ICS 271
Fall 2016
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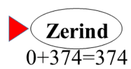
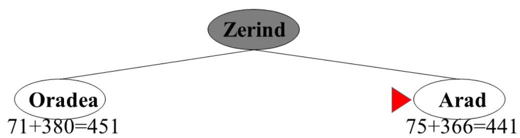
Instructor : Kalev Kask
Homework Assignment 2
Due Tuesday, 10/18

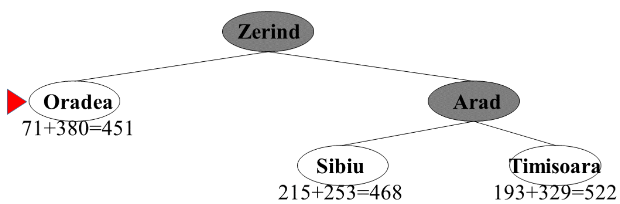
1. (a) Step 1



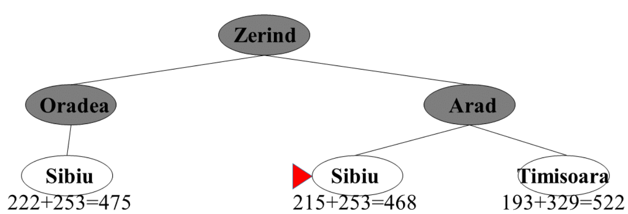
(b) Step 2



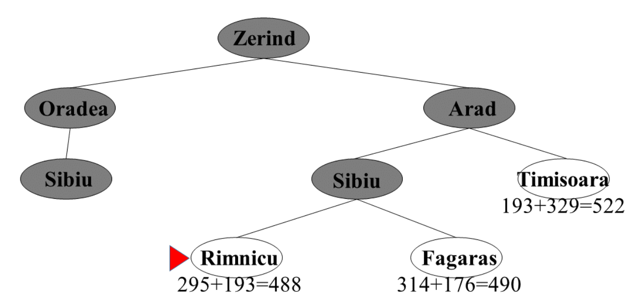
(c) Step 3



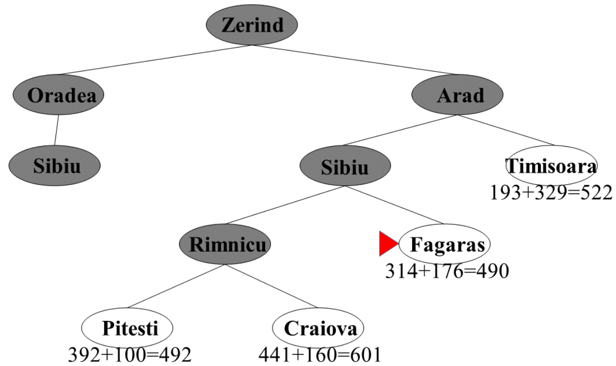
(d) Step 4



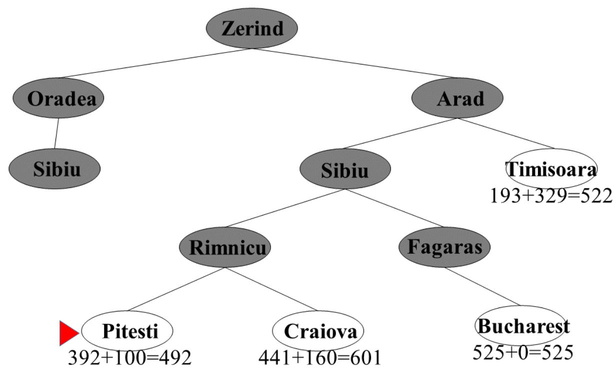
(e) Step 5



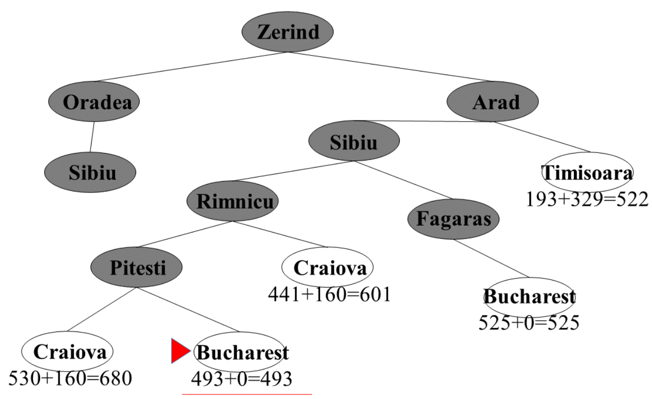
(f) Step 6



(g) Step 7



(h) Step 8



2. (a)

$$
\begin{aligned}
f(n+1) &= g(n+1) \\
&= g(n) + c(n, n+1) \\
&\geqslant g(n) \\
&\geqslant f(n)
\end{aligned} \tag{1}
$$

(b)

$$
\begin{aligned}
h(n) &= max(h_1(n), h_2(n)) \\
&\leqslant max(h_1(n') + c(n,n'), h_2(n') + c(n,n')) \\
&\leqslant max(h_1(n'), h_2(n')) + c(n,n') \\
&\leqslant h(n') + c(n,n')
\end{aligned} \tag{2}
$$

(c) h is consistent, so $h(n) \leqslant h(n') + c(n, n')$. Also we have $h(n^{goal}) = 0$. Then,

$$\begin{aligned}
h(n^{goal-1}) &\leqslant h(n^{goal}) + c(n^{goal-1}, n^{goal}) \\
&\leqslant c(n^{goal-1}, n^{goal}) \\
h(n^{goal-2}) &\leqslant h(n^{goal-1}) + c(n^{goal-2}, n^{goal-1}) \\
&\leqslant c(n^{goal-2}, n^{goal}) \\
&. \\
&. \\
&. \\
h(n^{goal-i}) &\leqslant h(n^{goal-i}) + c(n^{goal-i-1}, n^{goal-i}) \\
&\leqslant c(n^{goal-i}, n^{goal})
\end{aligned} \tag{3}$$

For any node, it's admissible since it always underestimates the path cost to the goal state.

(d)

$$\begin{aligned}
f(n) &= g(n) + h(n) \\
&\leqslant g(n) + h(n') + c(n, n') \\
&\leqslant g(n) + c(n, n') + h(n') \\
&\leqslant g(n') + h(n') \\
&\leqslant f(n')
\end{aligned} \tag{4}$$

$f(n)$ is always increasing, once a node has been visited, it cannot be visited again at a smaller cost.

(e) For node $h_1(n) > h_2(n)$, we have $f_1(n) > f_2(n)$. If node n has the smallest value in opened nodes, the same node is expanded by both heuristics. If exist a node n' in opened nodes, that $f_1(n) > f_1(n')$ and $f_2(n) < f_2(n')$, we should choose n' for f_1 but keep n for f_2. If n' leed to the goal, heuristic h_2 would need more steps to the goal. In this way, A^* with h_1 always expands less nodes than A^* with h_2.

3. If $0 \leqslant \omega \leqslant 1$, Complete

   If $0 \leqslant \omega \leqslant 1$, Optimal

   If $\omega = 0$, $f(n) = 2g(n)$, Uninformed best-first search

   If $\omega = 1$, $f(n) = g(n) + h(n)$, A^* search

   If $\omega = 2$, $f(n) = 2h(n)$, Greedy best-first search

4. Yes. When we compute the cost($g(n)$) of one node, if $g(n) \geqslant f_U$, we can close this node because this path would cost more than the exist path U.

5. When a goal node has been found, it only can say that it's one solution but not the optimal solution.

   For example, let's look at Question 1 of this homework. In Step 7, it's the first time we reached the goal city Bucharest with cost of 525. But this is not the lowest cost of path. The lowest cost should be in Step 8, and the cost is 493, smaller than 525.