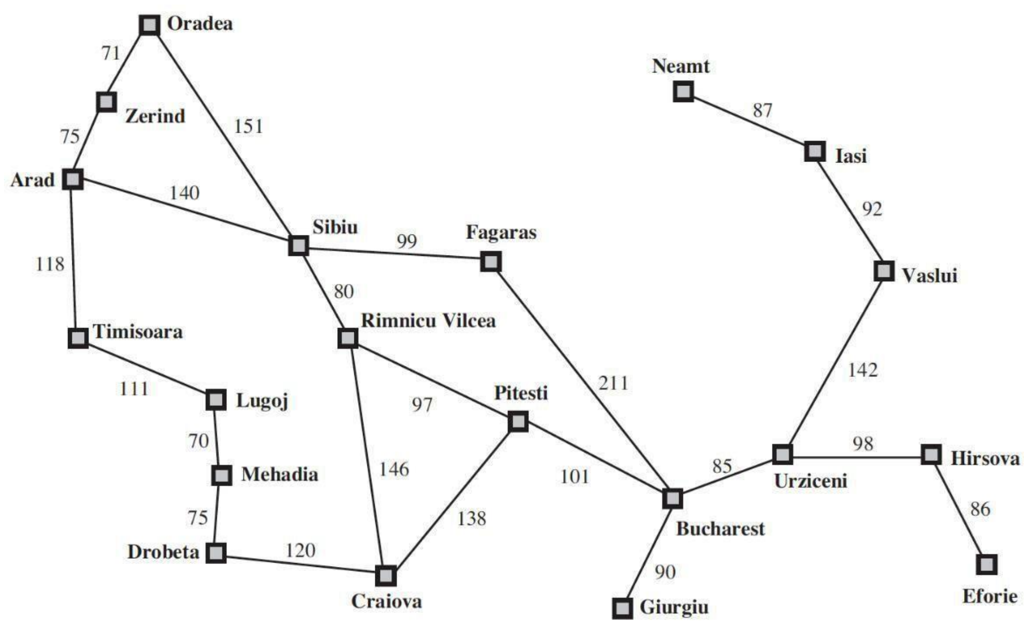
Goal Formulation

Problem Formulation

Search Phase

Execution Phase

Optimizes the Objective (Local | Global) Limits the Actions



Problem Solving Agents

Goal Formulation

↓

Problem Formulation

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Search Phase

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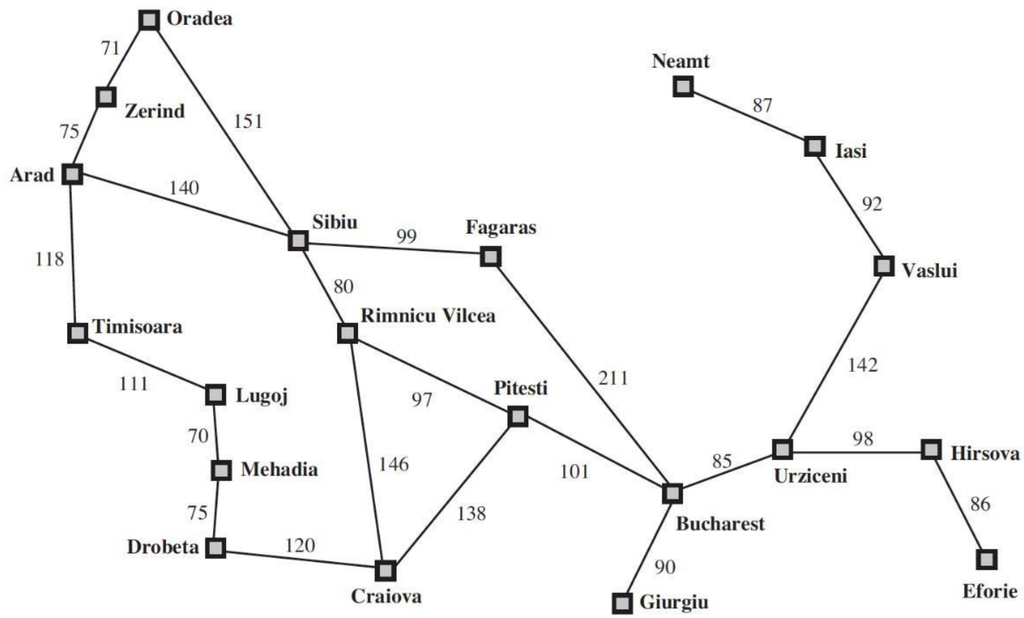
Execution Phase

Phases of Solution Search by PSA

State Space Creations [in the path of Goal]
Lists the Actions



Problem Solving Agents

Goal Formulation

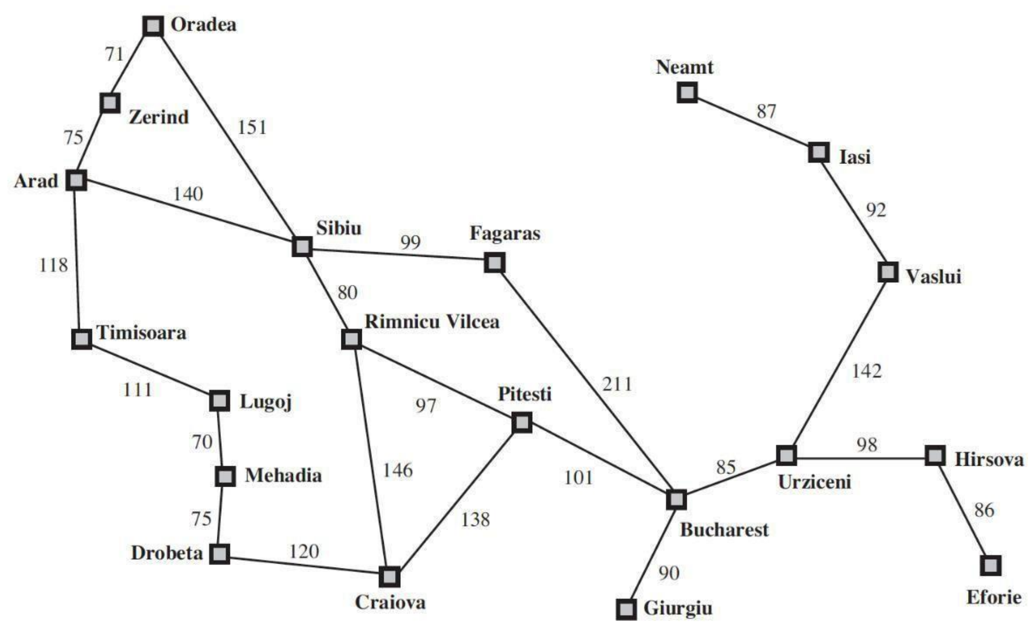
Problem Formulation

Search Phase

Execution Phase

Phases of Solution Search by PSA

Assumptions – Environment :
Static
Observable Discrete
Deterministic



Problem Solving Agents

Phases of Solution Search

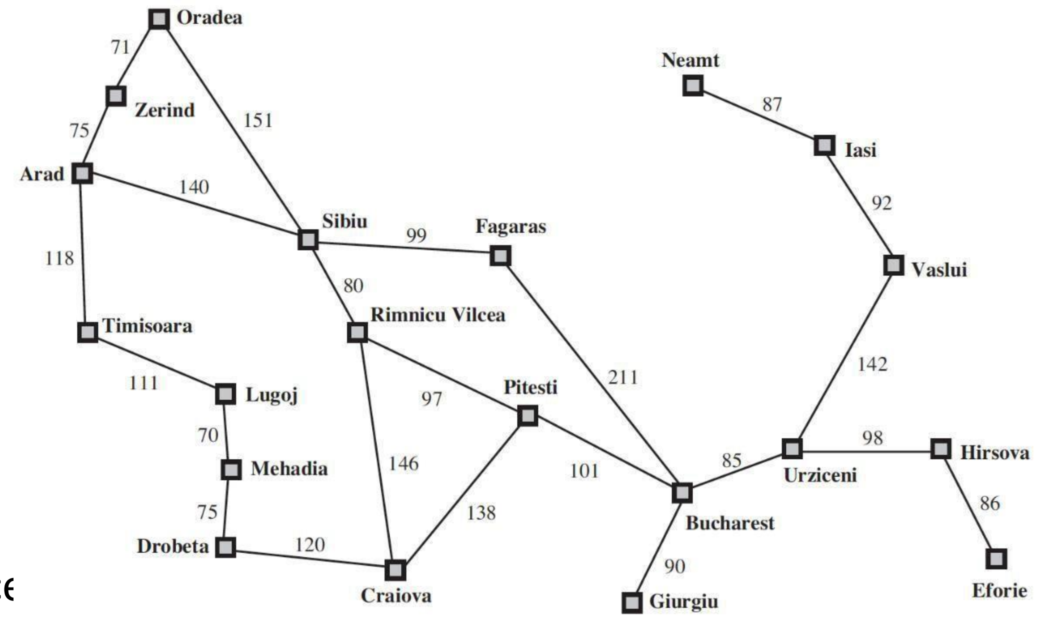
Goal Formulation

Problem Formulation

Search Phase

Execution Phase

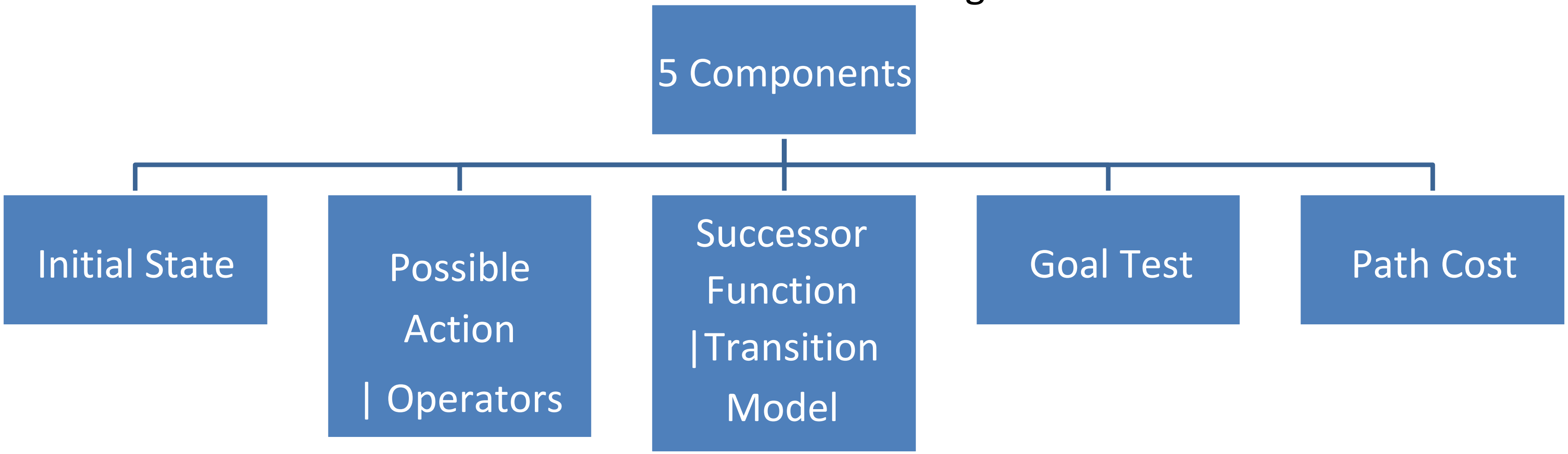
Examine all sequence
Choose best | Optimal



Problem Solving Agents – Problem Formulation

Abstraction Representation

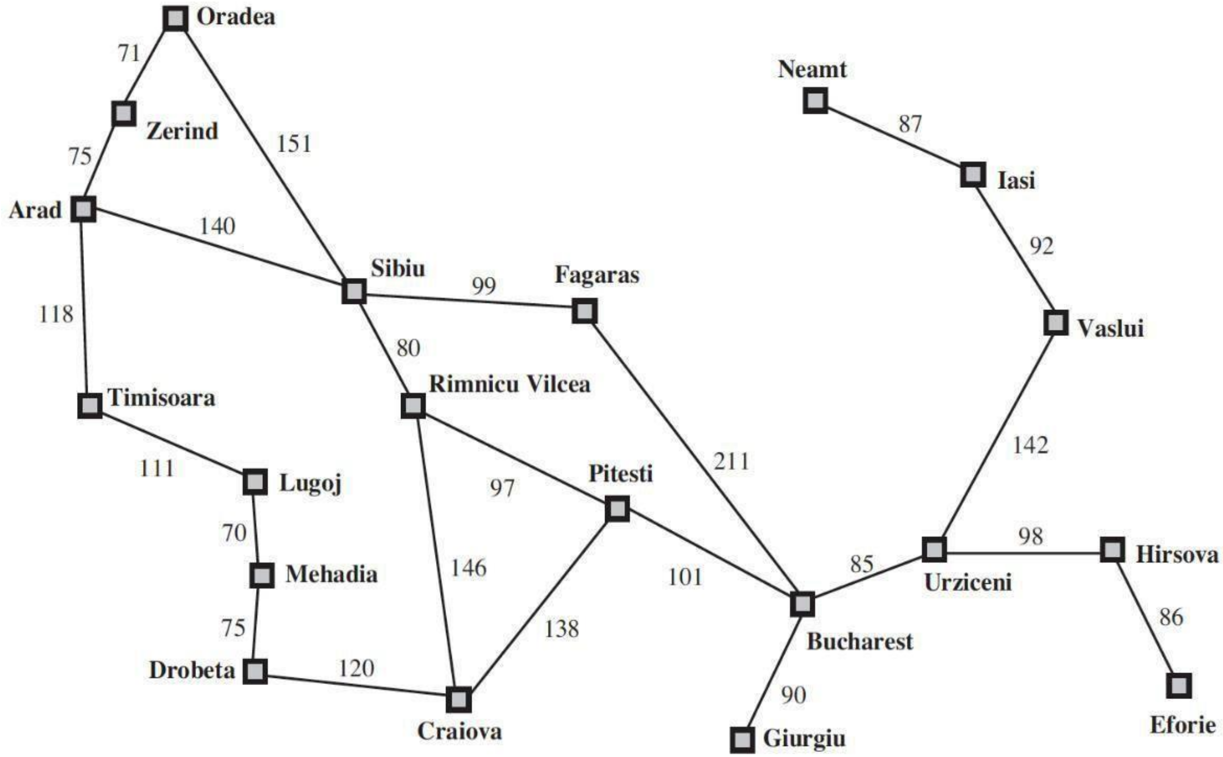
Decide what actions under states to take to achieve a goal



A function that assigns a numeric cost to each path. A path is a series of actions. Each action is given a cost depending on the problem.

Solution = Path Cost Function + Optimal Solution

Problem Solving Agents – Problem Formulation: Book Example



Initial State –E.g., *In(Arad)*

Possible Actions – *ACTIONS(s)* → *{Go(Sibiu), Go(Timisoara), Go(Zerind)}*

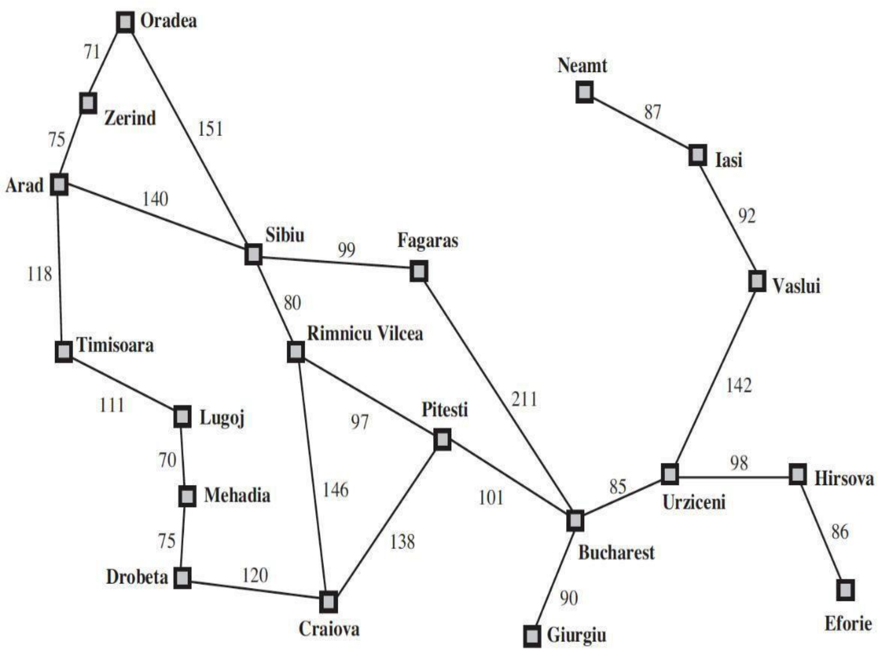
Transition Model – *RESULT(In(Arad), Go(Sibiu)) = In(Sibiu)*

Goal Test – *IsGoal(In(Bucharest)) = Yes*

Path Cost – *cost(In(Arad), go(Sibiu)) = 140 kms*

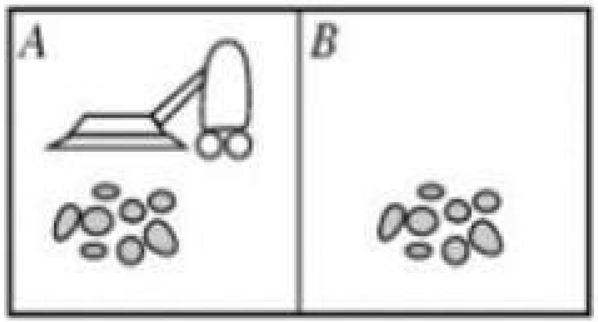
Example Problem Formulation

	Travelling Problem
Initial State	Based on the problem
Possible Actions	Take a flight | Train | Shop
Transition Model/ Successor Function	[A, Go(A->S)] = [S]
Goal Test	Is current = B (destination)
Path Cost	Cost + Time + Quality



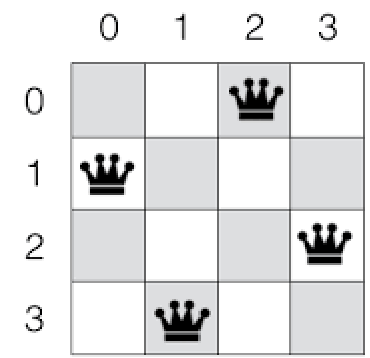
Example Problem Formulation

	Vacuum World
Initial State	Any
Possible Actions	[Move Left, Move Right, Suck, NoOps]
Transition Model/ Successor Function	[A, ML] = [B , Dirty] [A, ML] = [B, Clean]
Goal Test	Is all room clean? [A, Clean] [B, Clean]
Path Cost	No of steps in path



Example Problem Formulation

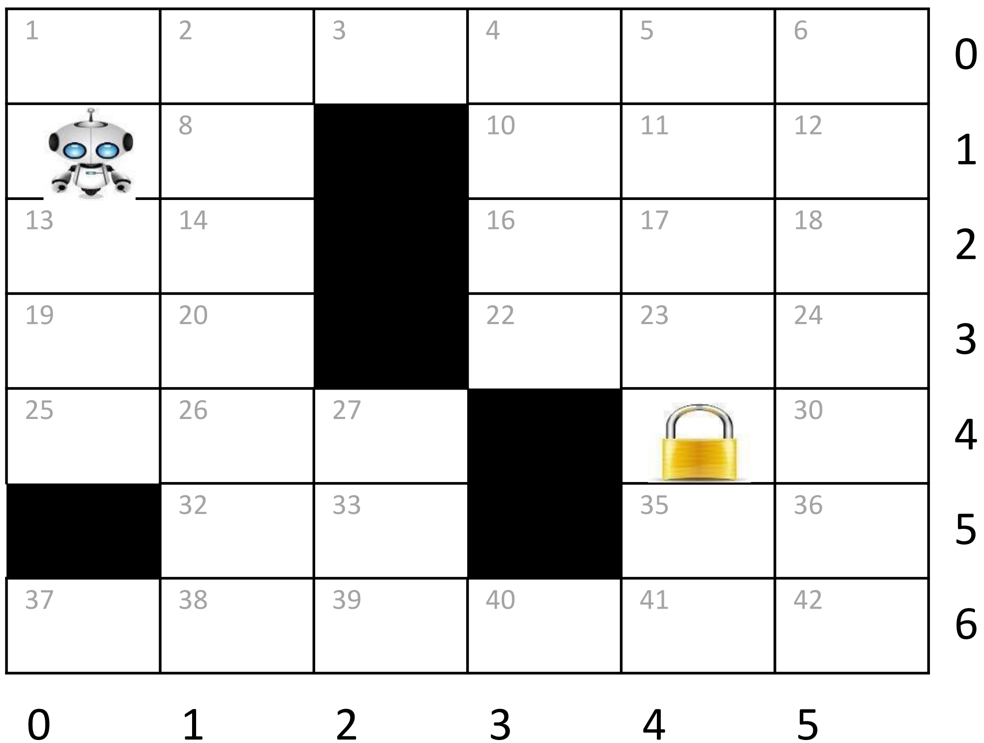
	N-Queen
Initial State	Empty | Partial | Full
Possible Actions	
Transition Model/ Successor Function	
Goal Test	
Path Cost	



board[r][c]

Path finding Robot

Successor Function Design



N-W-E-S

Graph Searching

- Graph as state space (node = state, edge = action)
- For example, game trees, mazes, ...

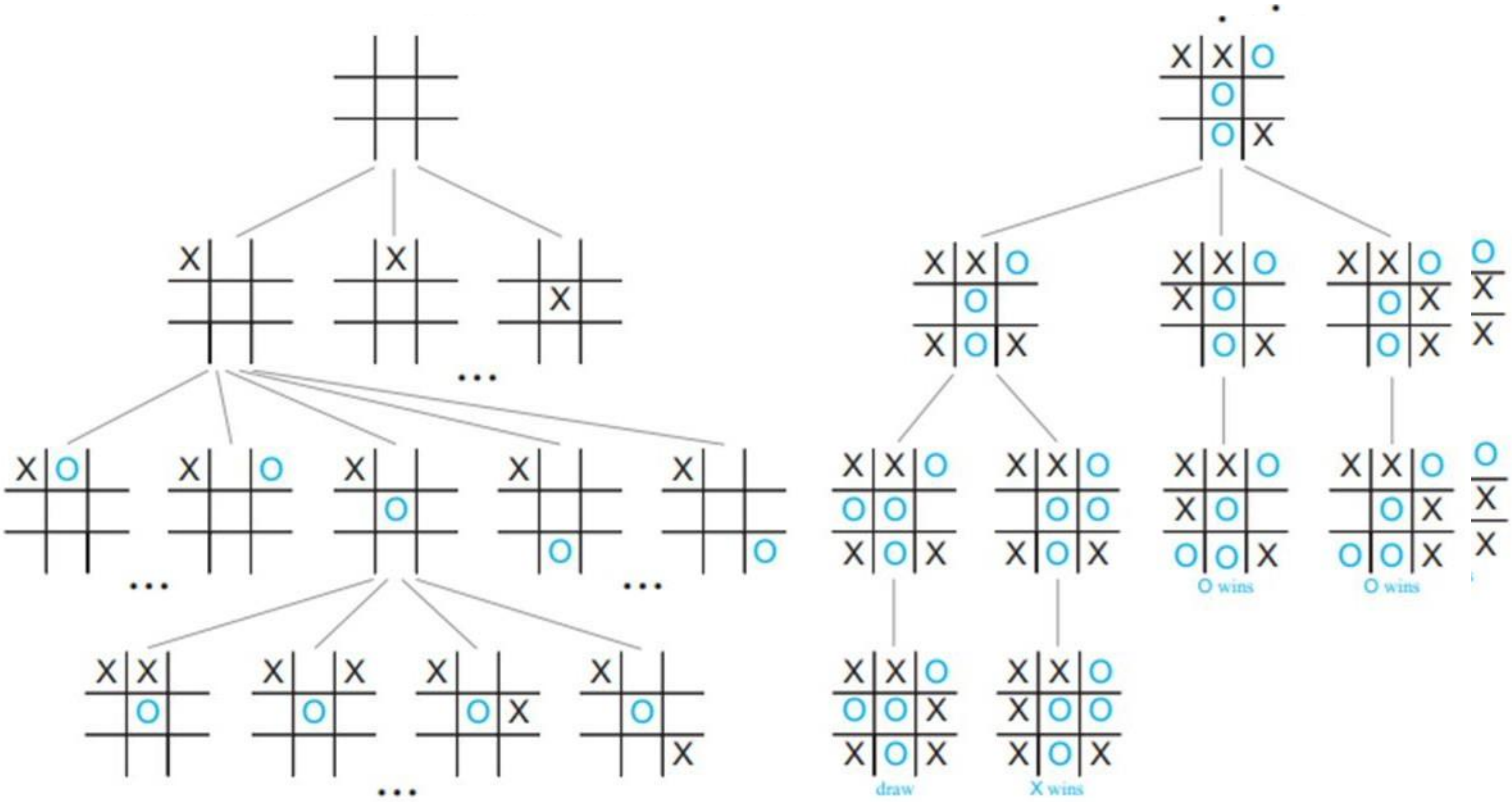
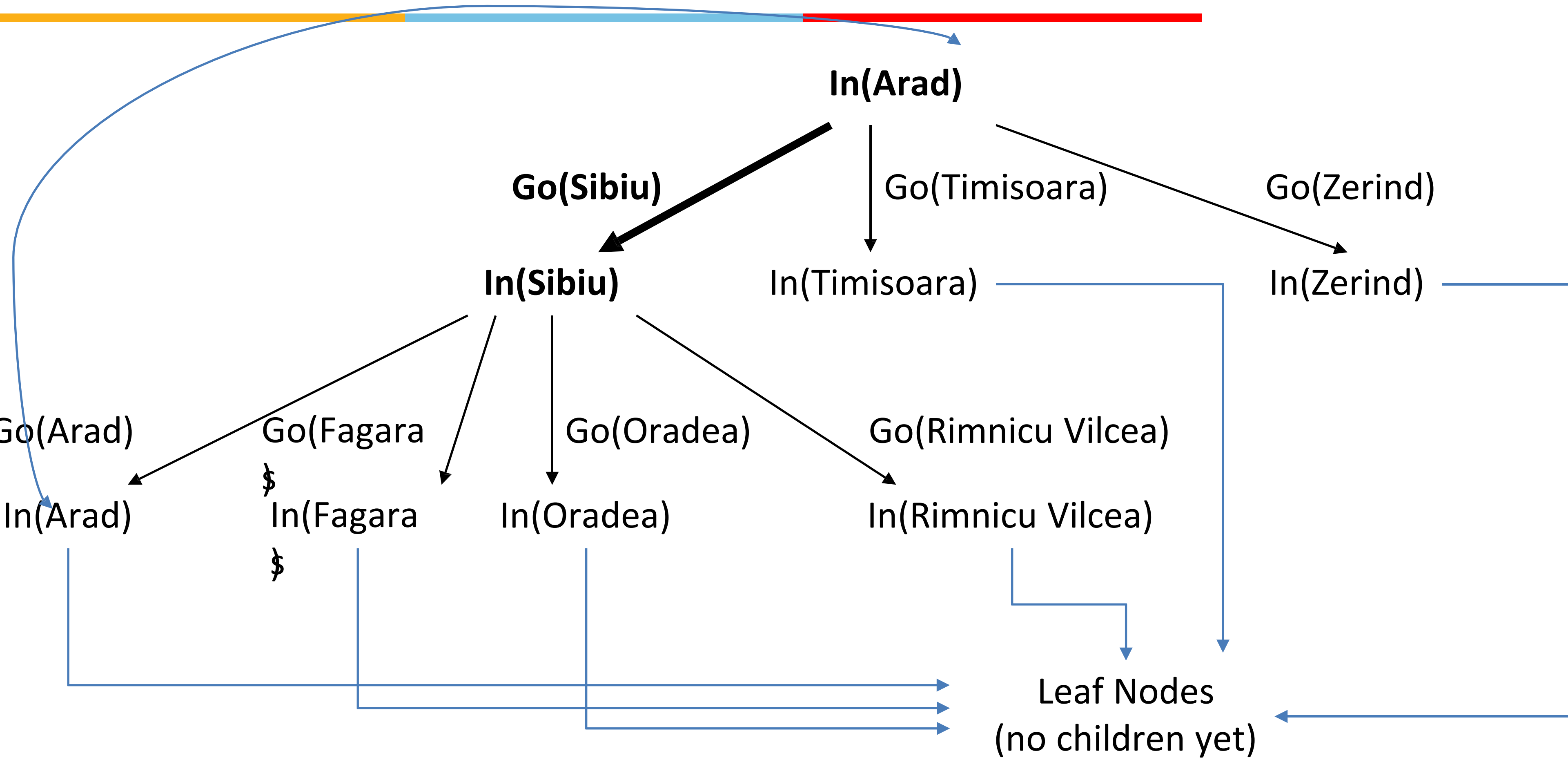


FIGURE 8 Some of the Game Tree for Tic-Tac-Toe.

Searching for Solutions

Choosing the current state, testing possible successor function, expanding current state to generate new state is called Traversal. Choice of which state to expand – Search Strategy

- Search Strategy (under certainty)
  - **Uninformed (will be discussed in next class)**
    - BFS, DFS, UCS
    - IDS, DLS
    - Bi-Directional
  - **Informed (will be discussed in next class)**
    - Best First
    - Search A*


In(Arad)
Go(Sibiu)
Go(Timisoara)
Go(Zerind)
In(Sibiu)
In(Timisoara)
In(Zerind)
Go(Arad)
Go(Fagara
Go(Oradea)
Go(Rimnicu Vilcea)
In(Arad)
In(Fagara
In(Oradea)
In(Rimnicu Vilcea)
Leaf Nodes
(no children yet)

Next Class Plan

- Uninformed Search Algorithms
  - BFS vs DFS – An overview
  - Uniform Cost Search
  - Iterative Depth First Search
- Informed Search Algorithms
  - Greedy Best First search
  - A* Search (Start)

Required Reading: AIMA - Chapter #1, 2, 3.1, 3.2, 3.3

Thank You for all your Attention

Note : Some of the slides are adopted from AIMA TB materials