UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Workbook:
Iterative deepening search

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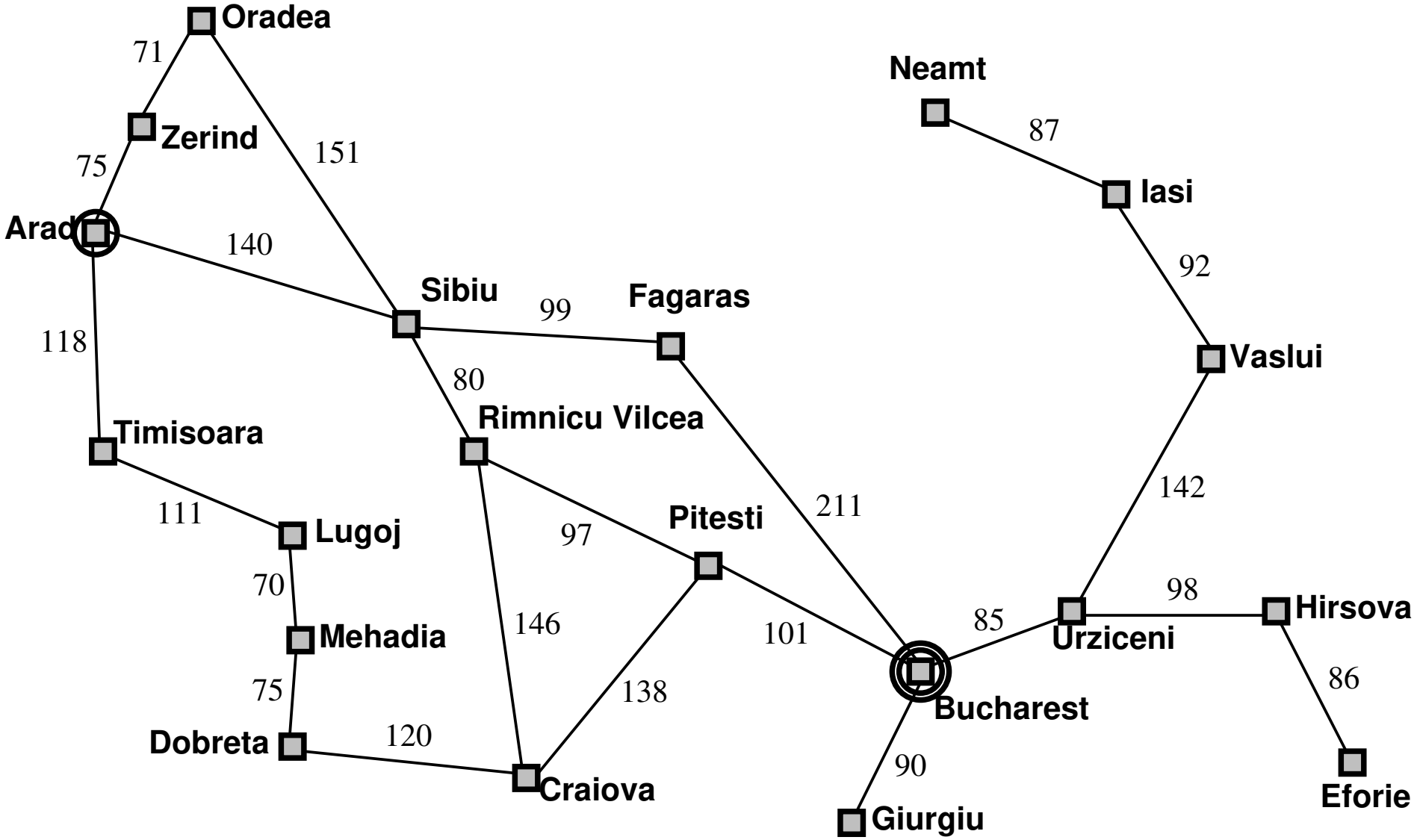
Learning objectives

- To describe iterative deepening search.
- To draw the trees of iterative deepening search.
- To apply iterative deepening search to a well-known problem
- To analyze the quality of iterative deepening search.

Problem: Shortest path between two points

Shortest path from Arad to Bucarest [1]:



Actions(Arad) = {Move(Sibiu), Move(Timisoara), Move(Zerind)}.

Iterative deepening search [2]

IDS(G, s) // ***Iterative deepening search***
  for $m = 0, 1, 2, \ldots$: **if** $(r = \text{DFS}(G, s, m)) \neq \text{NULL}$: **return** r

DFS(G, s', m) // ***Depth-first search*** with maximum depth of m
  $O = InitStack(s')$ // ***Open: search frontier-stack***
  while not $EmptyStack(O)$:
    $s = Pop(O)$ // selection ***LIFO (Last in, first out)***
    if $Goal(s)$ **return** s // solution found!
    if $Depth(s) < m$: // maximum depth not reached
      forall $(s, n) \in Adjacents(G, s)$: // generation: n child of s
        $Push(O, n)$ // n added to the stack
  return NULL // no solution found

- ***Question 1***: Write a trace of the ***IDS*** algorithm applied to the problem of finding the shortest path from Arad to Bucarest.

With $m = 0$

O	s
{Arad (d=0)}	$-$
{}	Arad (d=0)

With $m = 1$

O	s
{Arad (d=0)}	$-$
{Sibiu (d=1), Timisoara (d=1), Zerind (d=1)}	Arad (d=0)
{Timisoara (d=1), Zerind (d=1)}	Sibiu (d=1)
{Zerind (d=1)}	Timisoara (d=1)
{}	Zerind (d=1)

With $m = 2$

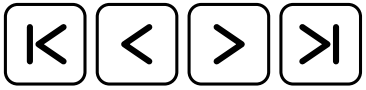
O	s
{Arad (d=0)}	$-$
{Sibiu (d=1), Timisoara (d=1), Zerind (d=1)}	Arad (d=0)
{Arad (d=2), Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Sibiu (d=1)
{Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Arad (d=2)
{Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Fagaras (d=2)
{Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Oradea (d=2)
{Timisoara (d=1), Zerind (d=1)}	Rimnicu (d=2)
{Arad (d=2), Lugoj (d=2), Zerind (d=1)}	Timisoara (d=1)
{Lugoj (d=2), Zerind (d=1)}	Arad (d=2)
{Zerind (d=1)}	Lugoj (d=2)
{Arad (d=2), Oradea (d=2)}	Zerind (d=1)
{Oradea (d=2)}	Arad (d=2)
{}	Oradea (d=2)

With $m = 3$

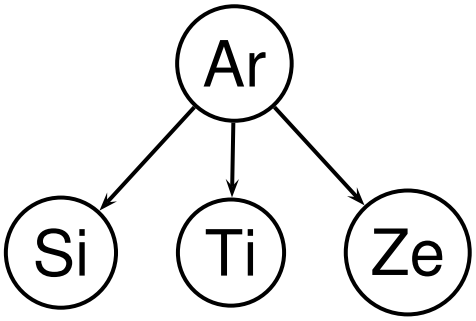
O	s
{Arad (d=0)}	–
{Sibiu (d=1), Timisoara (d=1), Zerind (d=1)}	Arad (d=0)
{Arad (d=2), Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Sibiu (d=1)
{Sibiu (d=3), Timisoara (d=3), Zerind (d=3), Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Arad (d=2)
{Timisoara (d=3), Zerind (d=3), Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Sibiu (d=3)
{Zerind (d=3), Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Timisoara (d=3)
{Fagaras (d=2), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Zerind (d=3)
{Bucharest (d=3), Sibiu (d=3), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Fagaras (d=2)
{Sibiu (d=3), Oradea (d=2), Rimnicu(d=2), Timisoara (d=1), Zerind (d=1)}	Bucharest (d=3)

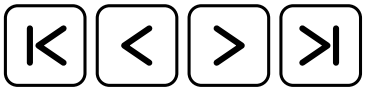
- ***Question 2***: Draw the search tree as a result of applying the ***IDS*** algorithm to the problem of finding the shortest path from Arad to Bucarest with maximum depth $m = 3$.

With $m = 0$

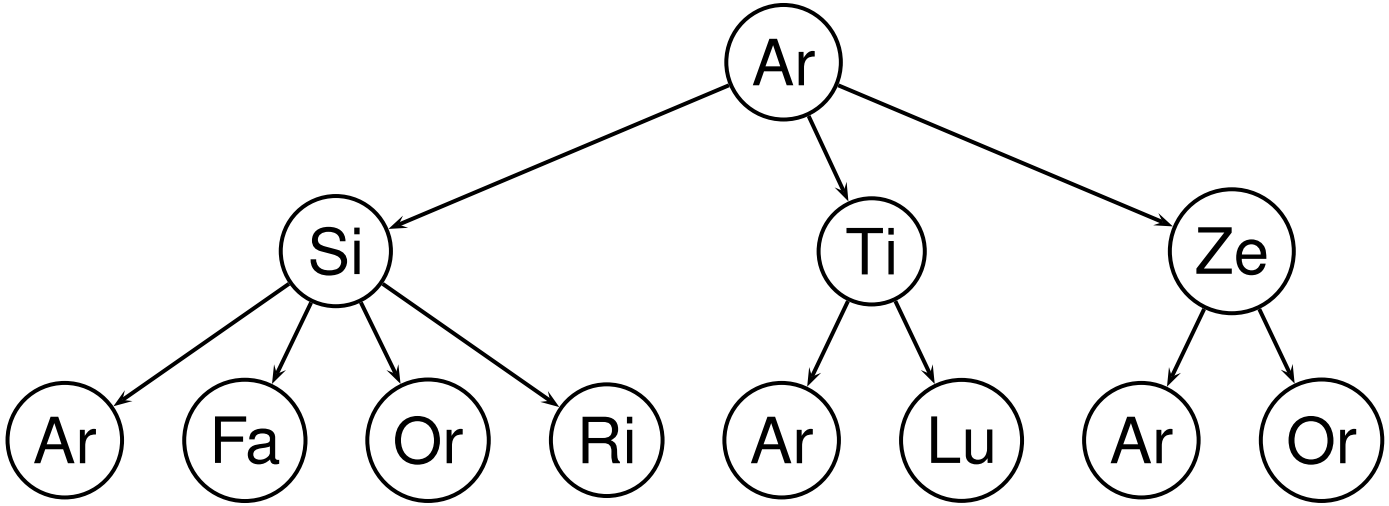


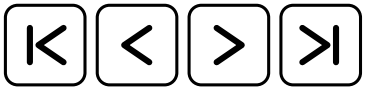
With $m = 1$



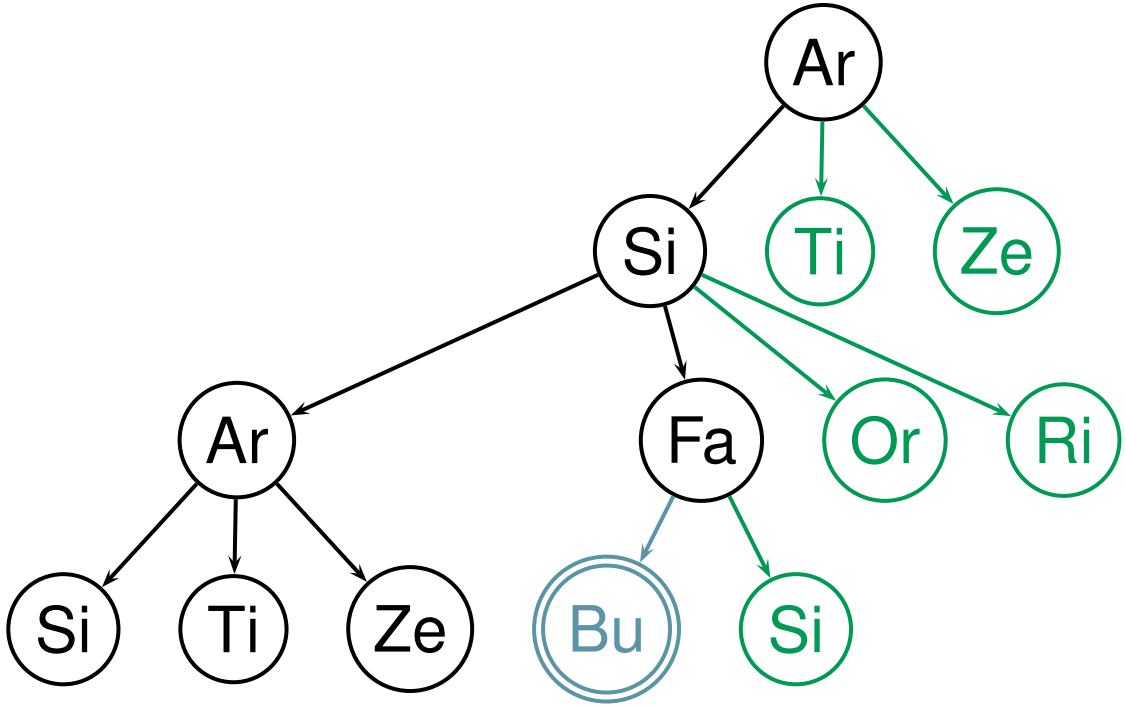


With $m = 2$





With $m = 3$



- ***Question 3***: Does the IDS algorithm find a solution? ***Yes***
- ***Question 4***: If the answer is "Yes":
  - How many iterations does the IDS algorithm need to find the solution? ***Four***
  - What the number of iterations depends on? ***On the depth at which the shortest solution in terms of number of actions (movements) is found***
  - What is the solution found? ***The solution path is: Arad, Sibiu, Fagaras, Bucharest***
  - What is the cost of this solution? ***450***
  - Is this the solution of minimum cost? ***No, because there is an alternative solution with lower cost of 418: Arad, Sibiu, Rimnicu, Pitesti, Bucharest***
  - What type of solution is found by the IDS algorithm? ***The IDS algorithm finds the shortest (shallowest) solution of the tree search in terms of number of actions (movements)***

References

[1] S. Russell and P. Norvig. *Artificial Intelligence: A Modern Approach*. Pearson, third edition, 2010.

[2] R. E. Korf. Depth-first iterative-deepening: An optimal admissible tree search. *Artificial Intelligence*, 1985.