Mansoura University
Faculty of Computers and Information
Department of Computer Science
First Semester: 2020-2021

[CS324P] Artificial Intelligence - 1 : Solving Problems By Searching

Grade: Third Year (Computer Science)

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Contents

Heuristics

Uninformed vs. Informed

Uninformed

Can only generate successors and distinguish goals from non-goals

Informed

Strategies that know whether one non-goal is more promising than another

Note

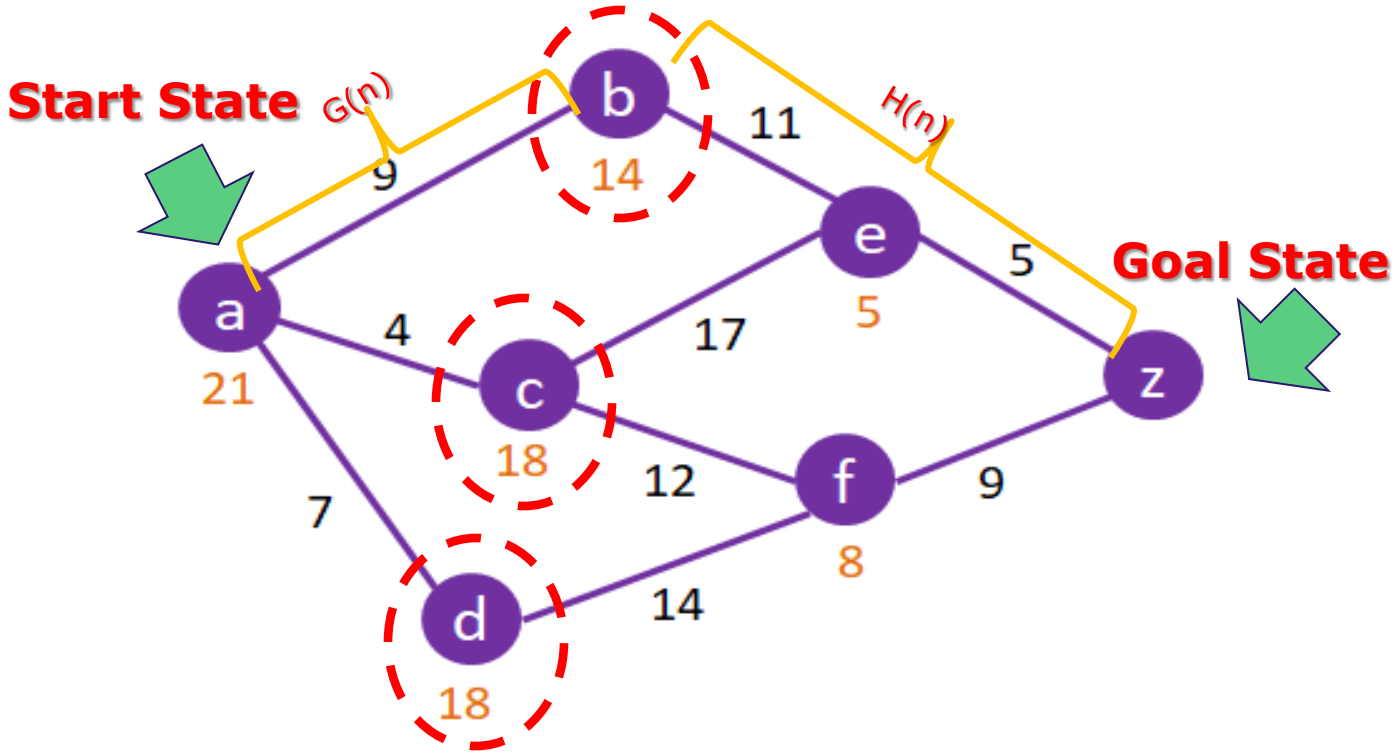


Image credit: https://www.101computing.net/a-star-search-algorithm/

Heuristics

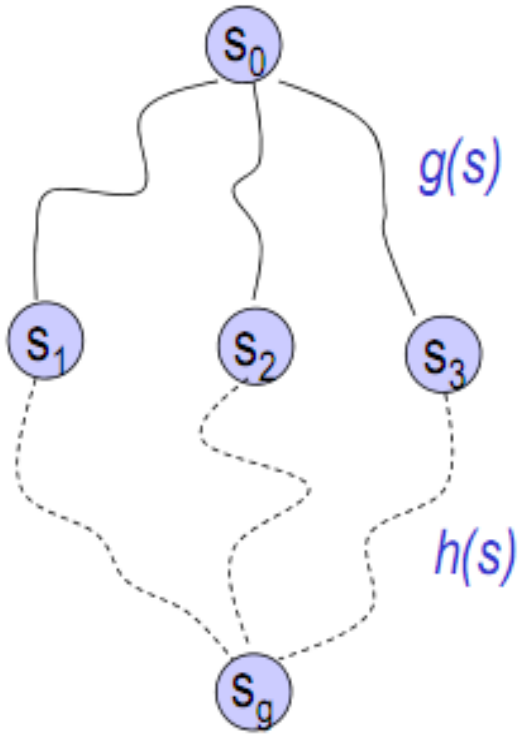
- Extra information used by the searching algorithm beside problem definition
- Heuristic is an estimated cost to goal node
- Recall, heuristic is not actual cost it is just an expectation (**optimistic**)

Heuristics

g(s): this is a function that measures the "cost" it incurred from the initial node s_o to the current node s.

h(s): this is a function (or "budget") that estimates the forth-coming cost from *s* to a goal node s_g.

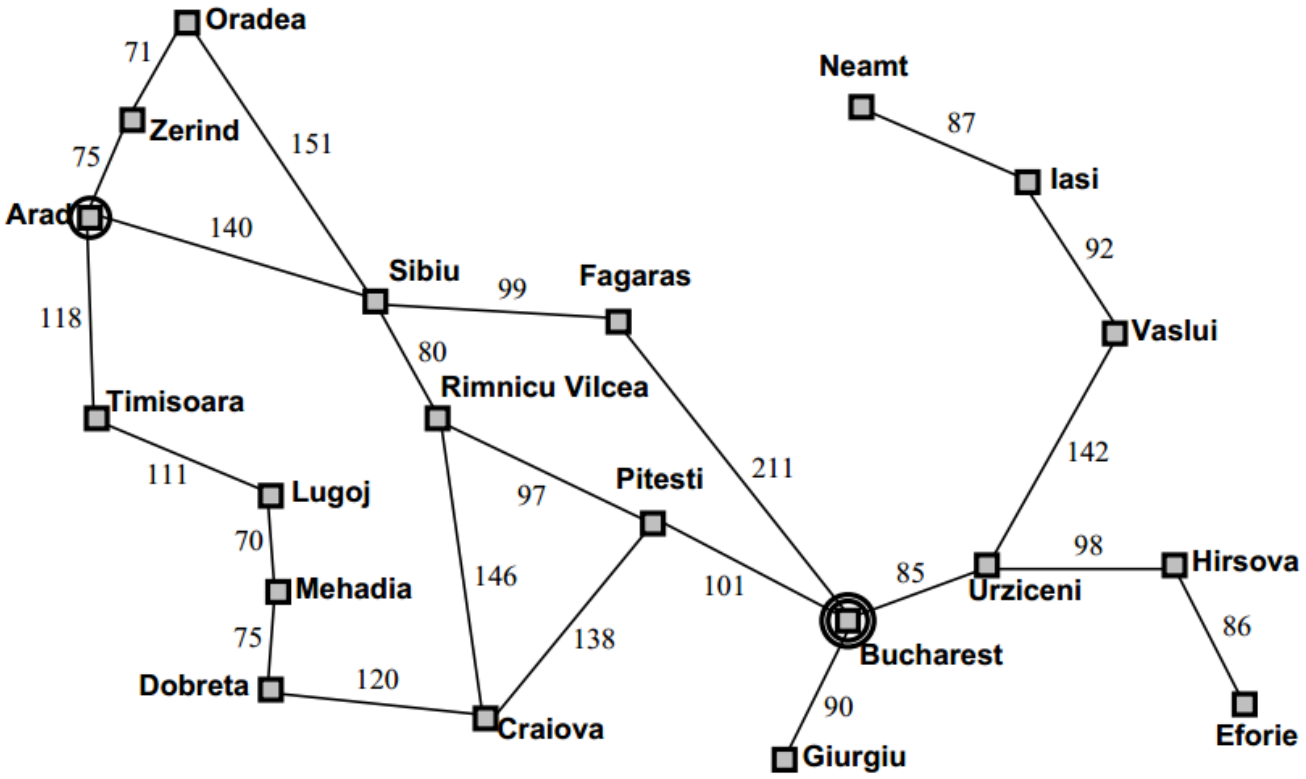
h(s) is called a ***heuristic function****.*



Heuristics, example

Route finding problems:

- h(n) = straight line distance (SLD) from node to goal



Straight-line distance to Bucharest	
Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	178
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
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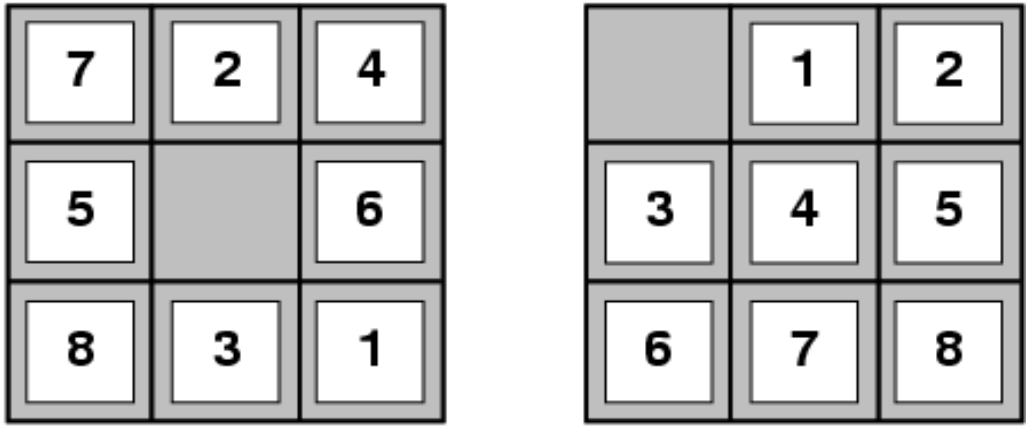
Heuristics, example

The 8-puzzle:

h(n) = number of misplaced tiles

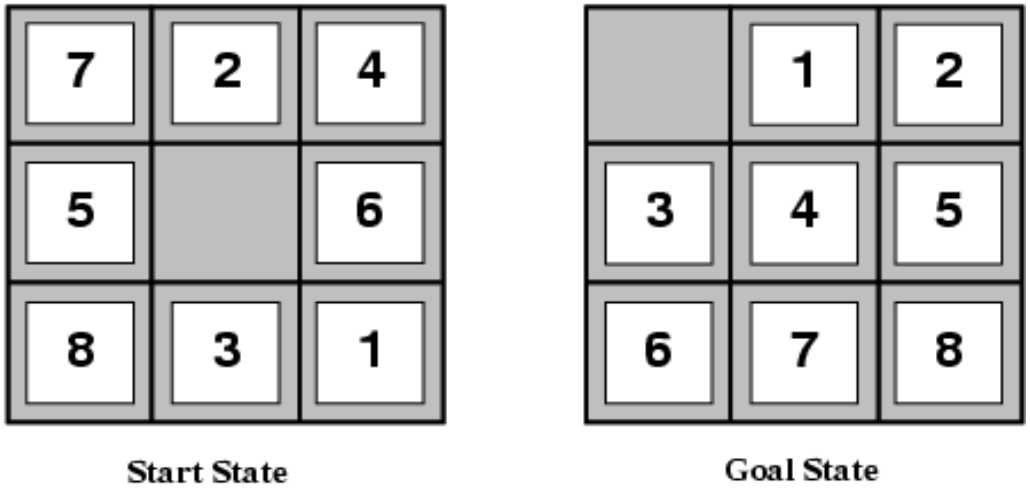


h(node) = 8

Heuristics, example

The 8-puzzle:

h(n) = total Manhattan distance (i.e., no. of squares from desired location of each tile)



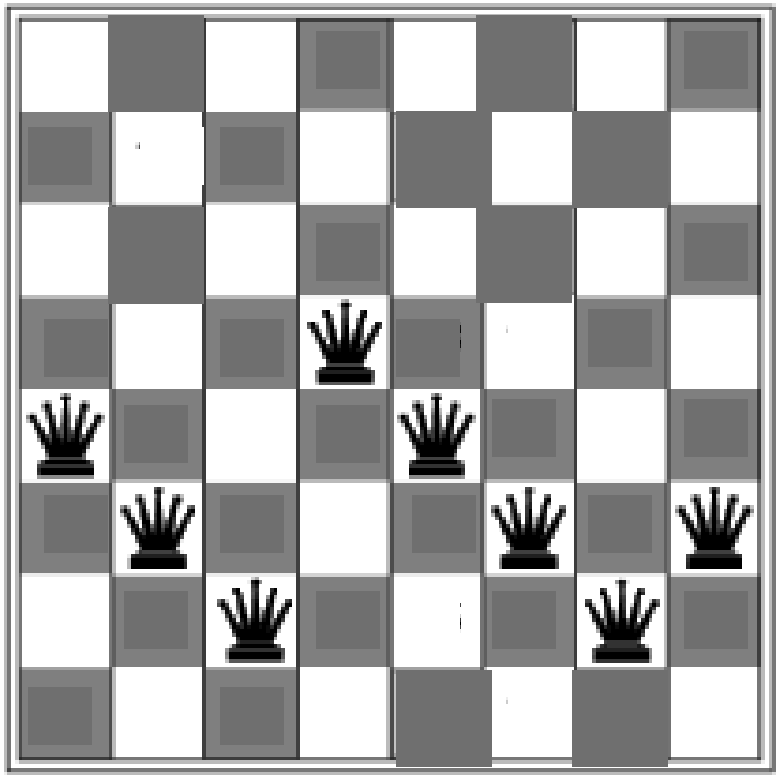
h(node) = 3+1+2+2+2+3+3+2 = 18

Heuristics, example

The 8-queens:

h(n) = number of pairs of queens that are attacking each other, either directly or indirectly

h(node) = 17



Informed search algorithms

- Use the heuristic function in order to optimize the search

- Informed search algorithms:
  1. Best-first search
     - 1.1 Greedy search
     - 1.2 A* search
  2. Local search
     - 2.1 Hill climbing algorithm
     - 2.2 Genetic algorithm

Best first search

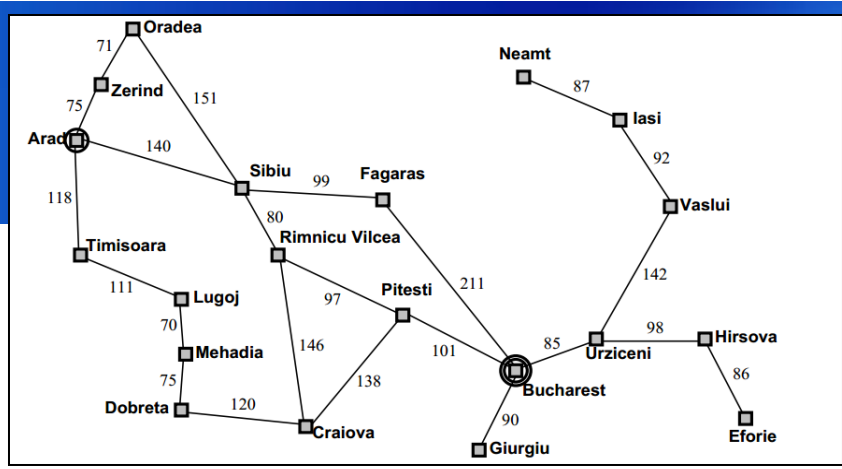
1. Greedy search

- Evaluation function f(n) = h(n)
- h(n) is the heuristic function
- Greedy best-first search expands the node that appears to be closest to goal

choose node with minimum f(n)

Best first search

1. Greedy search, example



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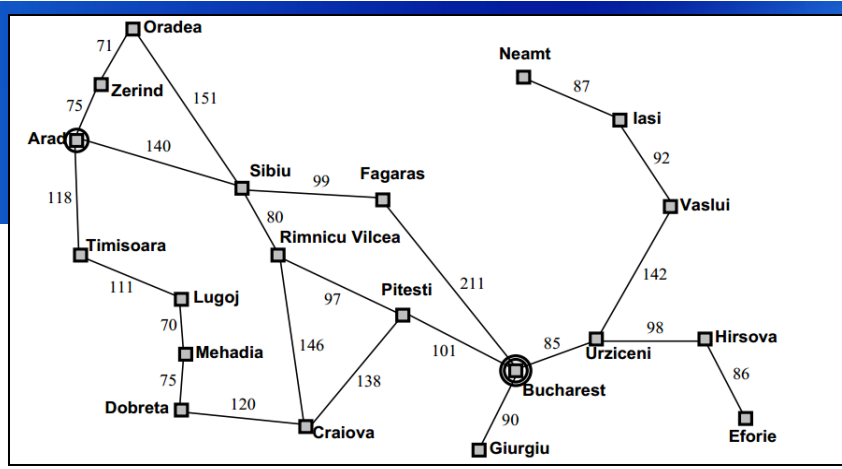
Best first search



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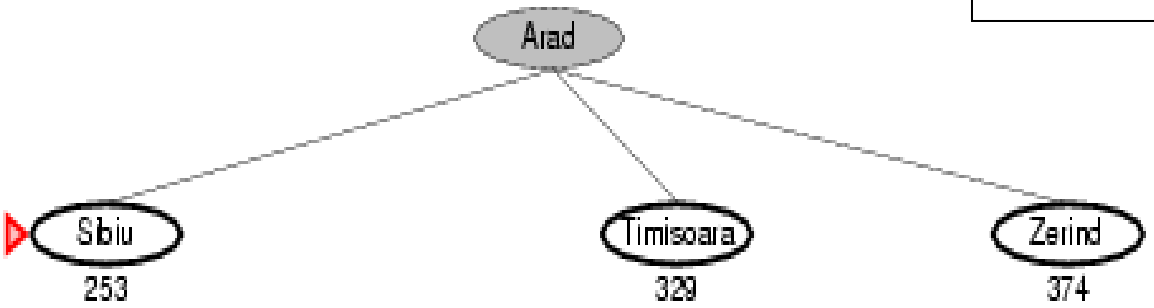

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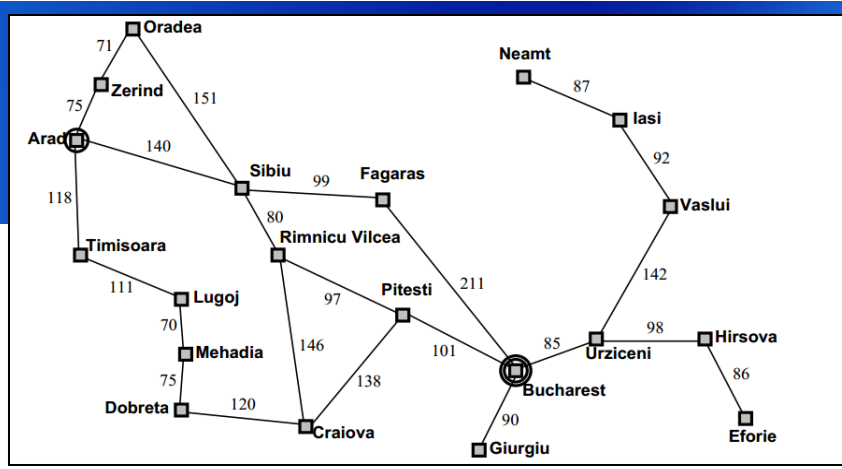
Best first search



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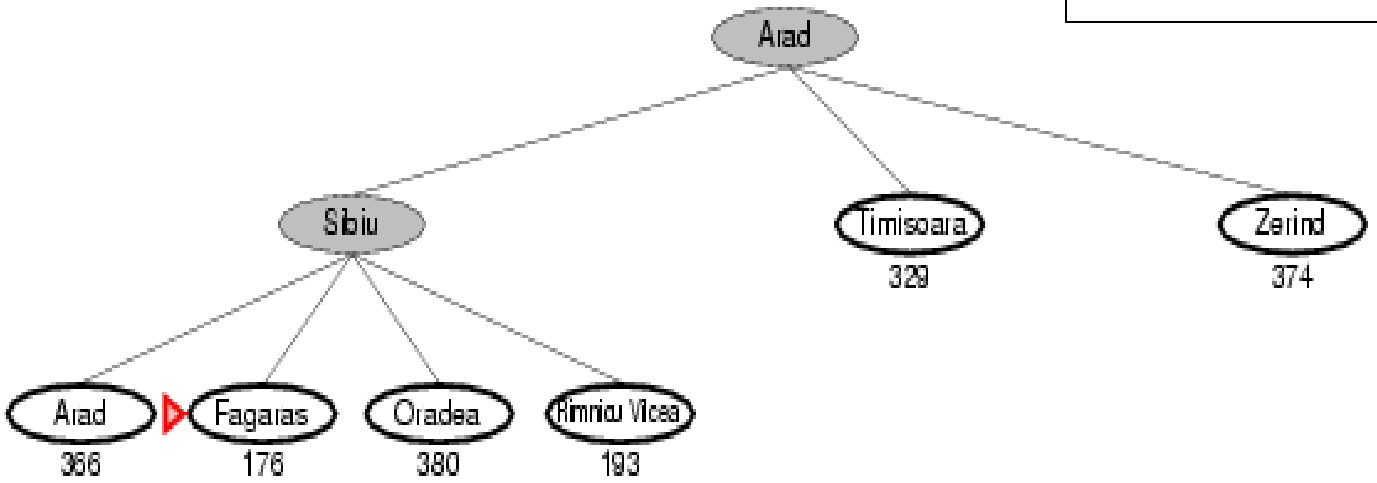

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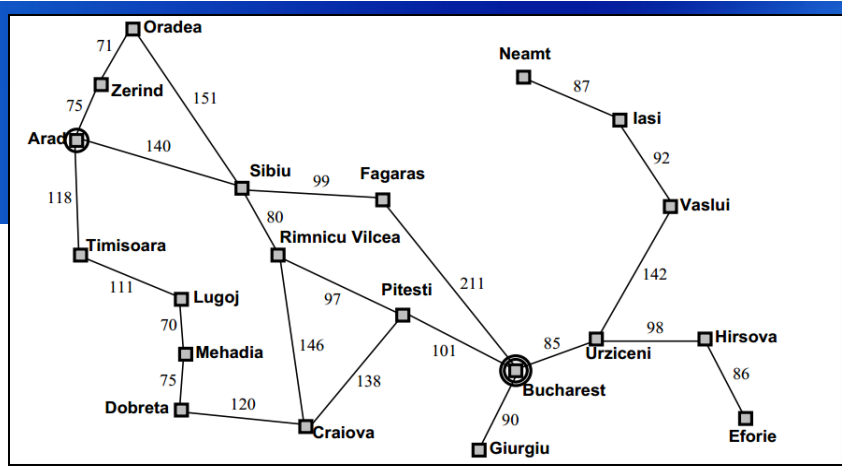
Best first search



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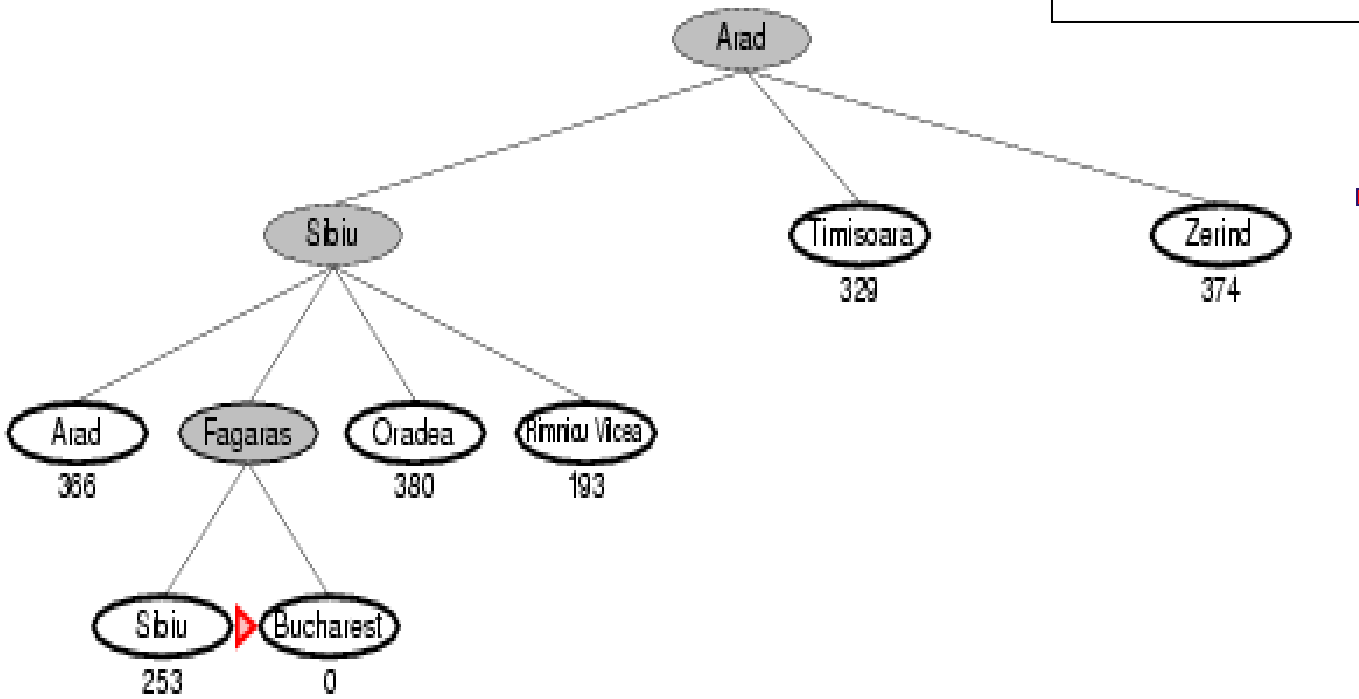

Goal is found!

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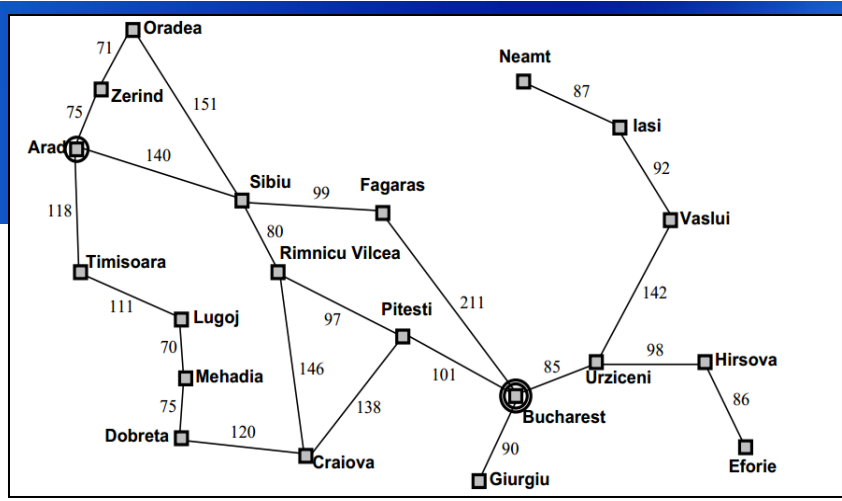
Best first search



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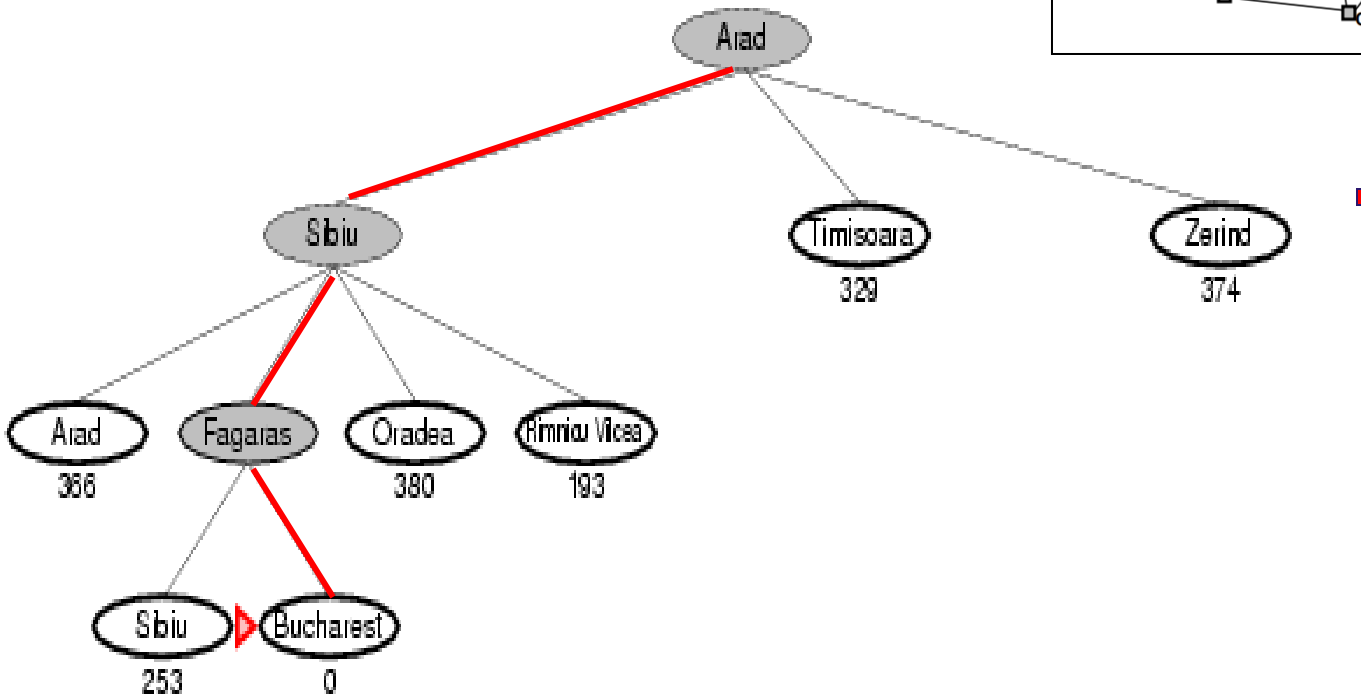

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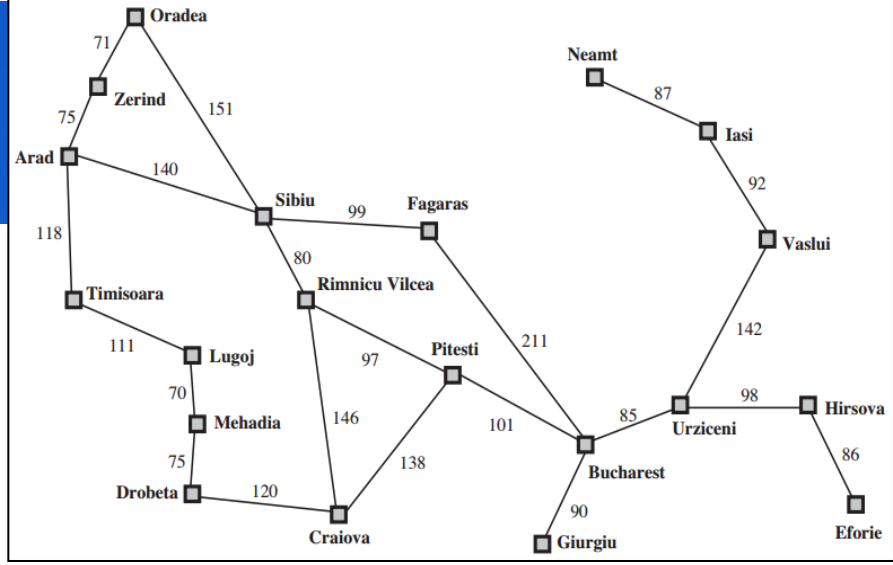
Total coast=140+99+211= 450

Is this the optimum solution ?

Evaluation



1. Greedy search

❖ Complete?

- Suppose we start in Iasi and the goal is Fagaras
- Greedy select Neamt for expand because it is closest to Fagaras
- But it is dead end, it only generate Iasi again
- It will stuck in the loop: Iasi → Neamt → Iasi → Neamt,……

Evaluation

1. Greedy search

- Complete? No (can stuck on loops)
- Time? Exponential (good heuristic can give dramatic improvement)
- Space? keeps all nodes in memory **(look at this)**
- Optimal? No

Best first search

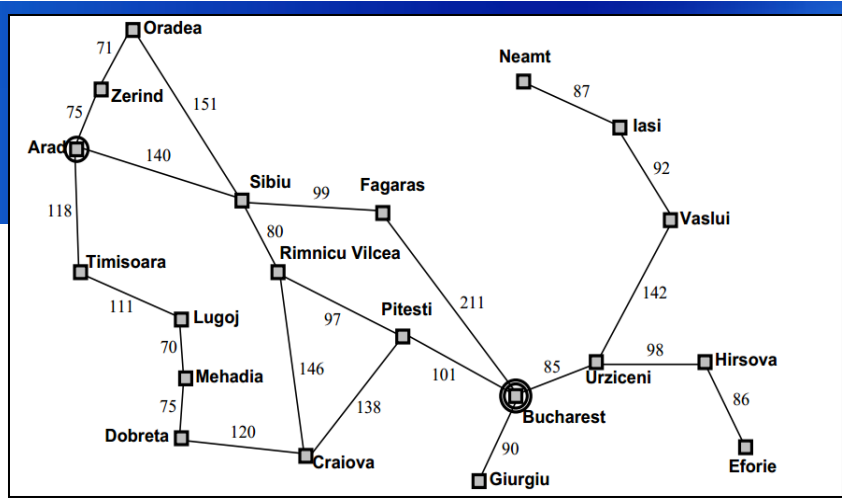
2. A* search

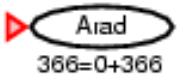
- Avoid expanding paths that are already expensive
- Evaluation function f(n) = g(n)+h(n)

  - g(n) = cost so far to reach n (actual)
  - h(n) = expected cost from n to goal (estimated)

Best first search

2. A*search, example





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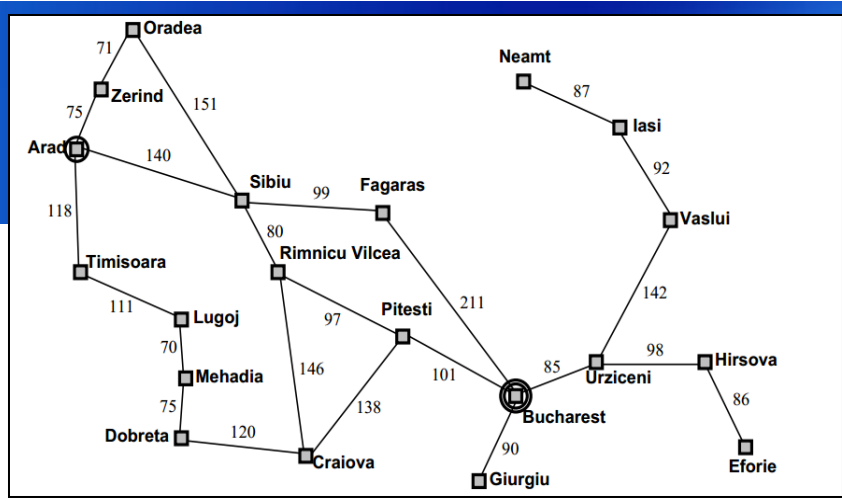
Best first search

2. A*search, example



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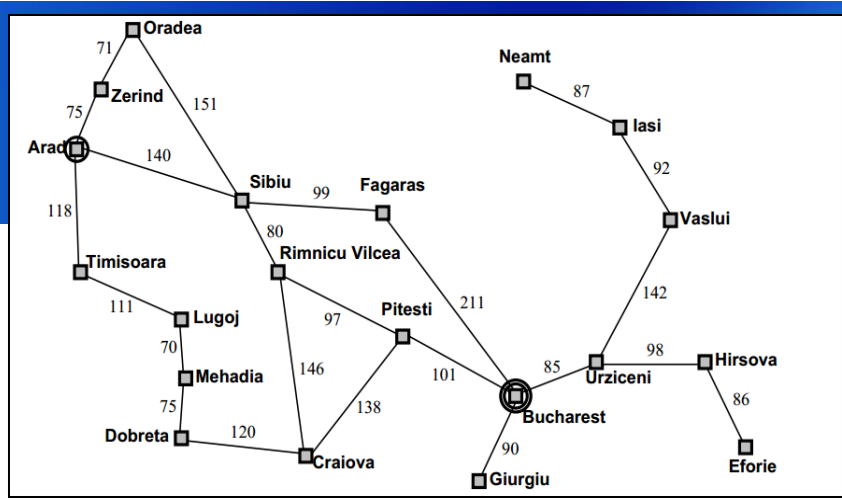
Best first search



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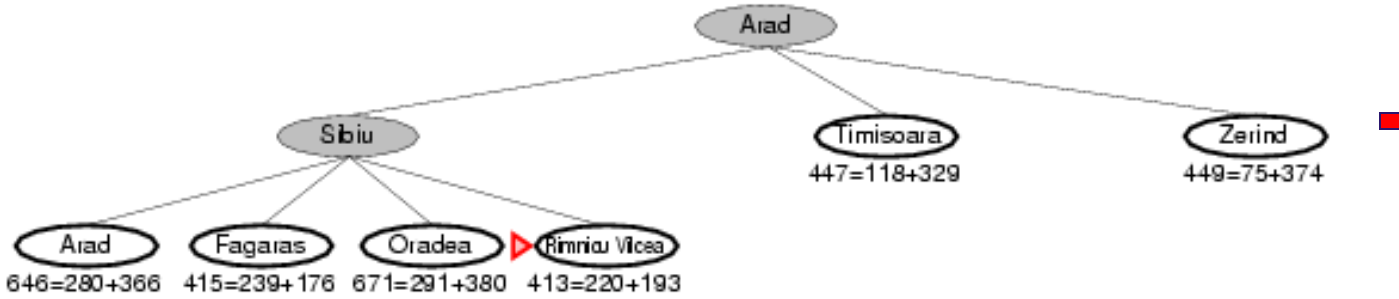

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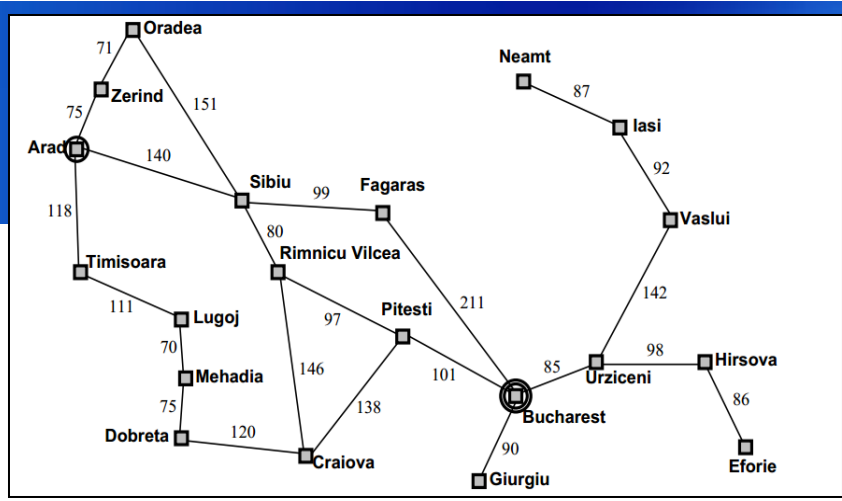

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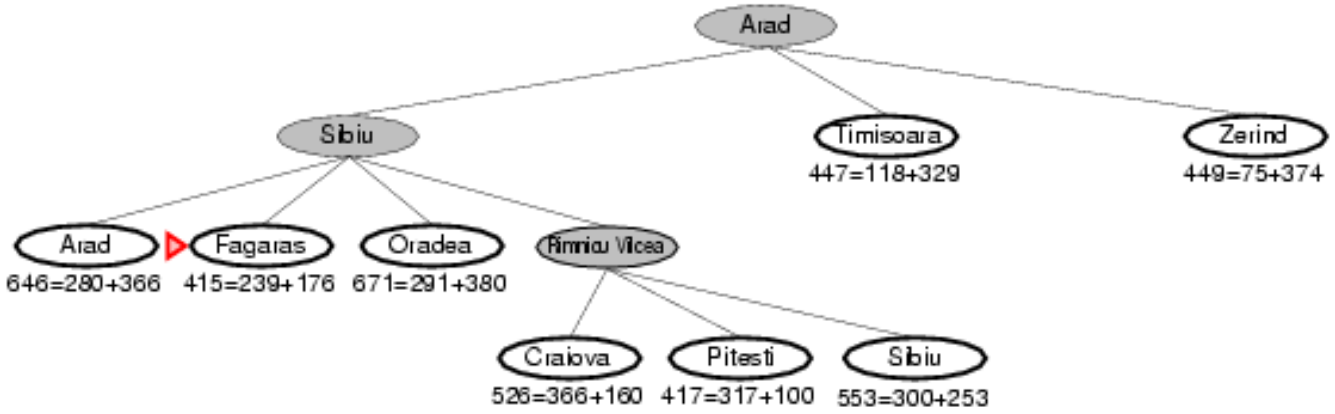

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Best first search

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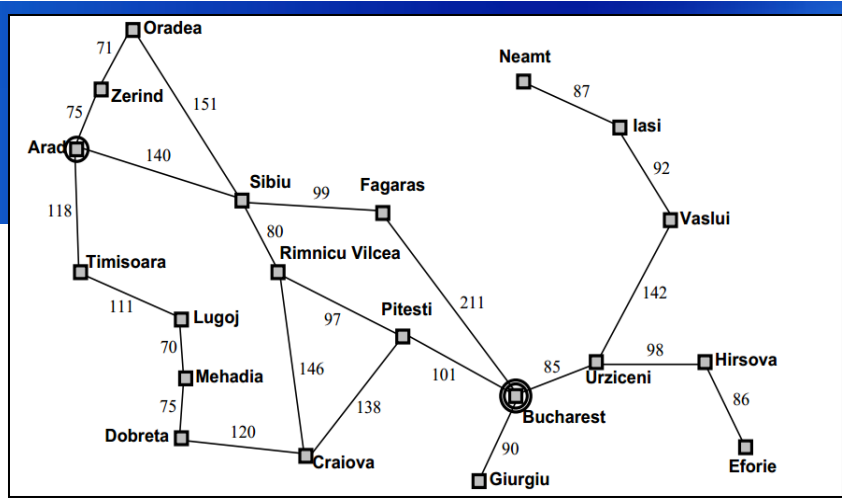

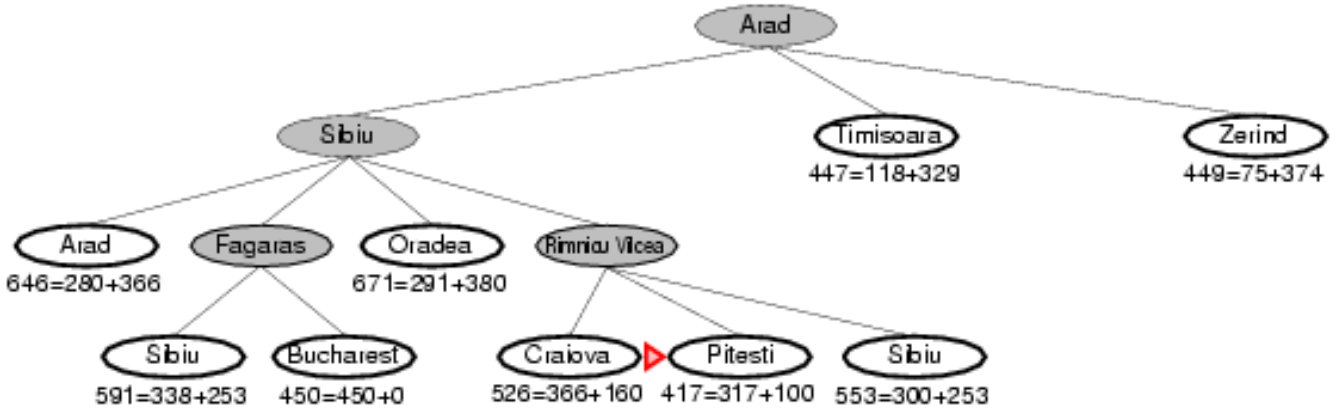

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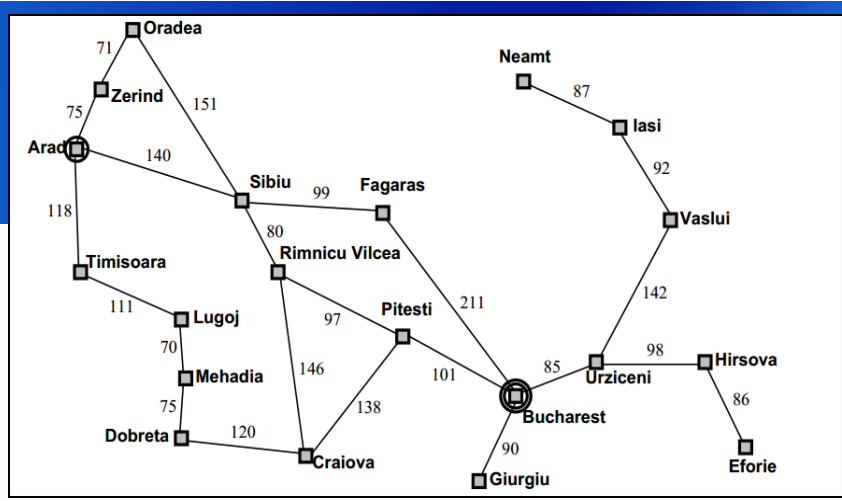

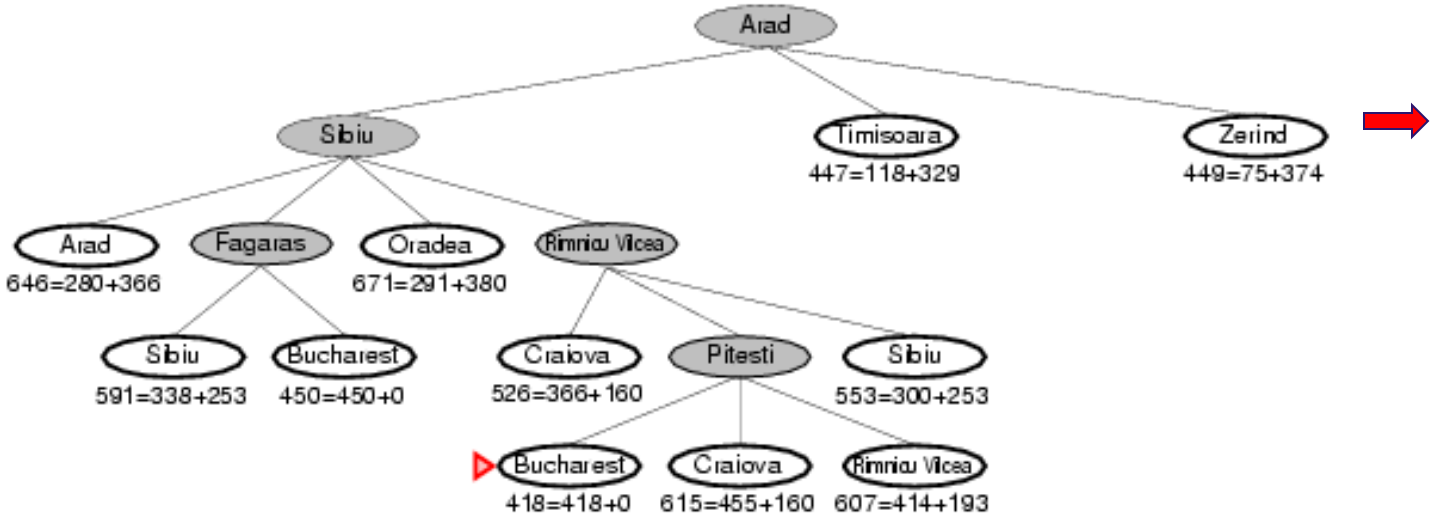

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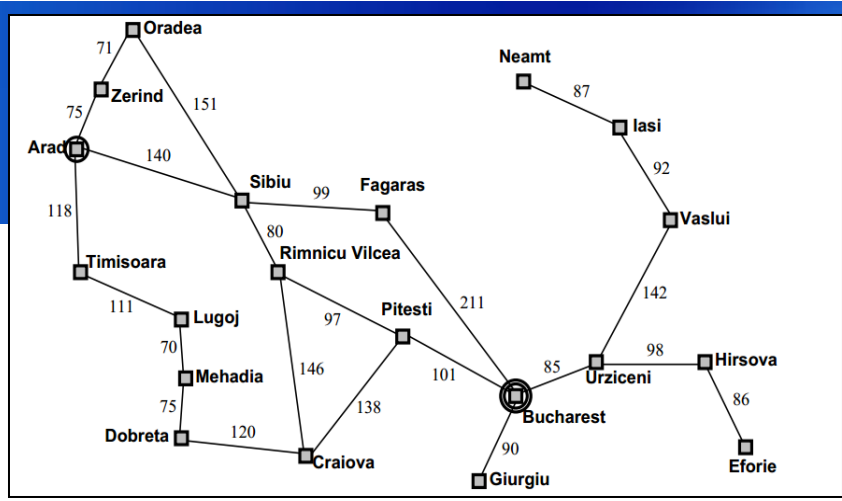
Goal is found!

Best first search



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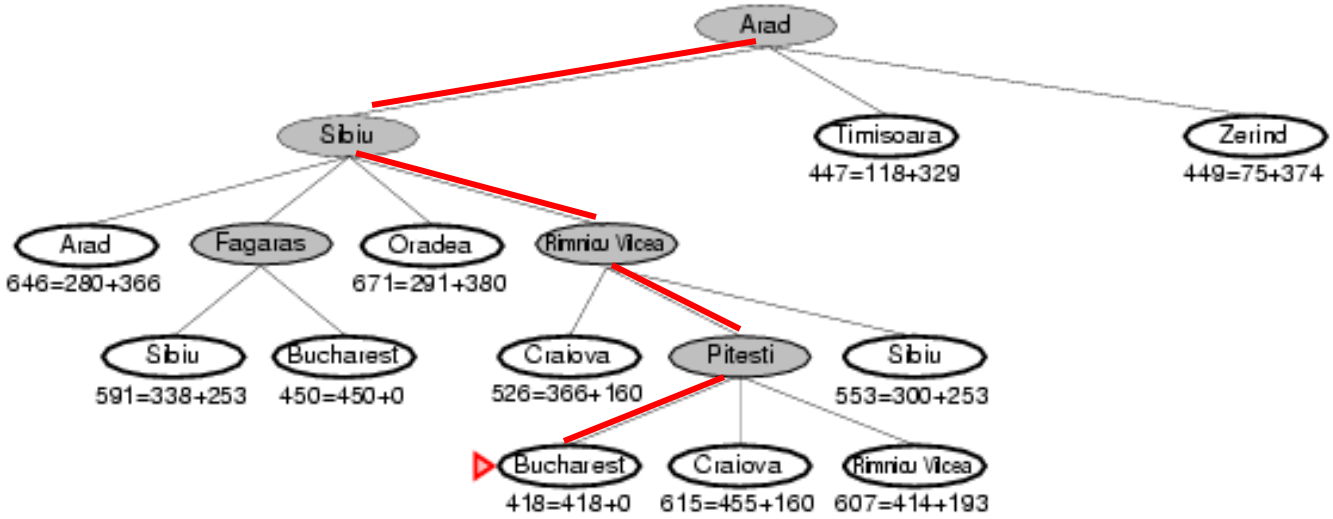

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Total coast =418

Is this the optimum solution ? yes

Evaluation

2. A* search

- Complete? yes
- Time? Exponential
- Space? keeps all nodes in memory (look at this)
- Optimal? yes

Evaluation

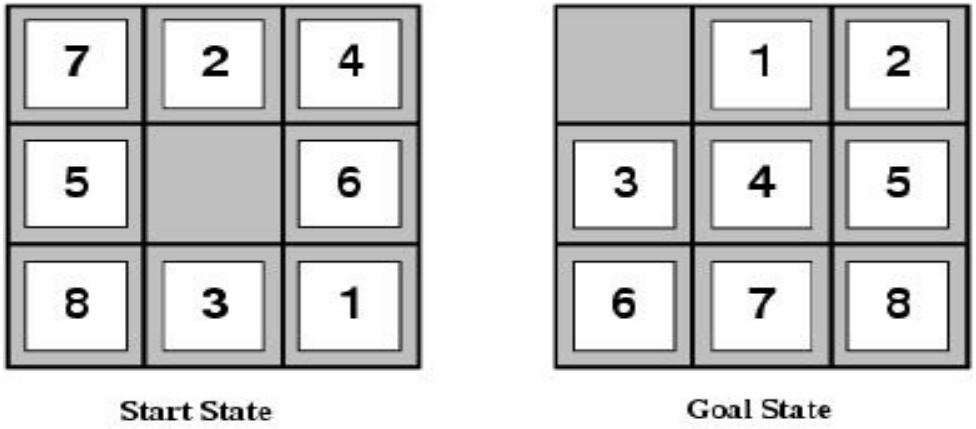
- Heuristic function should be admissible in order to find optimum solutions

- A heuristic h(n) is admissible if for every node n, **h(n) ≤ h*(n)** ,where h*(n) is the true (actual) cost to reach the goal state from n

- An admissible heuristic **never overestimates** the cost to reach the goal, i.e., it is optimistic

Evaluation

Dominance



- **h1** = the number of misplaced tiles **=8**
- **h2** = manhattan distance**= 18**

iff **h2(n) >= h1(n)** for all n **(both admissible)**
then h2 dominates h1,

- **h2 is better for search than h1**

Evaluation

Dominance

The following table gives the search cost of A* with the two heuristics, averaged over random 8-puzzles, for various solution lengths

Length	$A^*(h_1)$	$A^*(h_2)$
16	1301	211
18	3056	363
20	7276	676
22	18094	1219
24	39135	1641


Thank You !