3.5 INFORMED SEARCH AND EXPLORATION

Informed(Heuristic) Search Strategies

Informed search strategy is one that uses problem-specific knowledge beyond the definition of the problem itself. It can find solutions more efficiently than uninformed strategy.

Best-first search

Best-first search is an instance of general TREE-SEARCH or GRAPH-SEARCH algorithm in which a node is selected for expansion based on an **evaluation function** f(n). The node with lowest evaluation is selected for expansion, because the evaluation measures the distance to the goal. This can be implemented using a priority-queue, a data structure that will maintain the fringe in ascending order of f-values.

Heuristic functions

A **heuristic function** or simply a **heuristic** is a function that ranks alternatives in various search algorithms at each branching step basing on an available information in order to make a decision which branch is to be followed during a search.

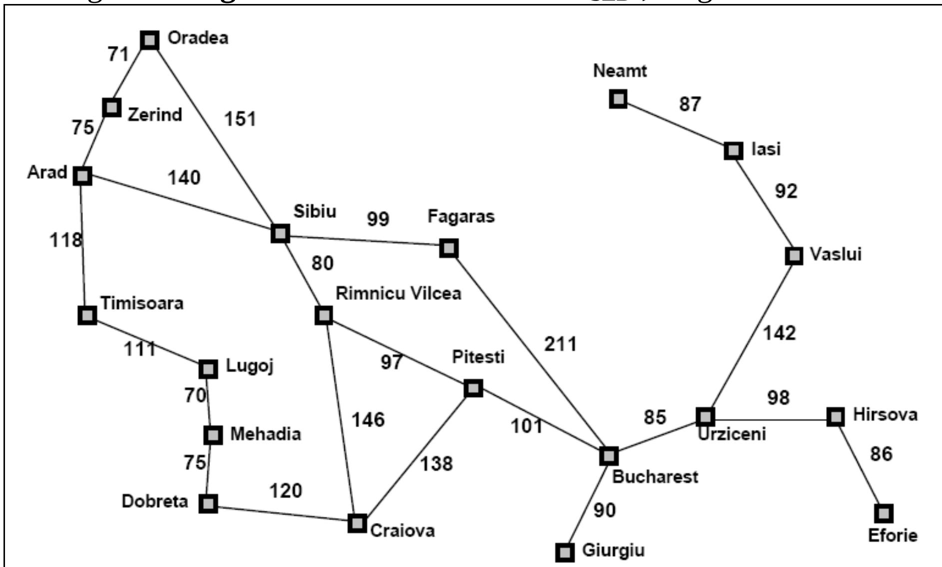
The key component of Best-first search algorithm is a **heuristic function**, denoted by h(n):

h(n) = estimated cost of the **cheapest path** from node n to a **goal node**.

For example, in Romania, one might estimate the cost of the cheapest path from Arad to Bucharest via a **straight-line distance** from Arad to Bucharest(Figure 2.1).
Heuristic function are the most common form in which additional knowledge is imparted to the search algorithm.

Greedy Best-first search

Greedy best-first search tries to expand the node that is closest to the goal, on the grounds that this is likely to a solution quickly.
It evaluates the nodes by using the heuristic function **f(n) = h(n).**
Taking the example of **Route-finding problems** in Romania, the goal is to reach Bucharest starting from the city Arad. We need to know the straight-line distances to Bucharest from various cities as shown in Figure 2.1. For example, the initial state is In(Arad) ,and the straight line distance heuristic h_{SLD}(In(Arad)) is found to be 366.
Using the **straight-line distance** heuristic $\mathbf{h_{SLD}}$ **,**the goal state can be reached faster.



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
Mehadia	241
Neamt	234
Oradea	380
Pitesti	98
Rimnicu Vilcea	193
Sibiu	253
Timisoara	329
Urziceni	80
Vaslui	199
Zerind	374

Figure 2.1 Values of h_{SLD} - straight line distances to Bucharest

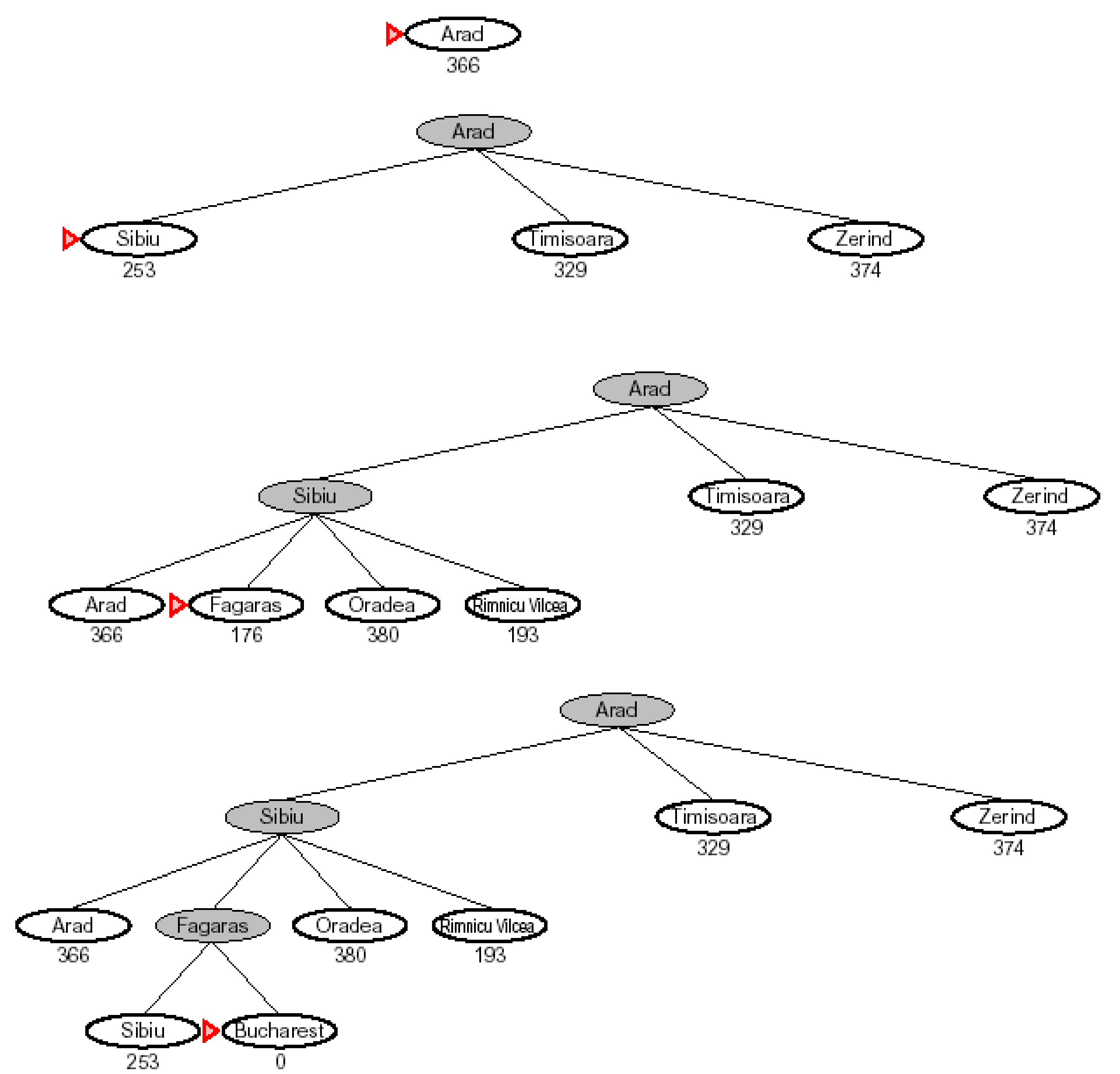


Figure 2.2 stages in greedy best-first search for Bucharest using straight-line distance heuristic h_{SLD}. Nodes are labeled with their h-values.

Figure 2.2 shows the progress of greedy best-first search using h_{SLD} to find a path from Arad to Bucharest. The first node to be expanded from Arad will be Sibiu,because it is closer to Bucharest than either Zerind or Timisoara. The next node to be expanded will be Fagaras,because it is closest. Fagaras in turn generates Bucharest,which is the goal.

Properties of greedy search

- **Complete??** No–can get stuck in loops, e.g.,
  Iasi ! Neamt ! Iasi ! Neamt !
  Complete in finite space with repeated-state checking
- **Time??** O(bm), but a good heuristic can give dramatic improvement

- **Space??** O(bm)—keeps all nodes in memory
- **Optimal??** No

Greedy best-first search is not optimal,and it is incomplete.
The worst-case time and space complexity is $O(b^m)$,where m is the maximum depth of the search space.

3.5.2 A* Search

A* Search is the most widely used form of best-first search. The evaluation function f(n) is obtained by combining

(1) **g(n) =** the cost to reach the node,and
(2) **h(n) =** the cost to get from the node to the **goal** :

$$f(n) = g(n) + h(n).$$

A* Search is both optimal and complete. A* is optimal if h(n) is an admissible(Deserving to be admitted) heuristic. The obvious example of admissible heuristic is the straight-line distance h_{SLD}. It cannot be an overestimate.
A* Search is optimal if h(n) is an admissible heuristic – that is,provided that h(n) never overestimates the cost to reach the goal.
An obvious example of an admissible heuristic is the straight-line distance h_{SLD} that we used in getting to Bucharest. The progress of an A* tree search for Bucharest is shown in Figure 2.2.
The values of 'g ' are computed from the step costs shown in the Romania map(figure 2.1). Also the values of h_{SLD} are given in Figure 2.1.

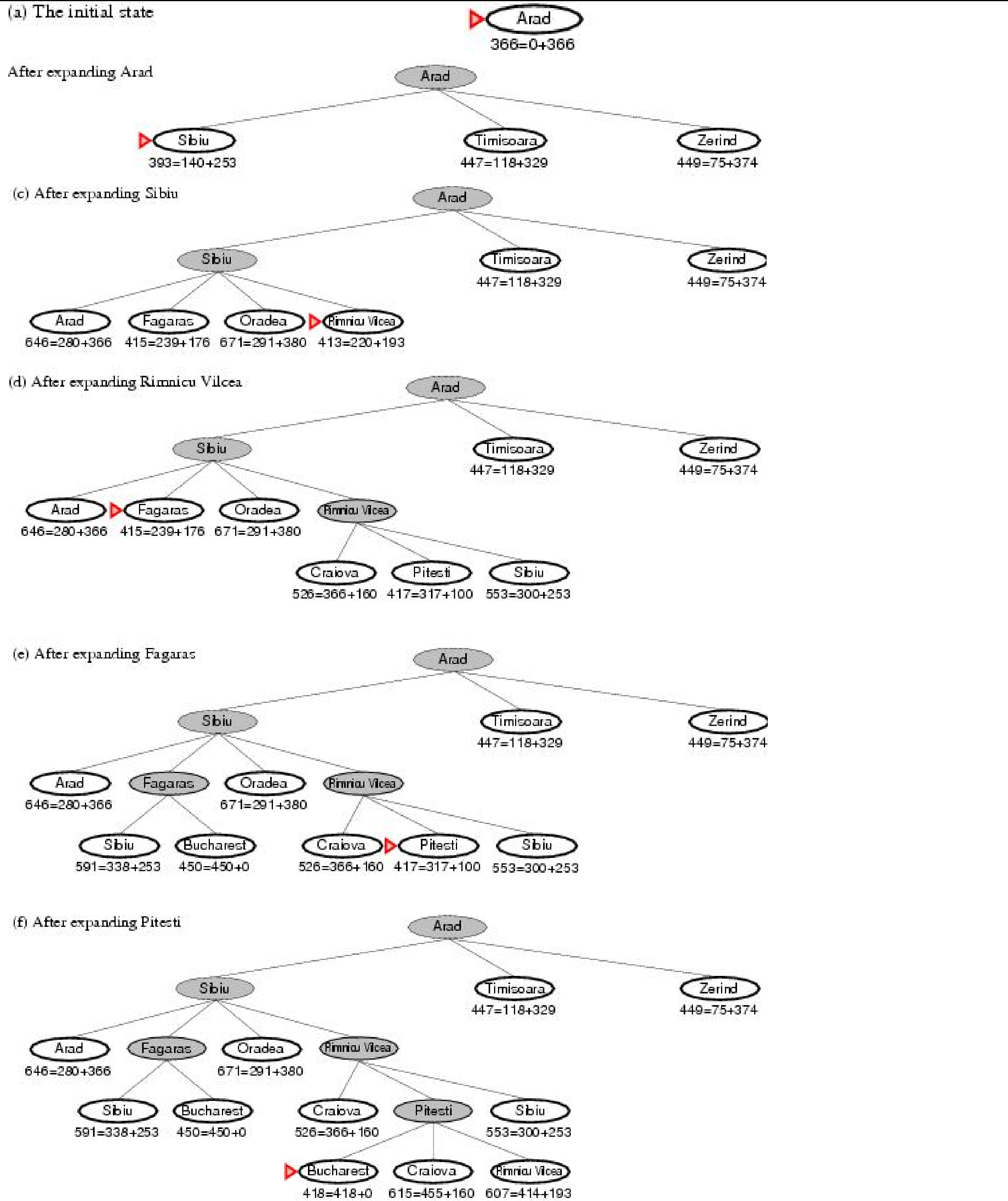


Figure 2.3 Stages in A^* Search for Bucharest. Nodes are labeled with $f = g + h$. The h-values are the straight-line distances to Bucharest taken from figure 2.1

2.1.2 Heuristic Functions

A **heuristic function** or simply a heuristic is a function that ranks alternatives in various search algorithms at each branching step basing on an available information in order to make a decision which branch is to be followed during a search

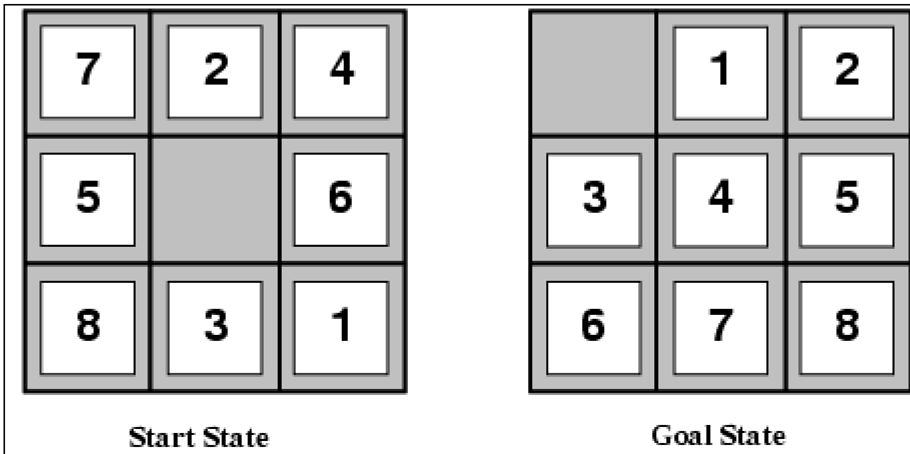


Figure 2.6 A typical instance of the 8-puzzle.
The solution is 26 steps long.