Artificial Intelligence

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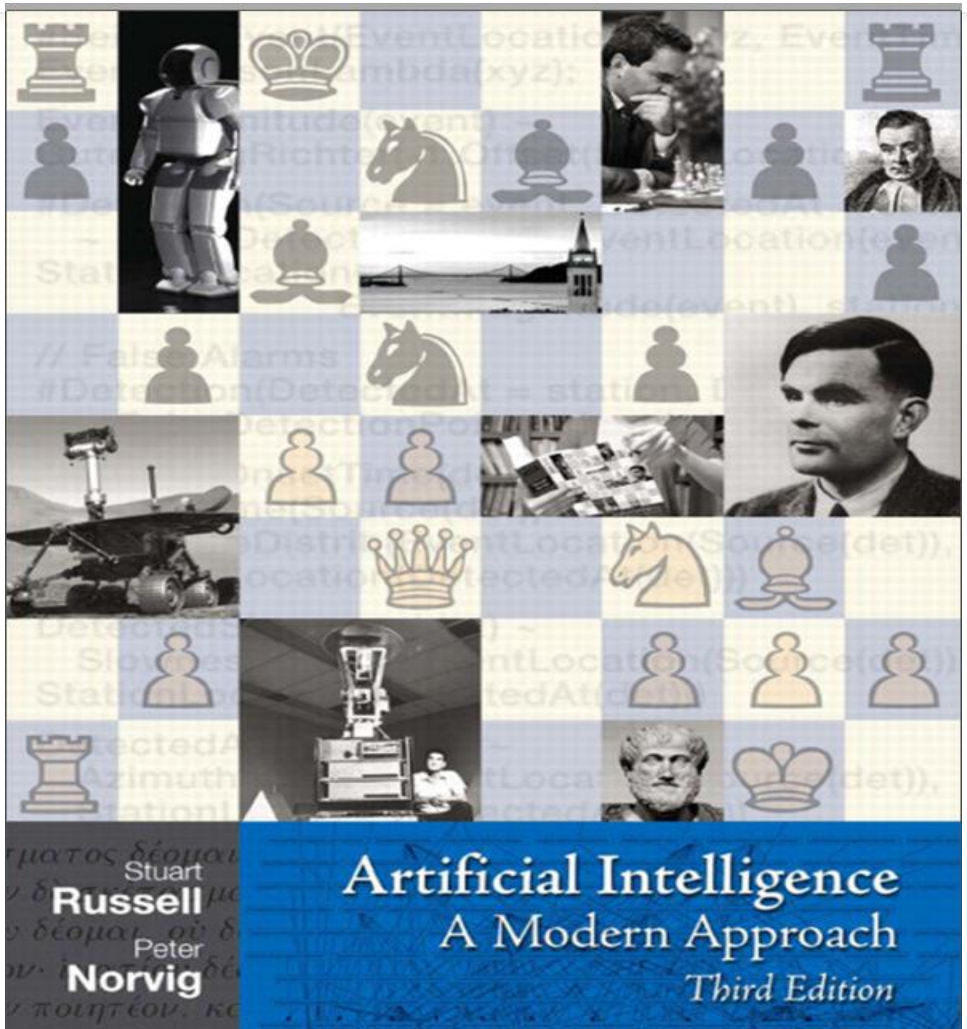
Lecture 5
Informed search algorithms

Lectures References

Artificial Intelligence
A Modern Approach

Third Edition

Stuart J. Russell and Peter Norvig



Agenda

- Best-first search
- Greedy best-first search
- A^* search

Informed search algorithms

- An informed search strategy—one that uses problem-specific knowledge beyond the definition of the problem itself—can find solutions more efficiently than an uninformed strategy.
- **Informed search algorithm** is also called **heuristic** search or directed search.
- In contrast to uninformed search algorithms, informed search algorithms require details such as
  - distance to reach the goal,
  - steps to reach the goal,
  - cost of the paths which makes this algorithm more efficient.
- Here, the goal state can be achieved by using the heuristic function.
-

Heuristic function

- The heuristic function is used to achieve the goal state with the lowest cost possible.
- Heuristic functions are the most common form in which additional knowledge of the problem is imparted to the search algorithm.
- This function estimates how close a state is to the goal.
- h(n) = estimated cost of the cheapest path from the state at node n to a goal state
- Specifically, h(n) = estimated cost (or distance) of minimal cost path from n to a goal state.
- h(n) takes a node as input, but, unlike g(n), it depends only on the state at that node.)
- If n is a goal node, then h(n) = 0.

Best-first search

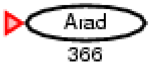
- **Best-first search** is an instance of the general TREE-SEARCH or GRAPH-SEARCH algorithm in which a node is selected for expansion based on an evaluation function, f(n).
- **The evaluation function** is construed as a cost estimate, so the node with the lowest evaluation is expanded first.
- **Implementation:**

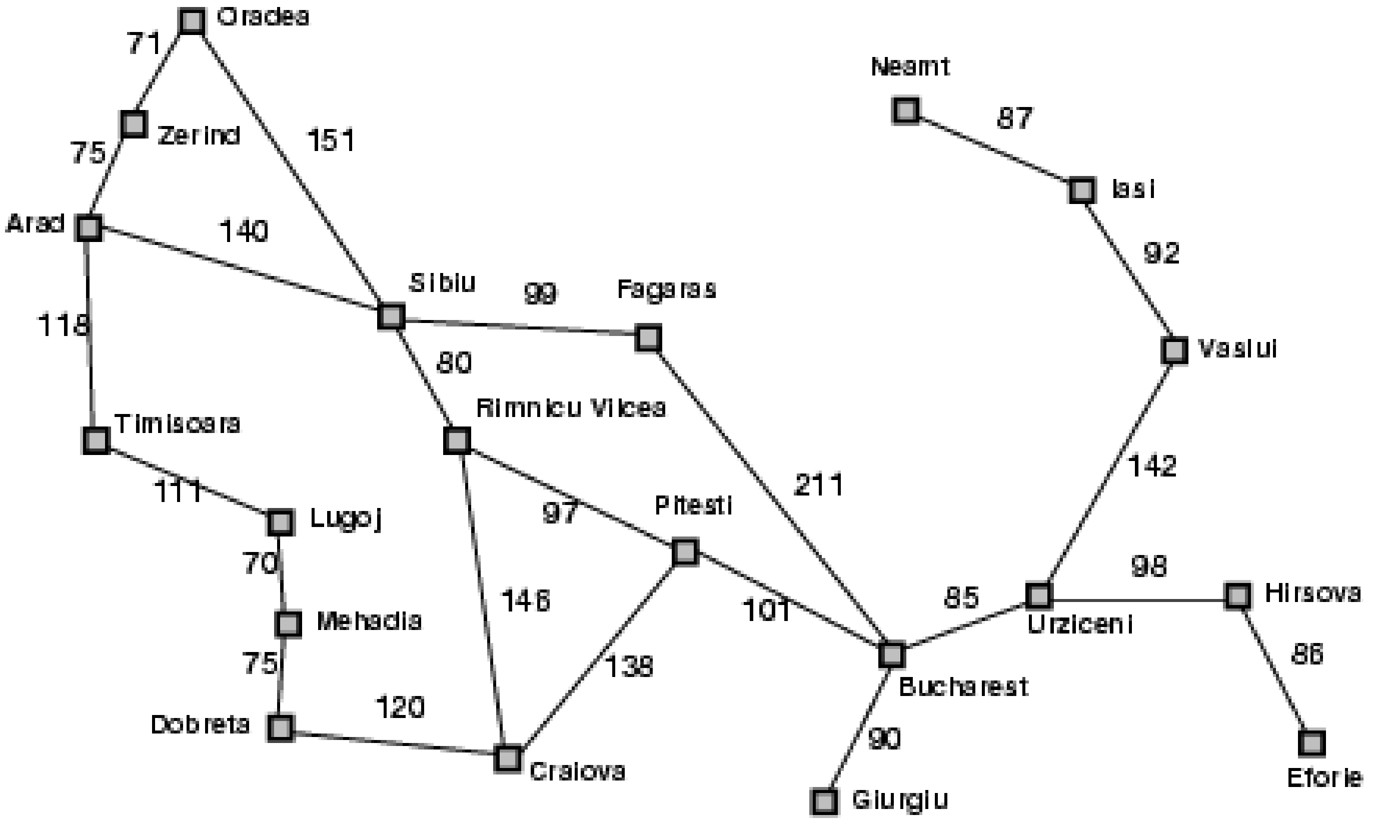
  Order the nodes in fringe increasing the order of cost.
- **Special cases:**
  - greedy best-first search
  - A* search
- If f(n)=g(n) uniform cost search
- If f(n)= h(n) greedy best search
- If f(n)=g(n)+h(n) A*

Greedy best-first search

- **Greedy best-first** search tries to expand the node that is closest to the goal, because this is likely to lead to a solution quickly.
- Greedy best-first search expands the node that appears to be closest to goal
- Thus, it evaluates nodes by using just the heuristic function; that is, f(n) = h(n).

Greedy best-first search example





Straight–line distance
to Bucharest

Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	176
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
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Urziceni	80
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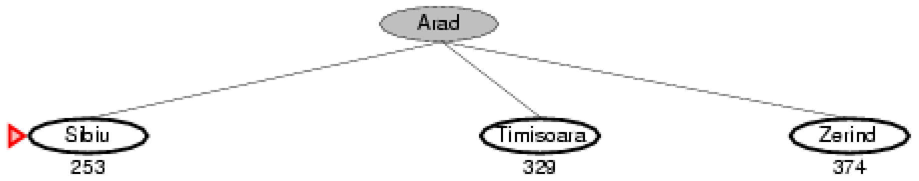
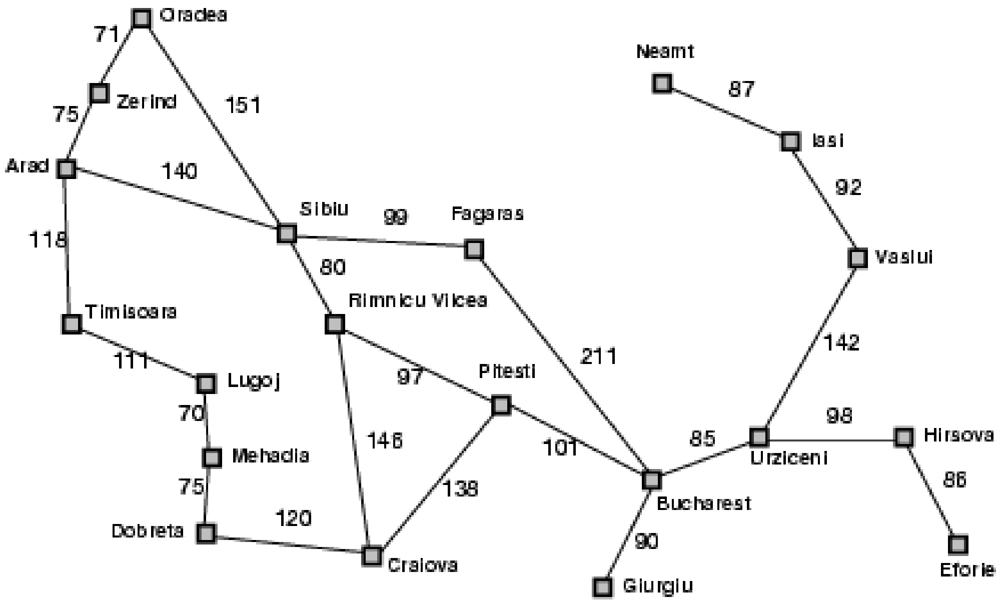
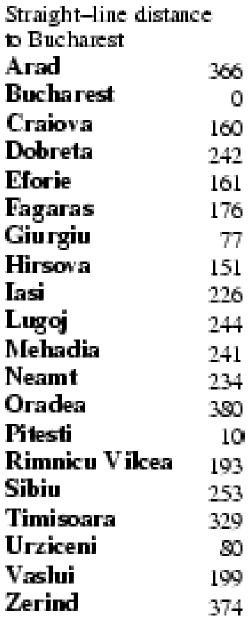
Zerind	374

Greedy best-first search example







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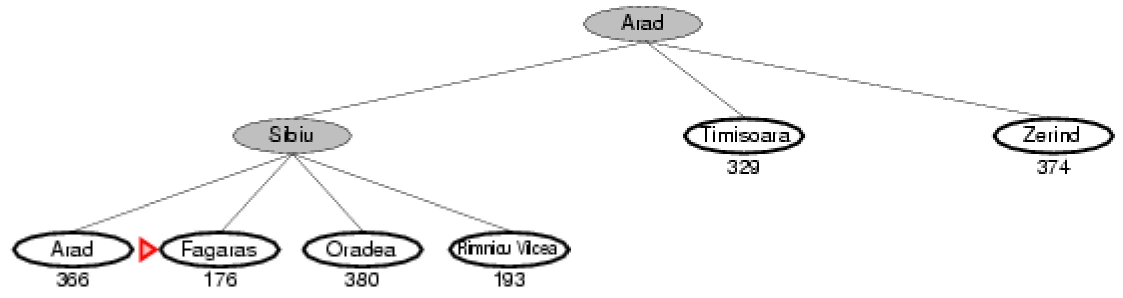
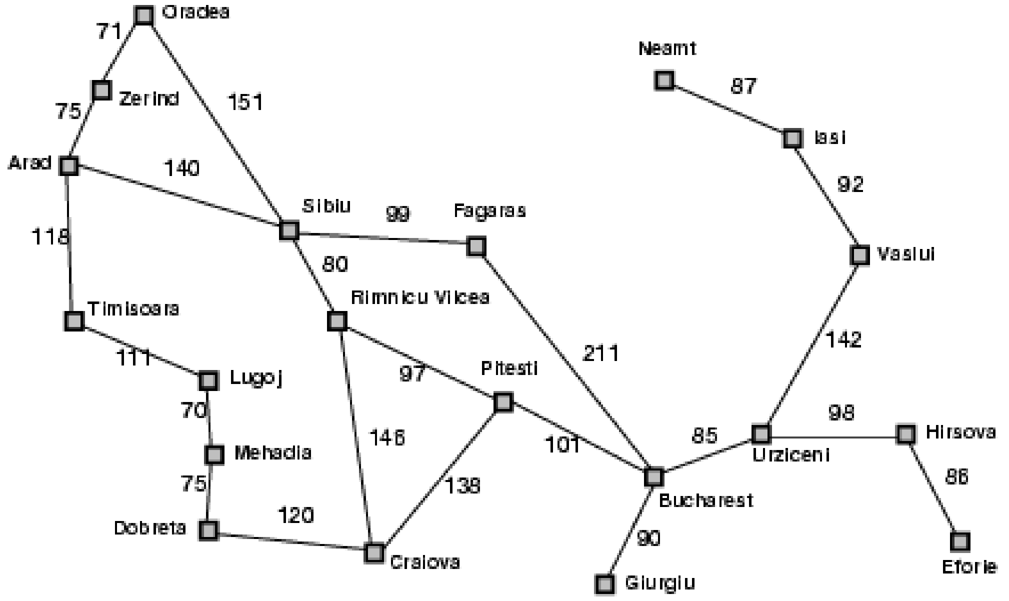
Greedy best-first search example





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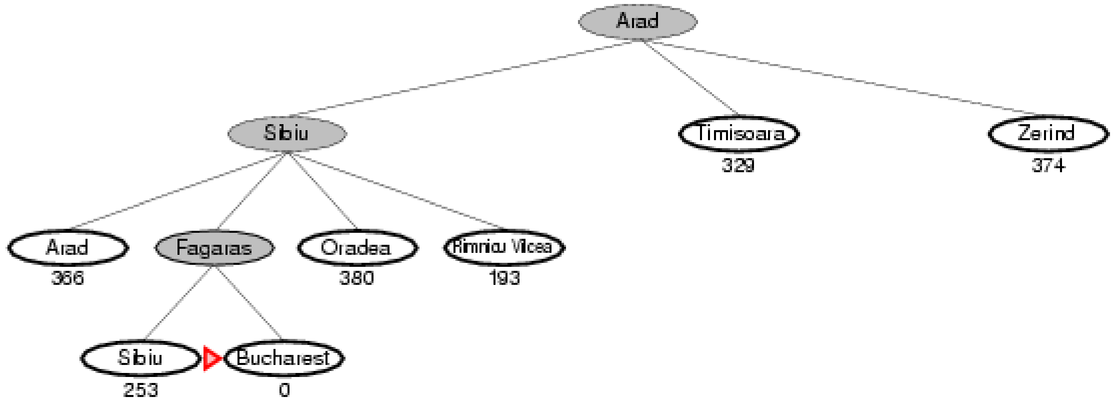
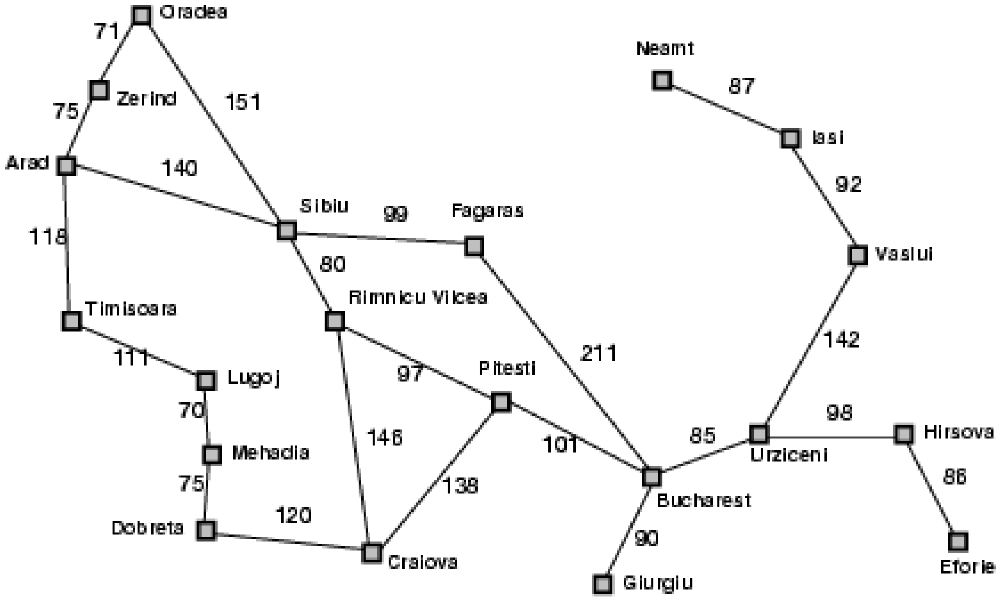
Greedy best-first search example





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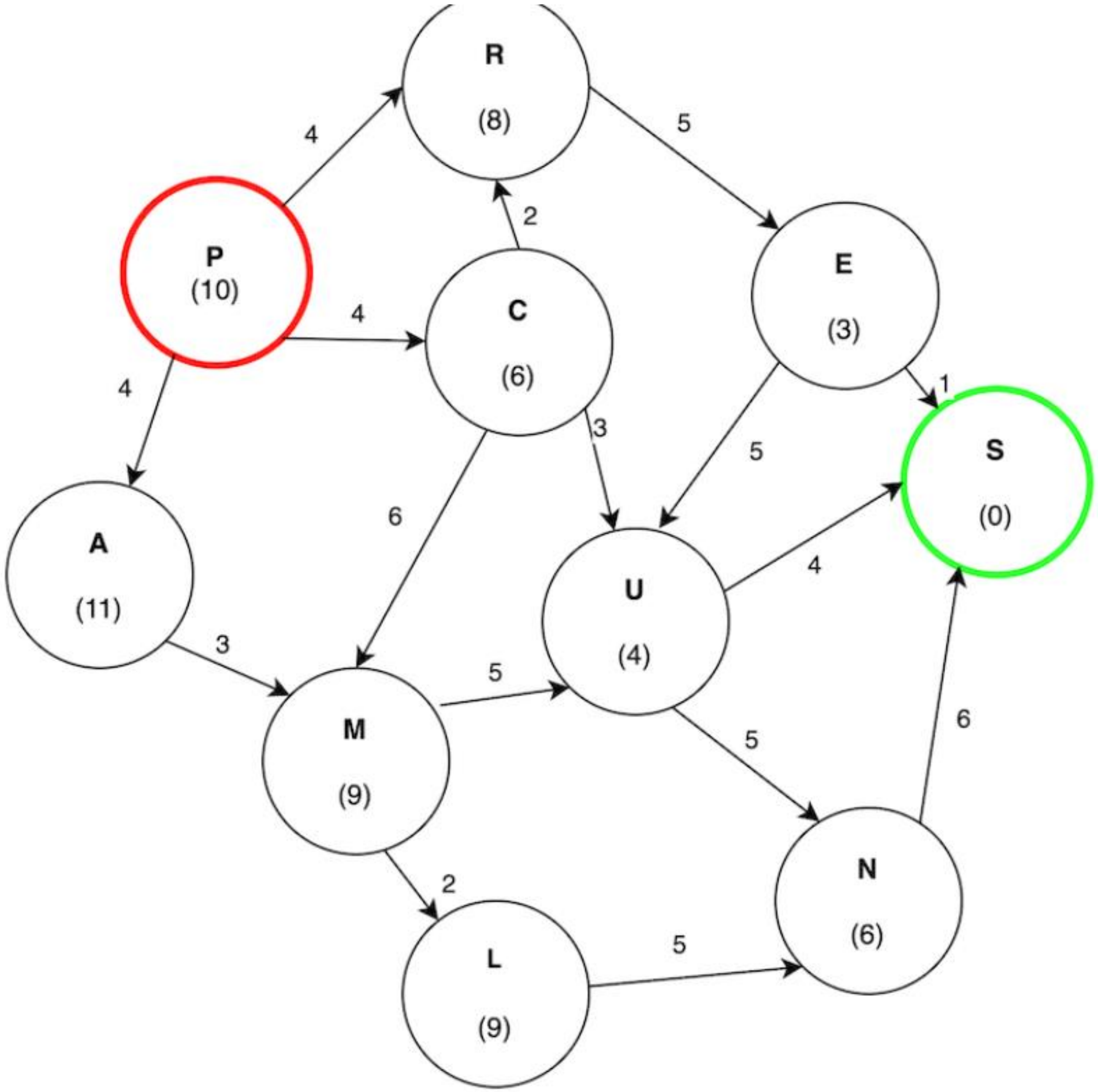
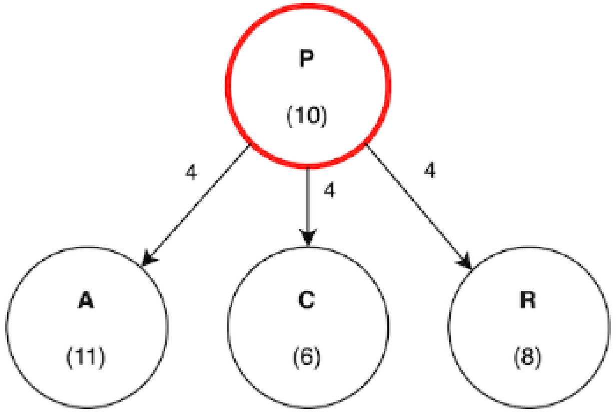
Example



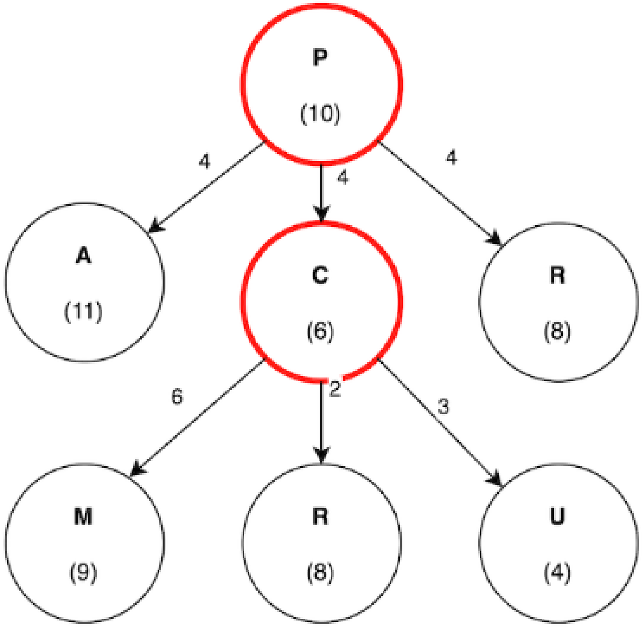
Example



Node[cost]
A[11]
C[6]
R[8]

Closed List
P

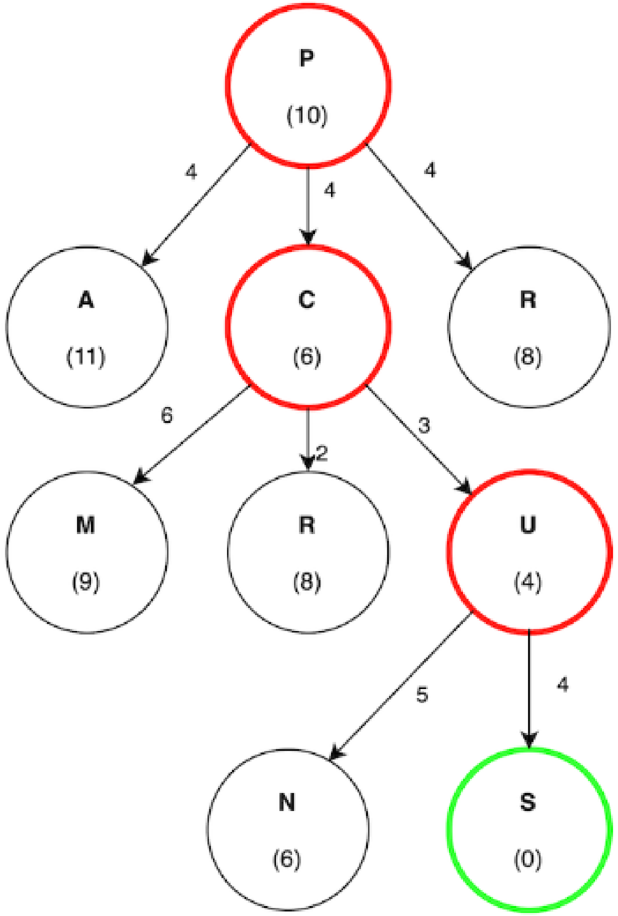
Example



Node[cost]
M[9]
R[8]
U[4]

Closed List
P
C

Example



Node[cost]
N[6]
S[0]

Closed List
P
C
U

Properties of greedy best-first search

Completeness: No – can get stuck in loops.

Optimality: no

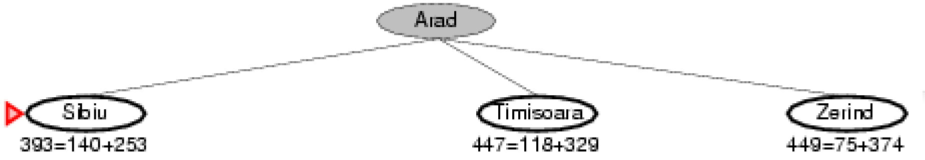
Time complexity: *exponential*

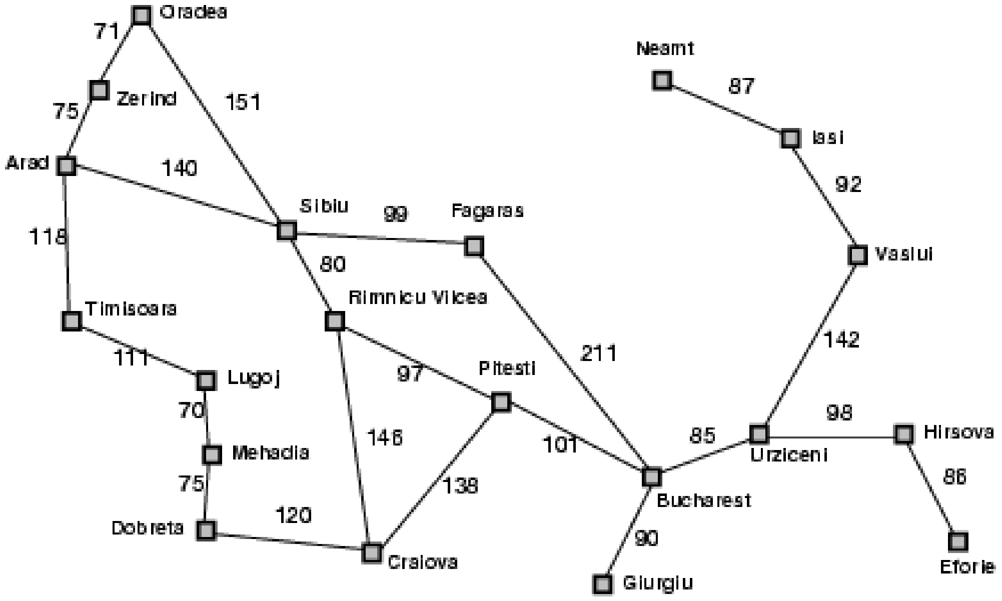
Space complexity: keeps all nodes in memory

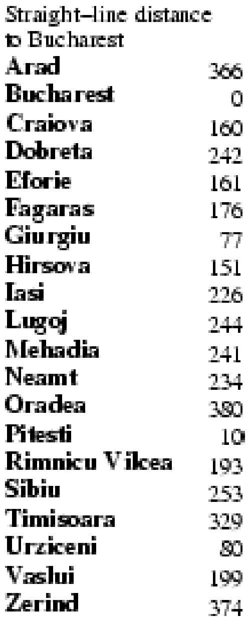
A* search

- Idea: avoid expanding paths that are already expensive
- Evaluation function $f(n) = g(n) + h(n)$
- $g(n)$ = cost so far to reach n
- $h(n)$ = estimated cost from n to goal
- $f(n)$ = estimated total cost of path through n to goal

A* search example







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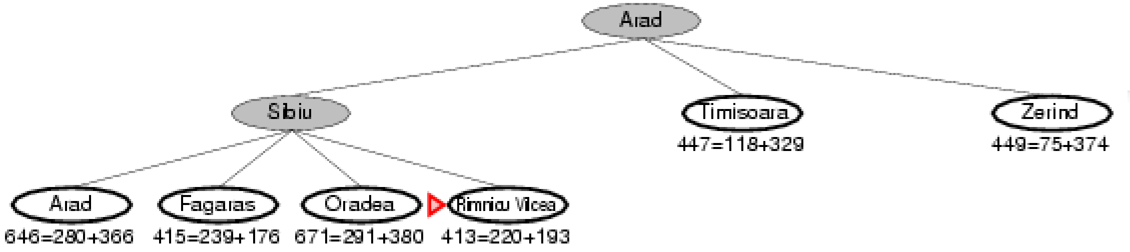
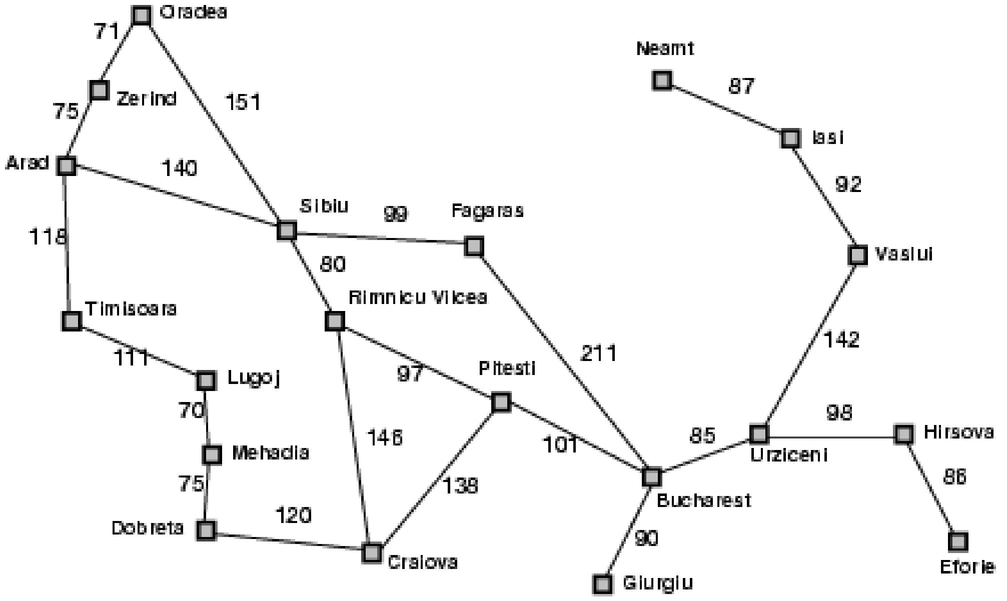
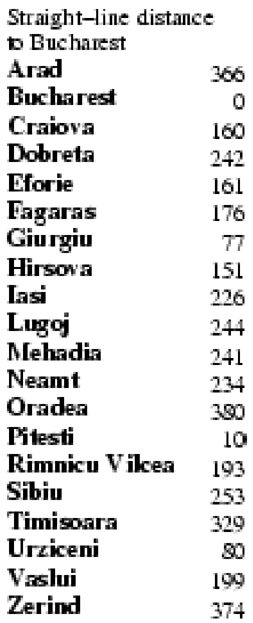
A* search example







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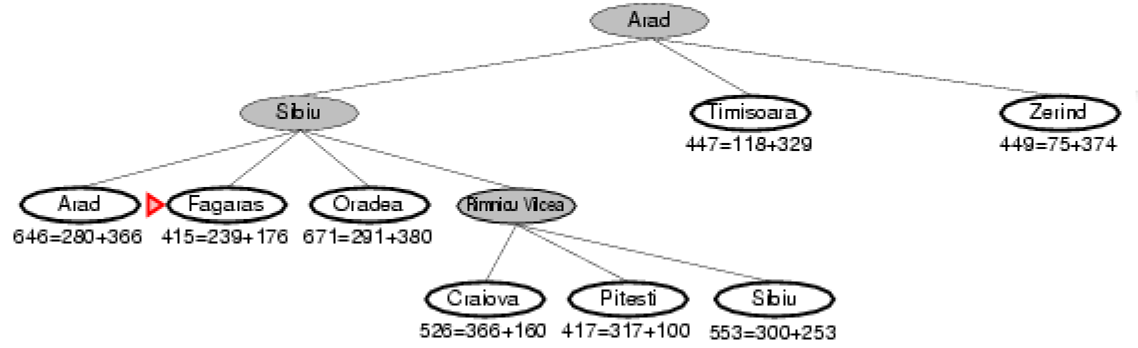

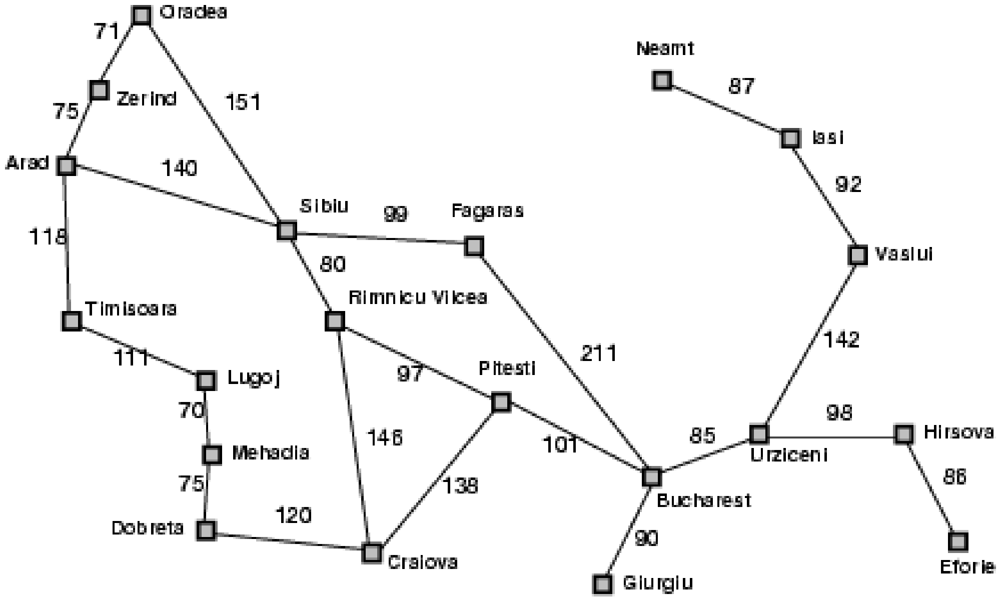

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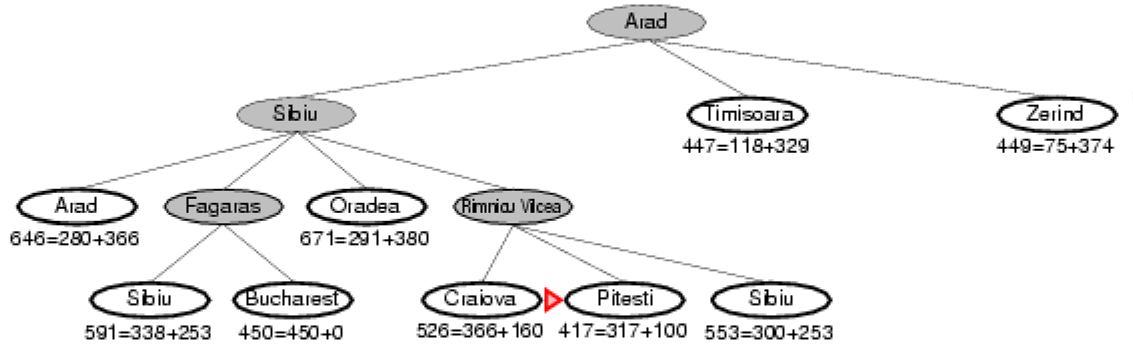

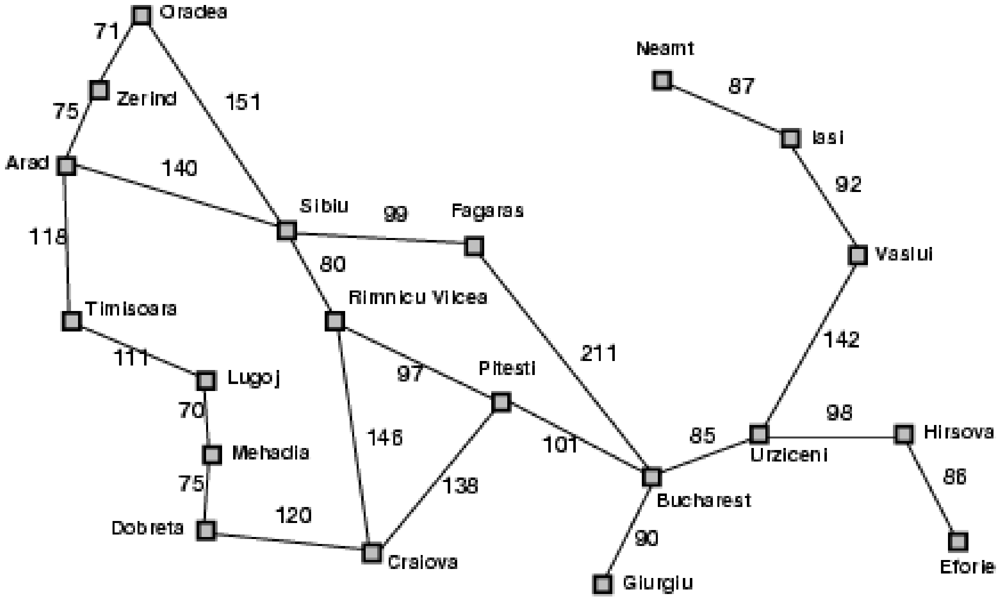

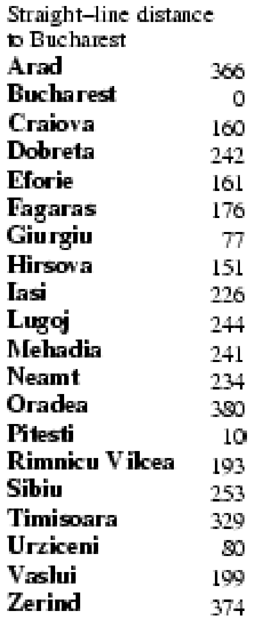

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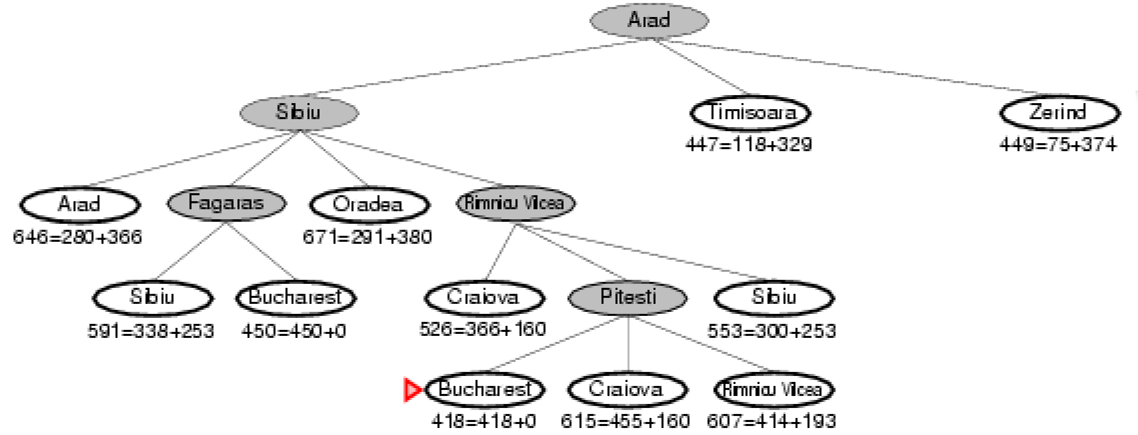
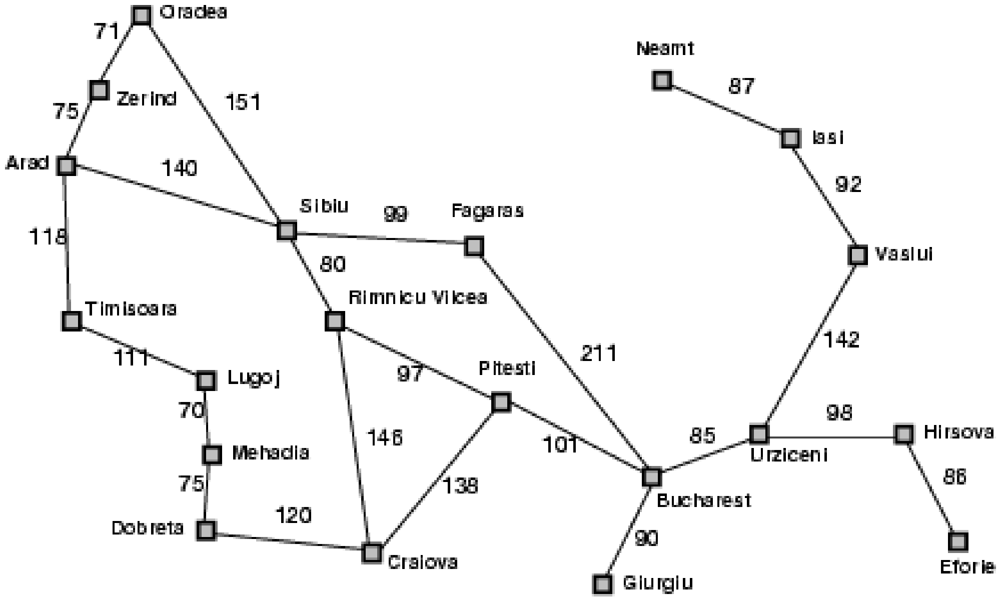
A* search example





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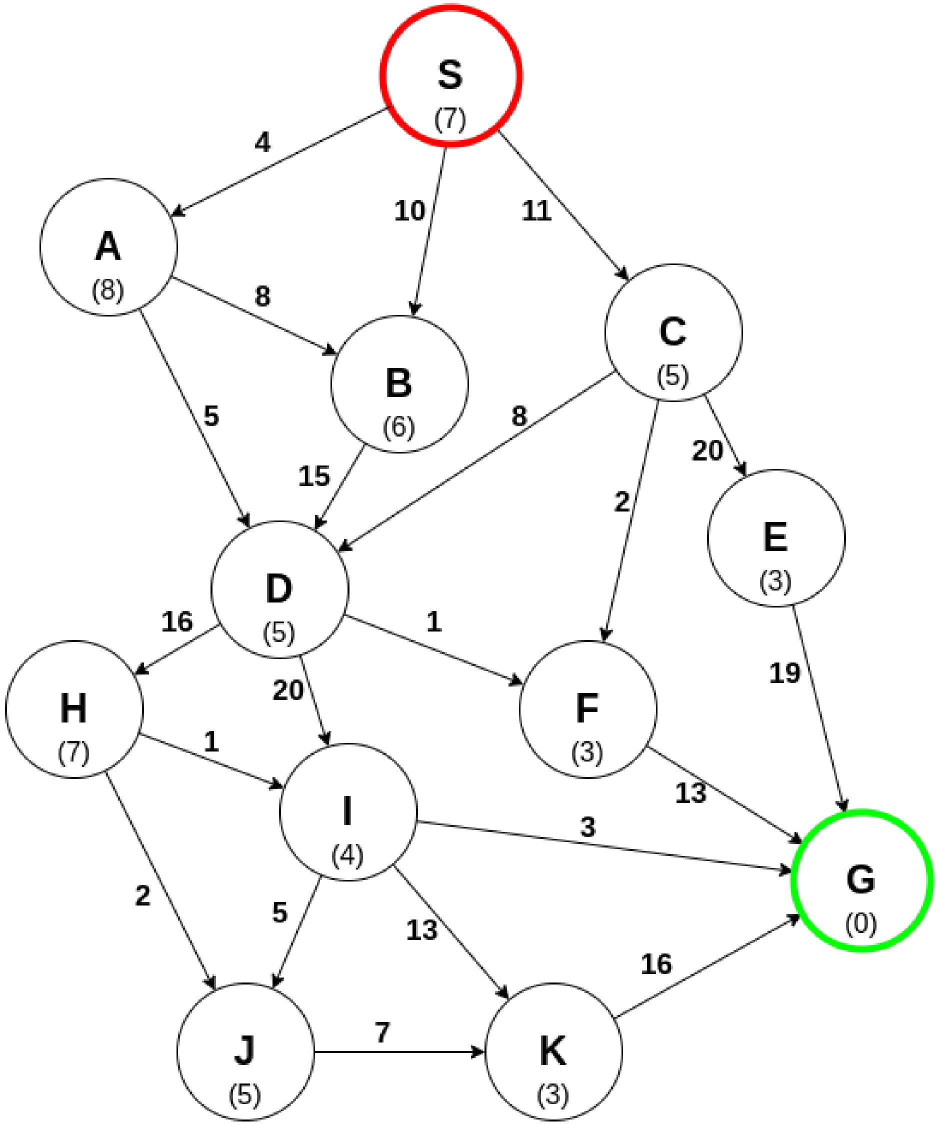
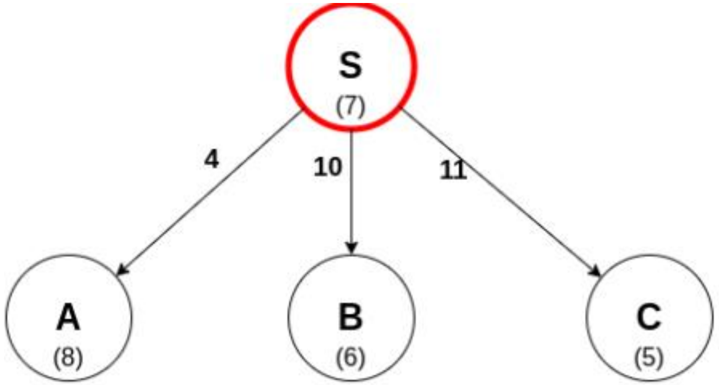
Example


S
(7)
4
10
11
A
(8)
8
B
(6)
C
(5)
5
15
8
20
2
E
(3)
D
(5)
16
1
19
H
(7)
20
F
(3)
1
13
I
(4)
3
G
(0)
2
5
13
16
J
(5)
7
K
(3)

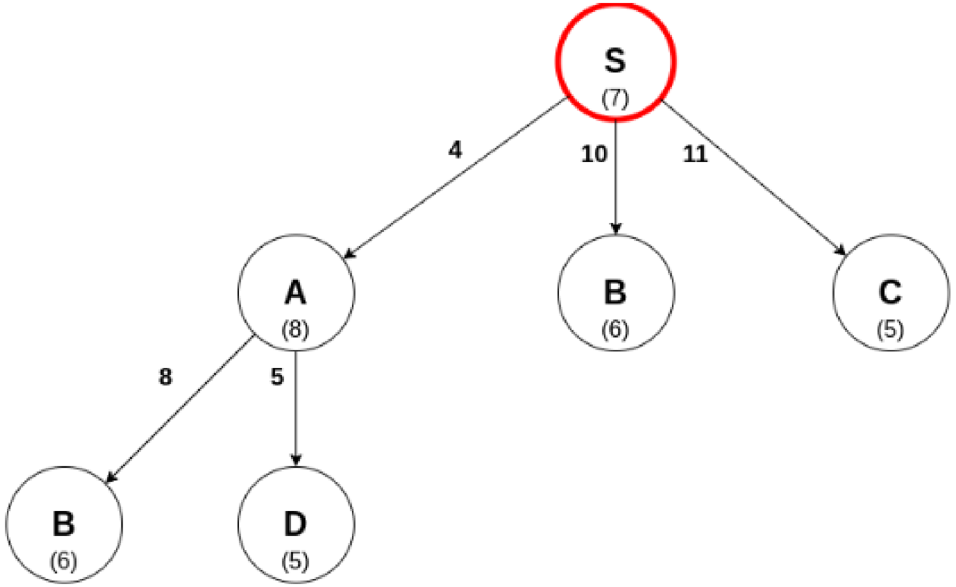
Example



Node[cost]
A[12]
B[16]
C[16]

Closed List
S

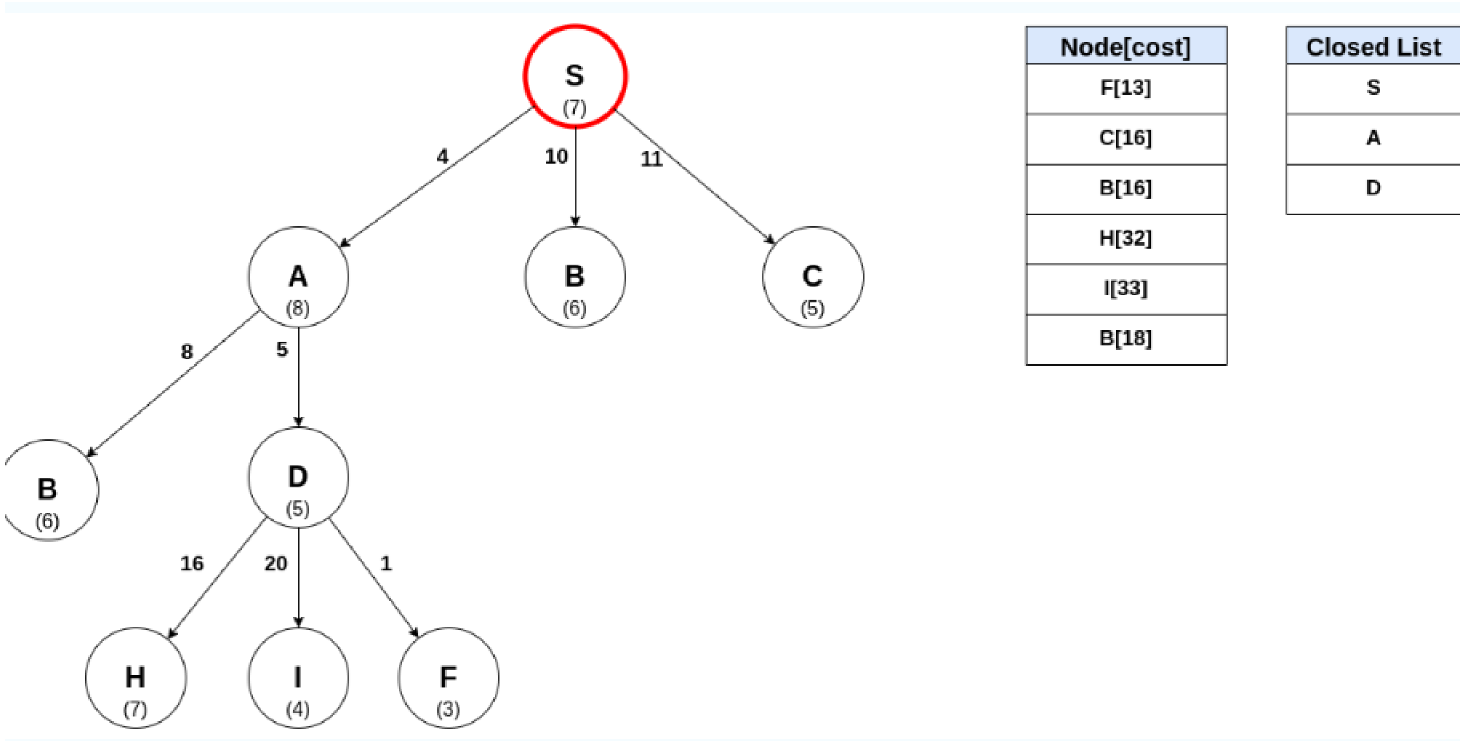
Example



Node[cost]
D[14]
C[16]
B[16]
B[18]

Closed List
S
A

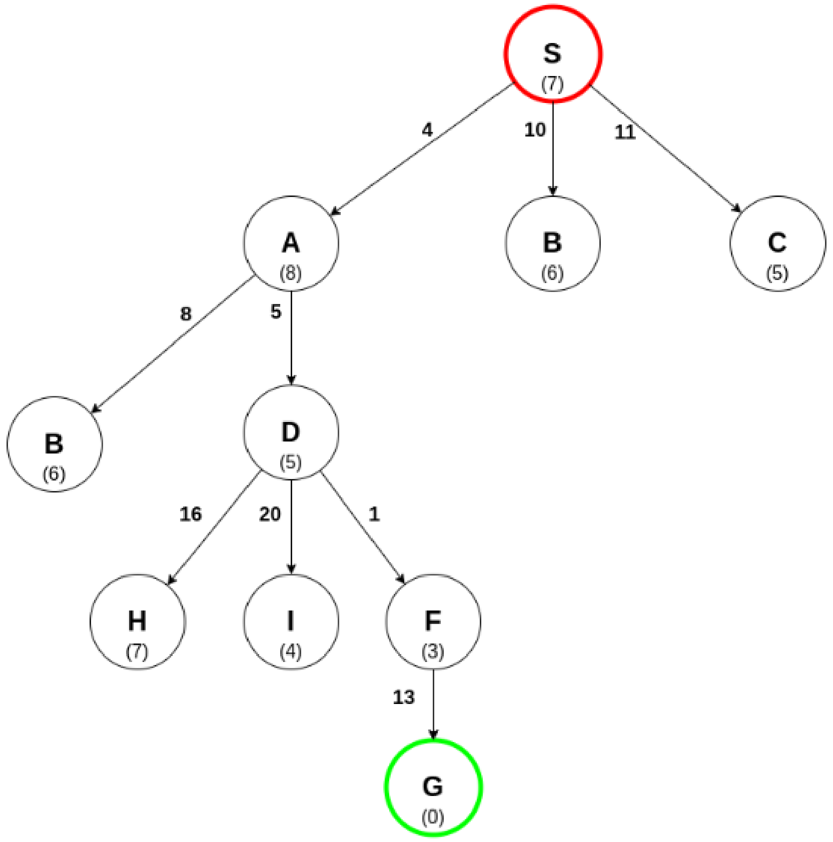
Example



Node[cost]
F[13]
C[16]
B[16]
H[32]
I[33]
B[18]

Closed List
S
A
D

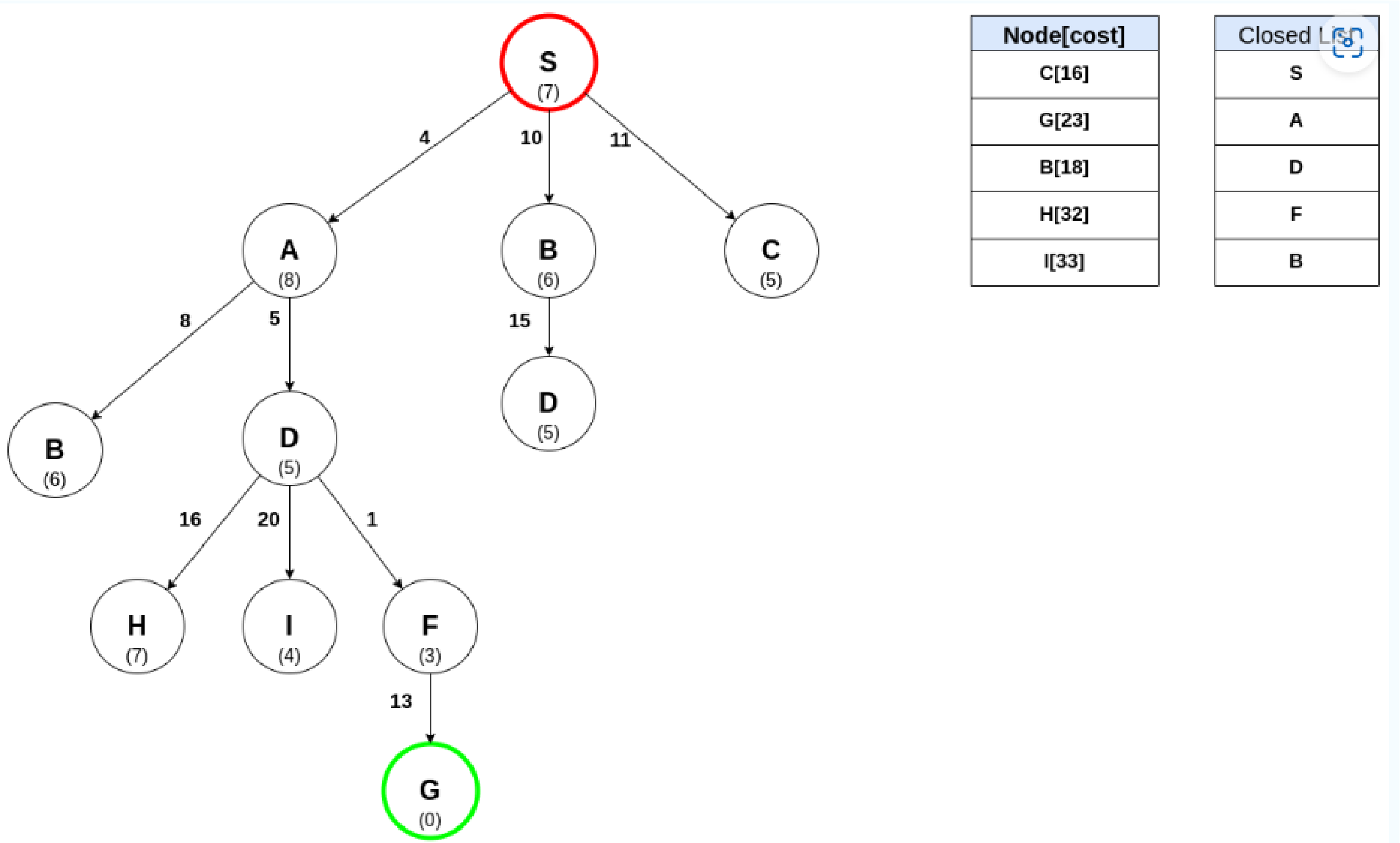
Example



Node[cost]
B[16]
C[16]
B[18]
H[32]
I[33]
G[23]

Closed List
S
A
D
F

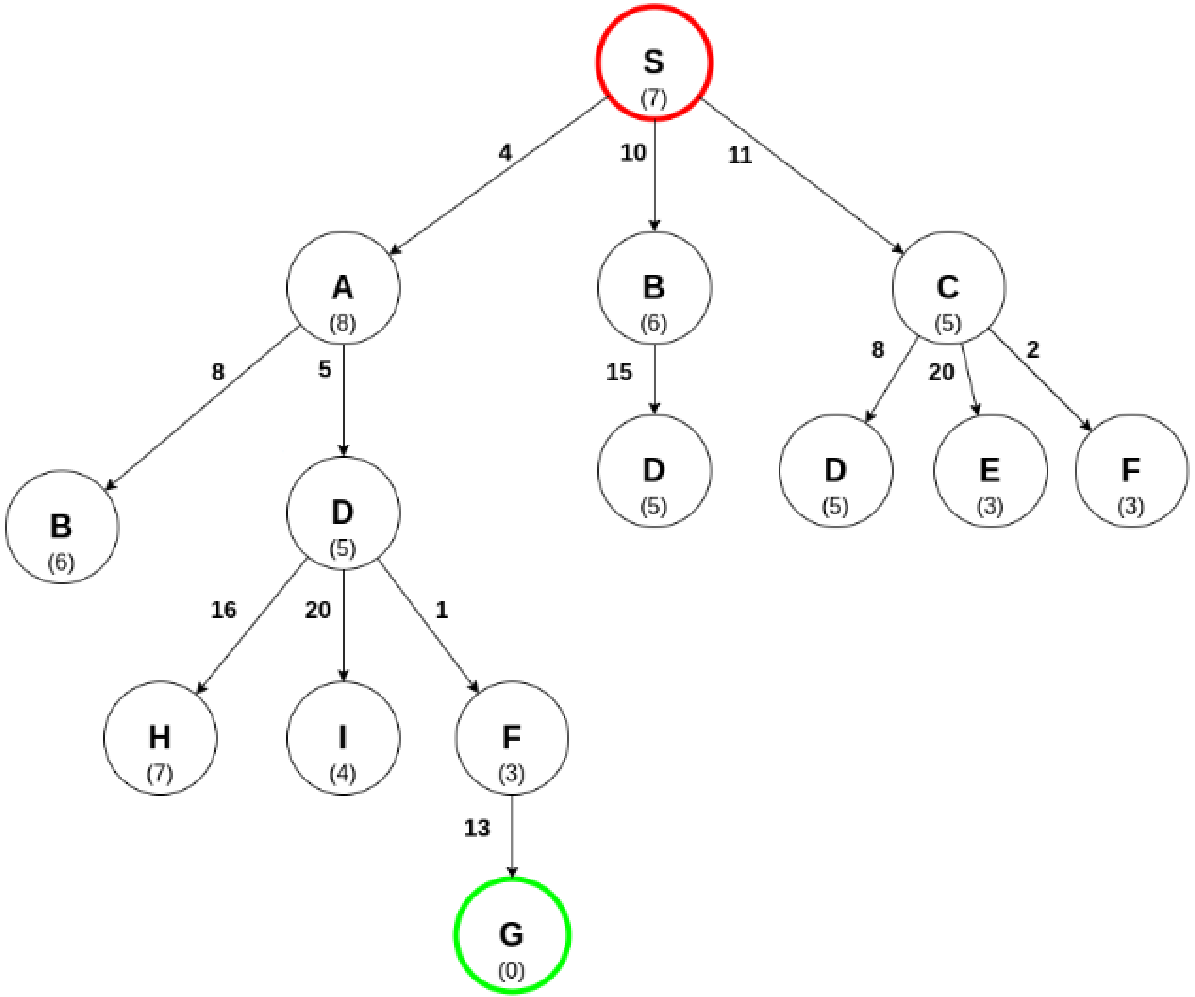
Example



Node[cost]
C[16]
G[23]
B[18]
H[32]
I[33]

Closed List
S
A
D
F
B

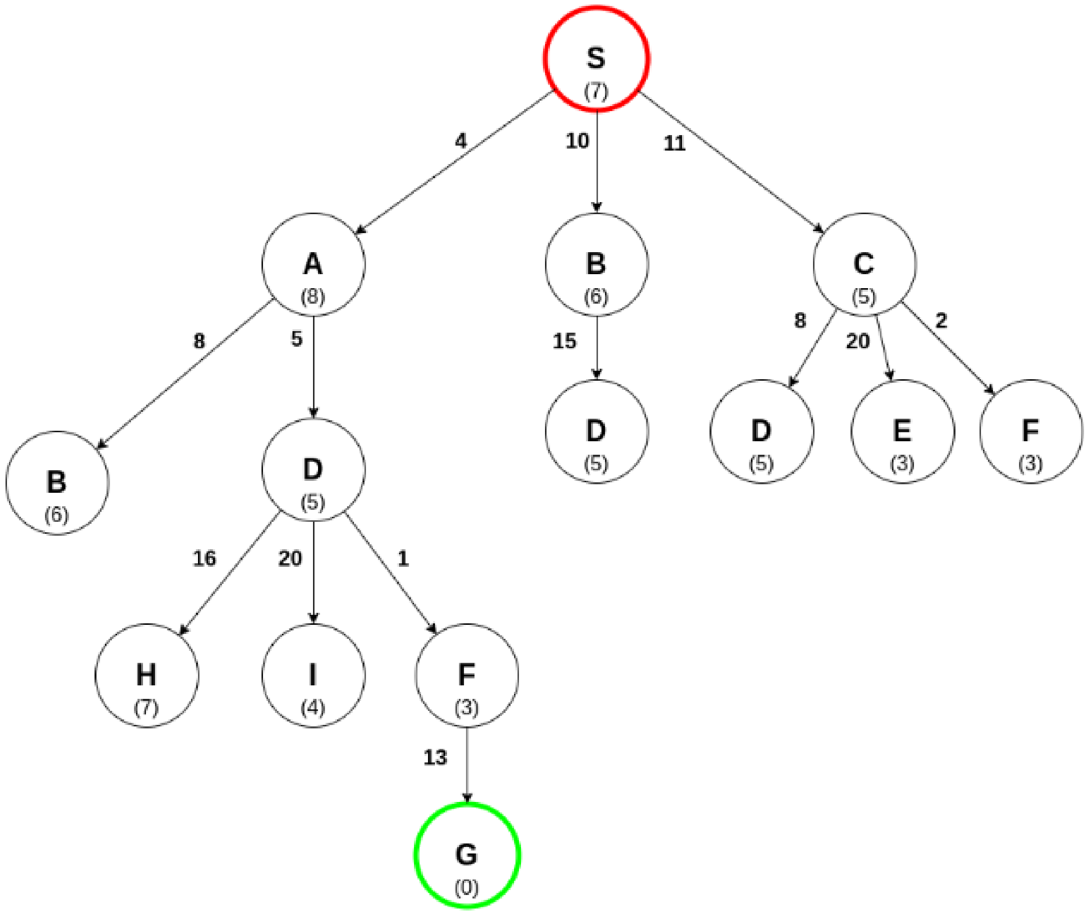
Example



Node[cost]
B[18]
G[23]
I[33]
H[32]
E[36]

Closed List
S
A
D
F
B
C

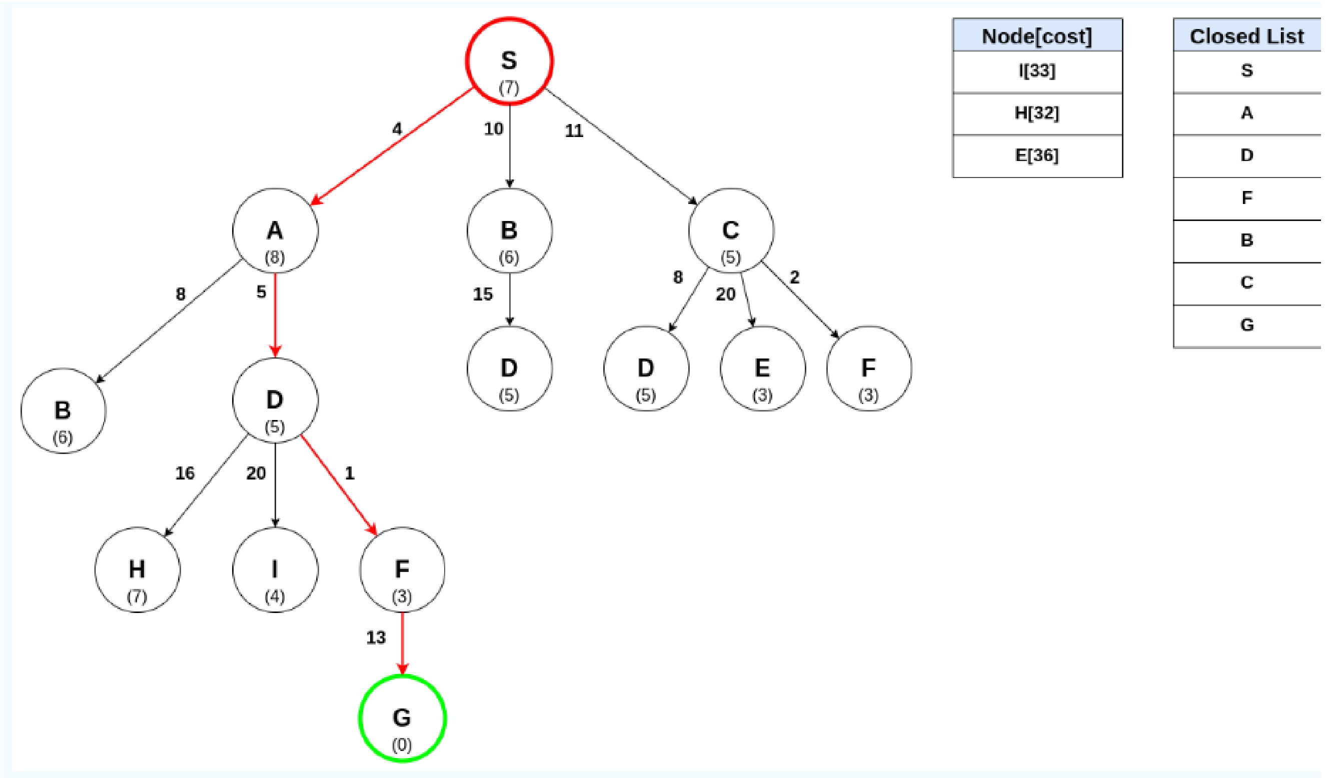
Example



Node[cost]
G[23]
I[33]
H[32]
E[36]

Closed List
S
A
D
F
B
C

Example



Node[cost]
I[33]
H[32]
E[36]

Closed List
S
A
D
F
B
C
G

Properties of A*search

Completeness: yes.

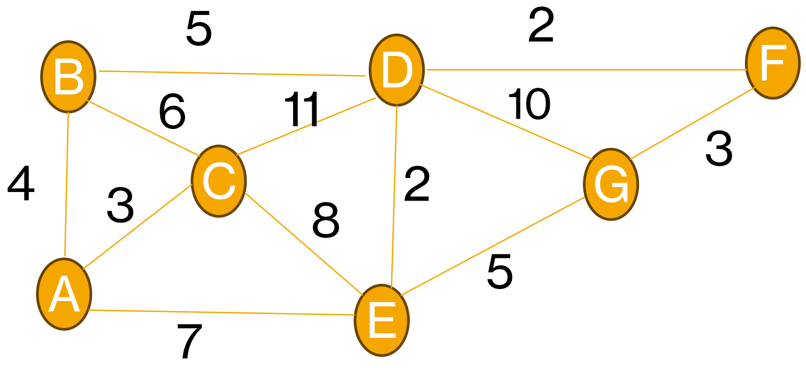
Optimality: yes

Time complexity: exponential

Space complexity: keep all nodes in memory

Assignment

- Let h(n)=node_level(n) *2
- node_level(n)=sum of all connected edges to n
- Find the shortest path between A and F using
  - greedy best search
  - A*
  - Uniform cost search



THANKYOU