SEARCH ALGORITHMS

BEST-FIRST SEARCH

How do we decide which node from the frontiers to expand first?

BEST-FIRST SEARCH

CHOOSE A NODE, N, WITH MINIMUM VALUE OF SOME EVALUATION FUNCTION, F(N).

```
function BEST-FIRST-SEARCH(problem, f) returns a solution node or failure
  node ← NODE(STATE=problem.INITIAL)
  frontier ← a priority queue ordered by f, with node as an element
  reached ← a lookup table, with one entry with key problem.INITIAL and value node
  while not IS-EMPTY(frontier) do
    node ← POP(frontier)
    if problem.IS-GOAL(node.STATE) then return node
    for each child in EXPAND(problem, node) do
      s ← child.STATE
      if s is not in reached or child.PATH-COST < reached[s].PATH-COST then
        reached[s] ← child
        add child to frontier
  return failure

function EXPAND(problem, node) yields nodes
  s ← node.STATE
  for each action in problem.ACTIONS(s) do
    s' ← problem.RESULT(s, action)
    cost ← node.PATH-COST + problem.ACTION-COST(s, action, s')
    yield NODE(STATE=s', PARENT=node, ACTION=action, PATH-COST=cost)
```

GRAPH (MAP OF ROMANIA)

Problem formulation

Initial State: Arad
Goal State: Bucharest
f = Minimum distance

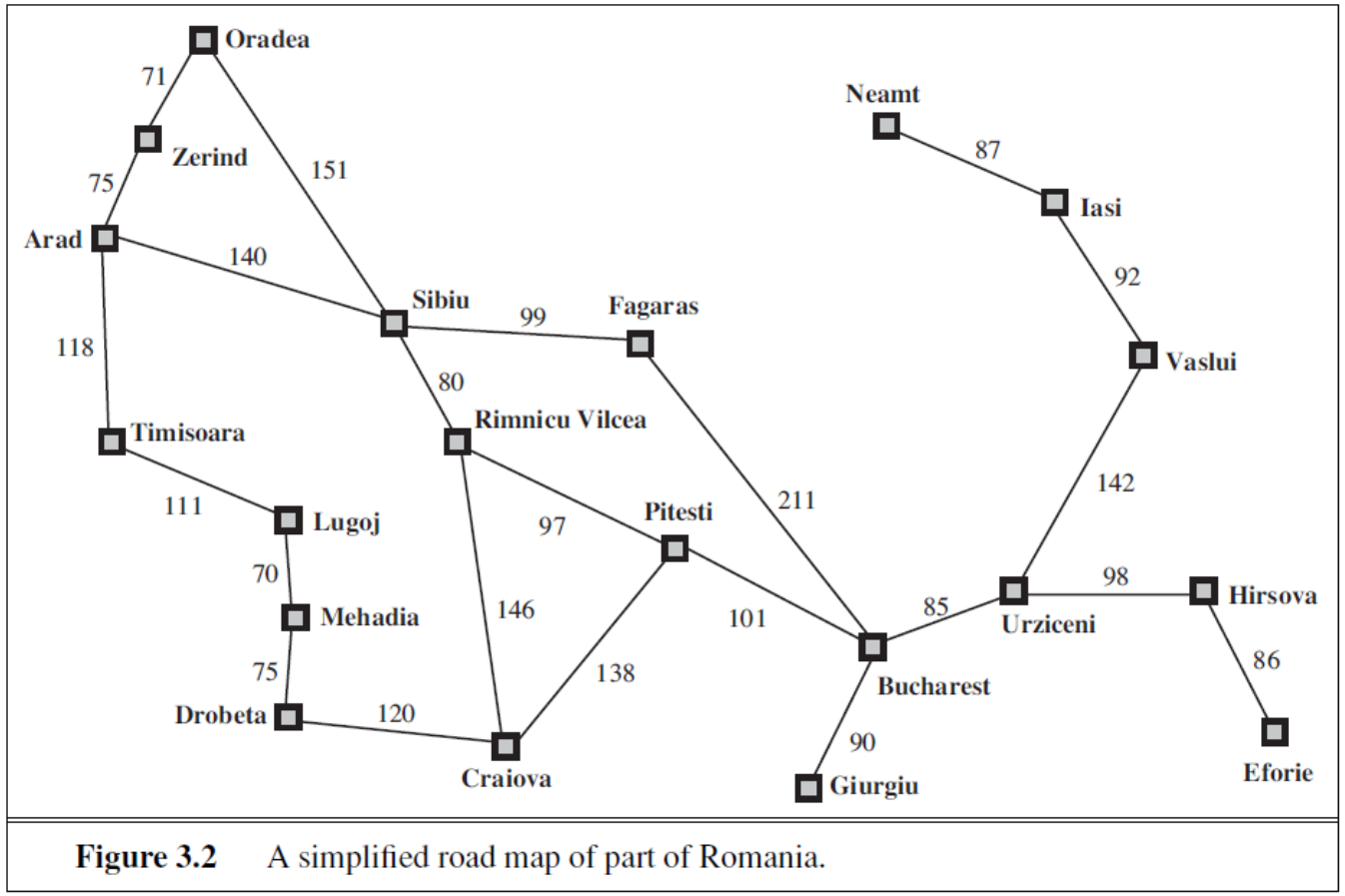

Figure 3.2 A simplified road map of part of Romania.

Iteration number	Frontier (Queue)	Reached (Look-up table)
0	Arad	Arad, Nil, Nil, 0
1	Zerind, Timisoara, Sibiu	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118
2	Timisoara, Sibiu, Oradia	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146
3	Sibiu, Oradia, Lugoj	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229

Iteration number	Frontier (Queue)	Reached (Look-up table)
4	Oradia, Rimnicu Vilcea, Lugoj, Fagaras	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239
5	Rimnicu Vilcea, Lugoj, Fagaras	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239

Iteration number	Frontier (Queue)	Reached (Look-up table)
6	Lugoj, Fagaras, Pitesti, Craiova	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366
7	Fagaras, Mehadia, Pitesti, Craiova	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299

Iteration number	Frontier (Queue)	Reached (Look-up table)
8	Mehadia, Pitesti, Craiova, Bucharest	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Bucharest, Fagaras, Go[Bucharest], 450
9	Pitesti, Craiova, Drobeta, Bucharest	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Bucharest, Fagaras, Go[Bucharest], 450 Drobeta, Mehadia, Go[Drobeta], 374

Iteration number	Frontier (Queue)	Reached (Look-up table)
10	Craiova, Drobeta, Bucharest	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Drobeta, Mehadia, Go[Drobeta], 374 Bucharest, Pitesti, Go[Bucharest], 418
11	Drobeta, Bucharest	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Drobeta, Mehadia, Go[Drobeta], 374 Bucharest, Pitesti, Go[Bucharest], 418

Iteration number	Frontier (Queue)	Reached (Look-up table)
12	Bucharest	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Drobeta, Mehadia, Go[Drobeta], 374 Bucharest, Pitesti, Go[Bucharest], 418
13	Nil	Arad, Nil, Nil, 0 Zerind, Arad, Go[Zerind], 75 Sibiu, Arad, Go[Sibiu], 140 Timisoara, Arad, Go[Timisoara], 118 Oradia, Zerind, Go[Oradia], 146 Lugoj, Timisoara, Go[Lugoj], 229 Rimnicu Vilcea, Sibiu, Go[R.V.], 220 Fagaras, Sibiu, Go[Fagaras], 239 Pitesti, Rimnicu Vilcea, Go[Pitesti], 317 Craiova, Rimnicu Vilcea, Go [Craiova], 366 Mehadia, Lugoj, Go[Mehadia], 299 Drobeta, Mehadia, Go[Drobeta], 374 Bucharest, Pitesti, Go[Bucharest], 418

BEST-FIRST SEARCH (FINAL SOLUTION)

- Bucharest, Pitesti, Go[Bucharest], 418
- Pitesti, Rimnicu Vilcea, Go[Pitesti], 317
- Rimnicu Vilcea, Sibiu, Go[R.V.], 220
- Sibiu, Arad, Go[Sibiu], 140
- Arad, Nil, Nil, 0

- Arad -> Sibiu -> Rimnicu Vilcea -> Pitesti -> Bucharest

UNINFORMED SEARCH STRATEGIES

- No clue about how close a state is to the goal(s).

- Breadth-first search
- Dijkstra's algorithm or uniform-cost search
- Depth-first search
- Depth-limited and iterative deepening search
- Bidirectional search

INFORMED SEARCH STRATEGIES

- Uses domain-specific hints about the location of goals.

- Greedy best-first search
- A* search
- Search contours
- Satisficing search
- Memory-bound search
- Bidirectional heuristic search