Informed Search

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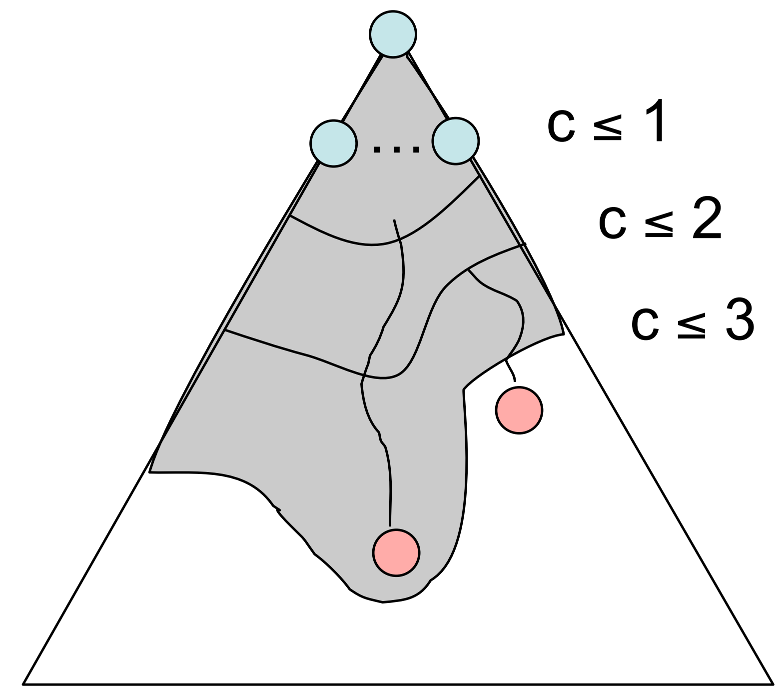
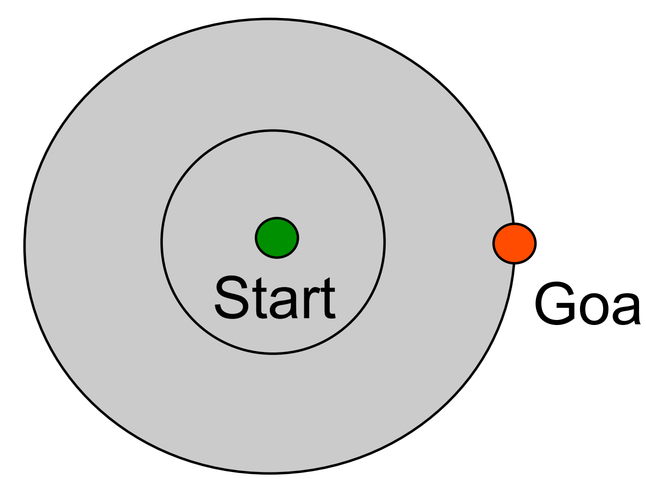
Slide material from CS 188: Artificial Intelligence at UCB
by Dan Klein, and Pieter Abbeel, used with permision

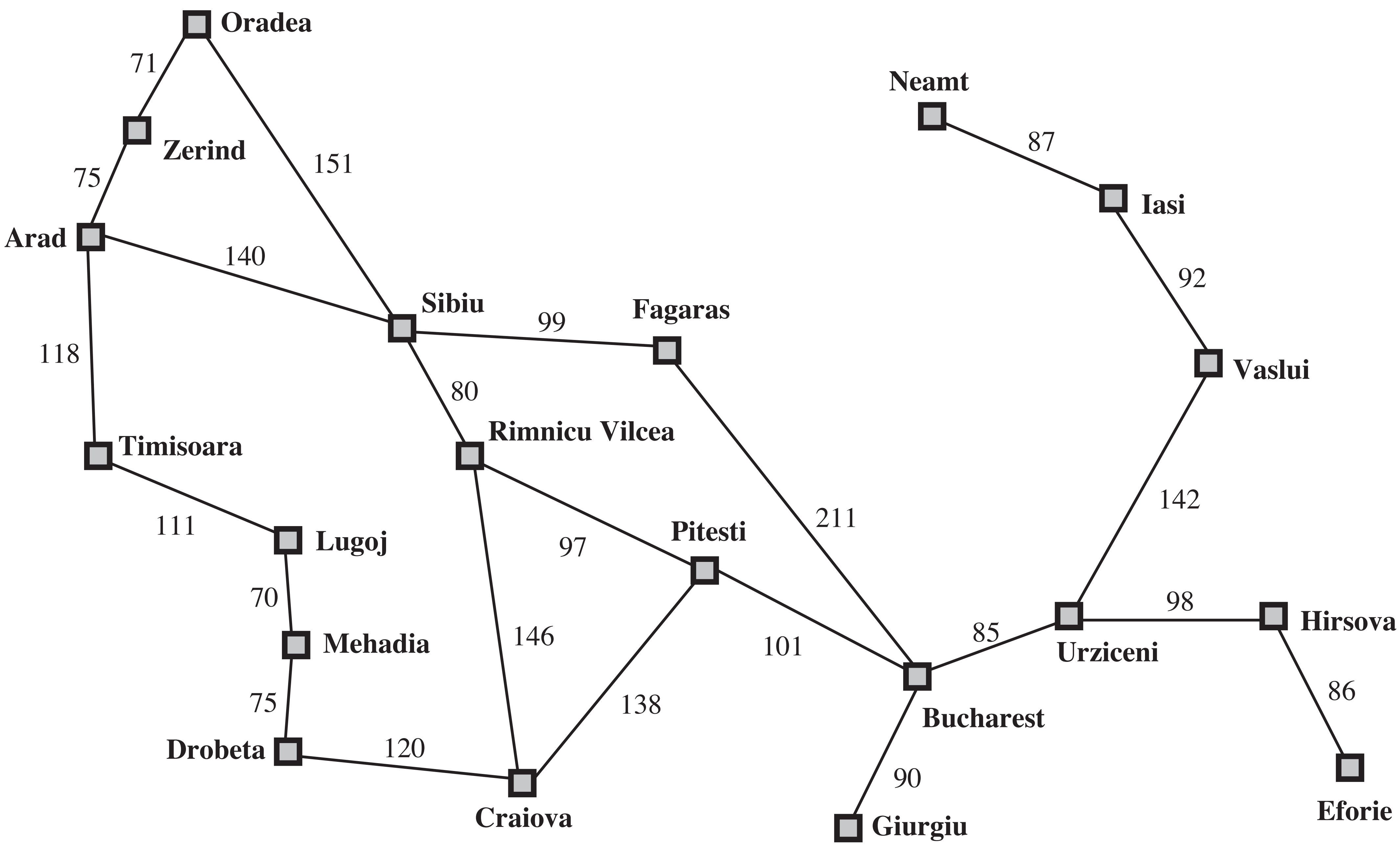
Uniform Cost Search

- Strategy: expand the lowest path cost
- UCS: complet and optimal
- but:
  - every direction
  - no info about the goal

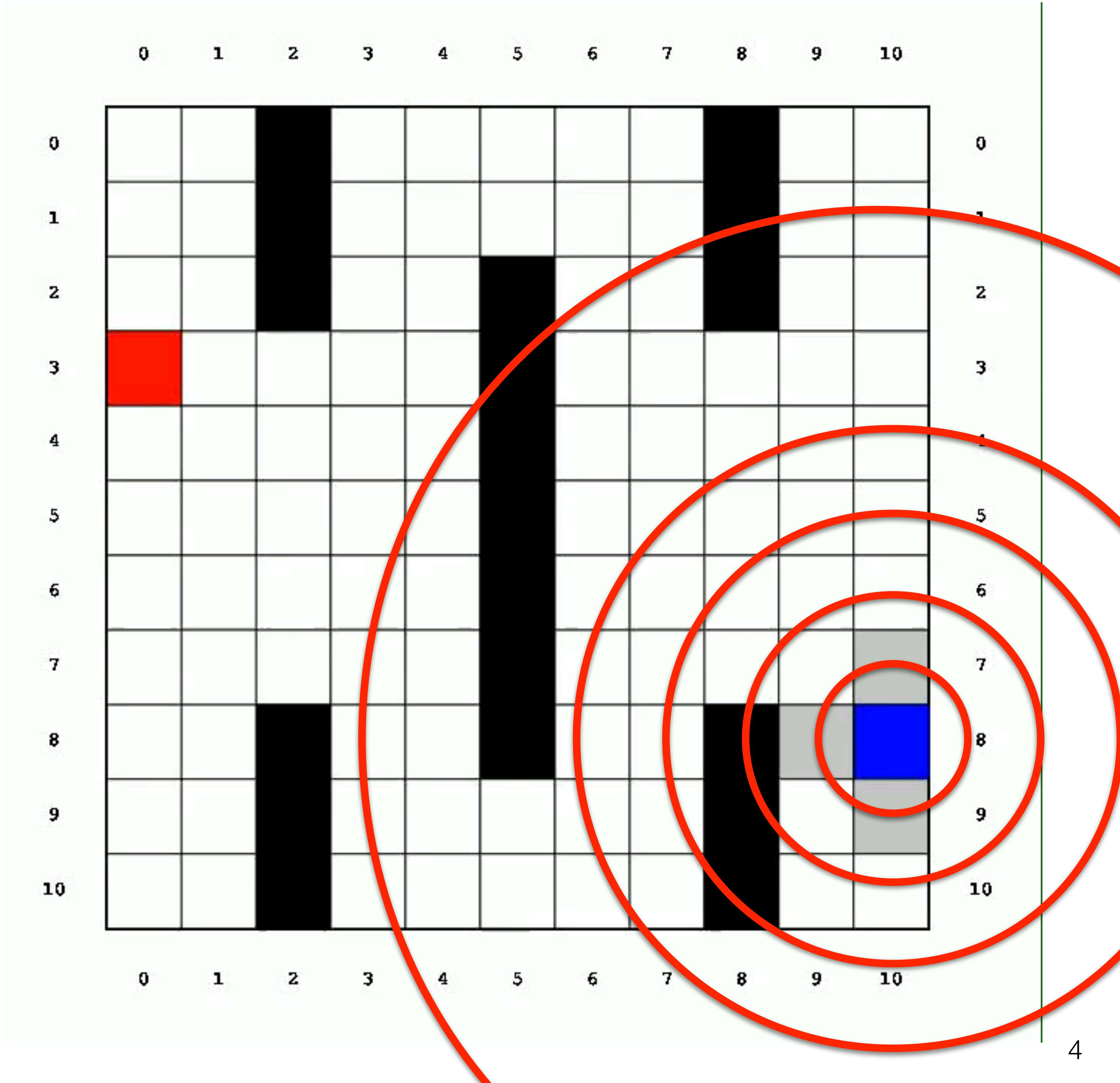




UCS - going blindly in all directions



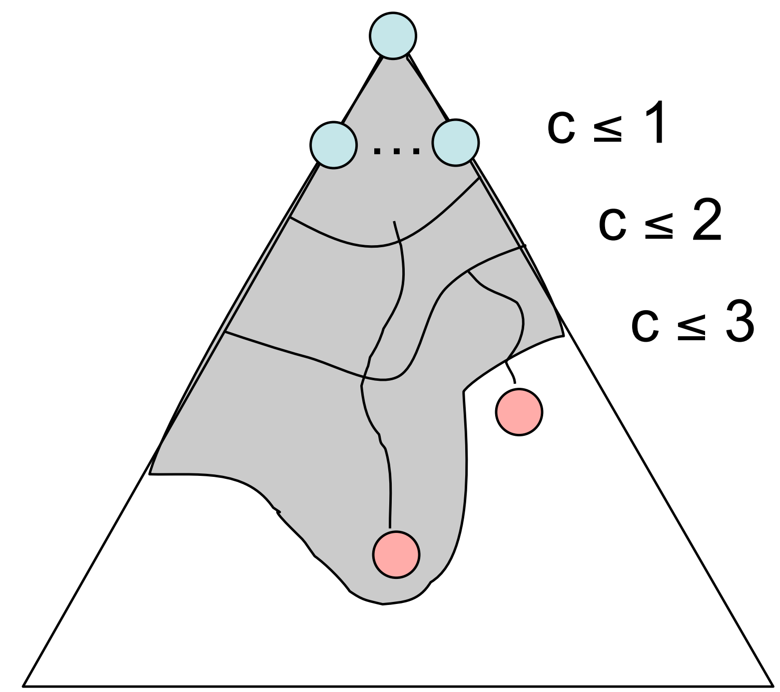
UCS search in all directions

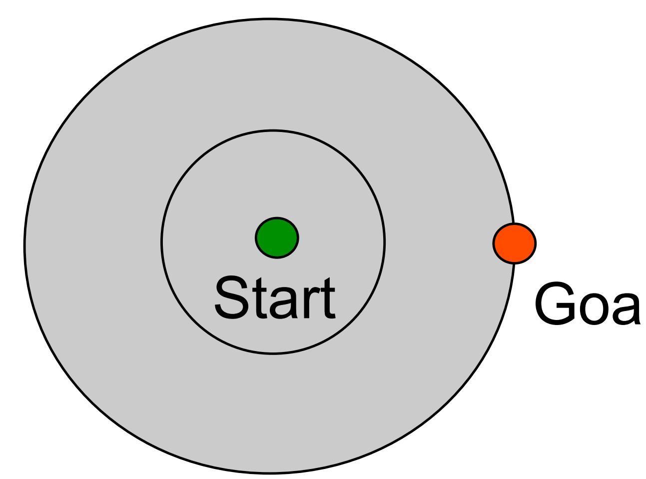


UCS strategy - recap

- take node/state closest (cheapest) to the **start**

- *f(n)* is the sum of all action costs



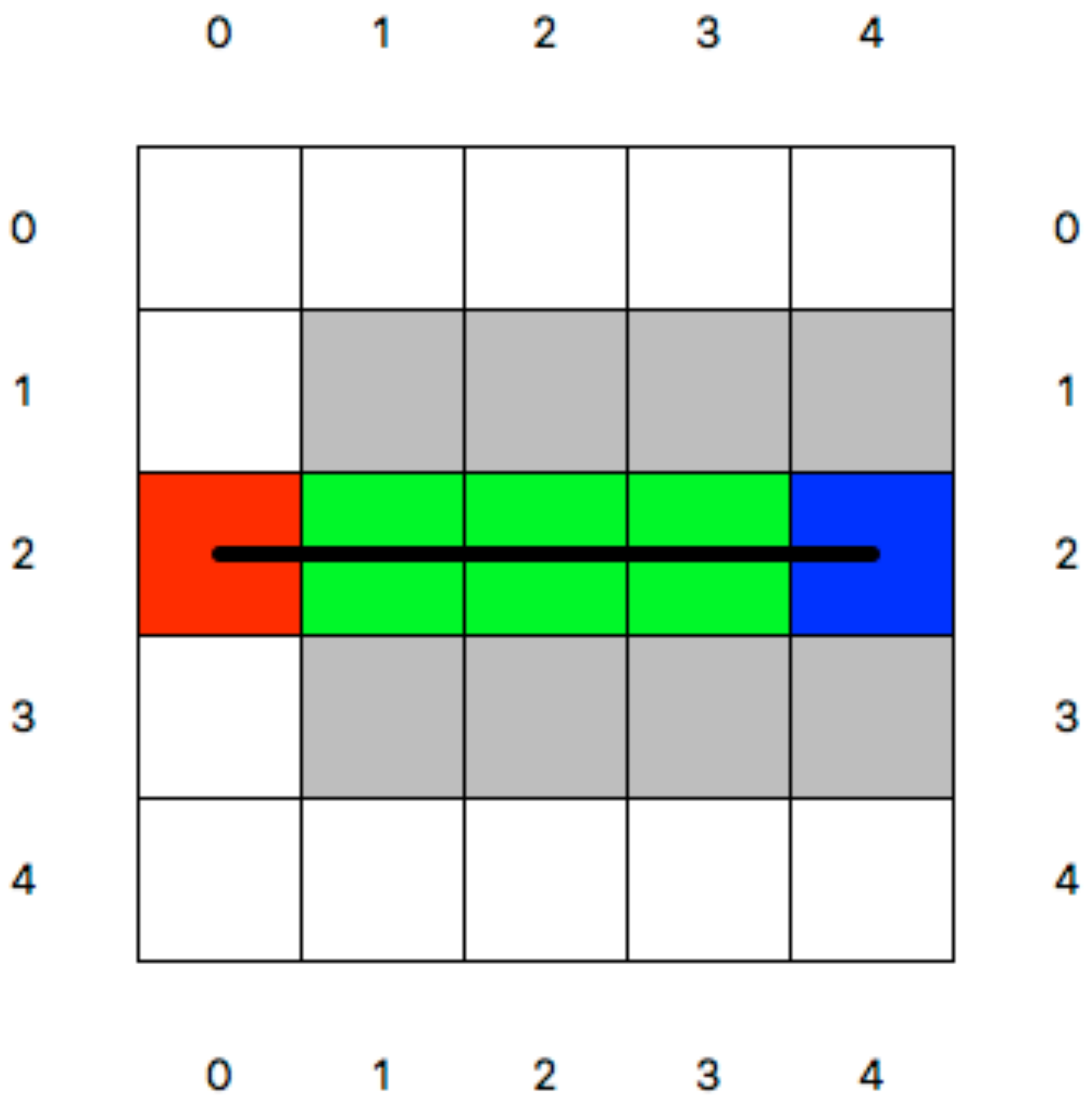


Informed Search

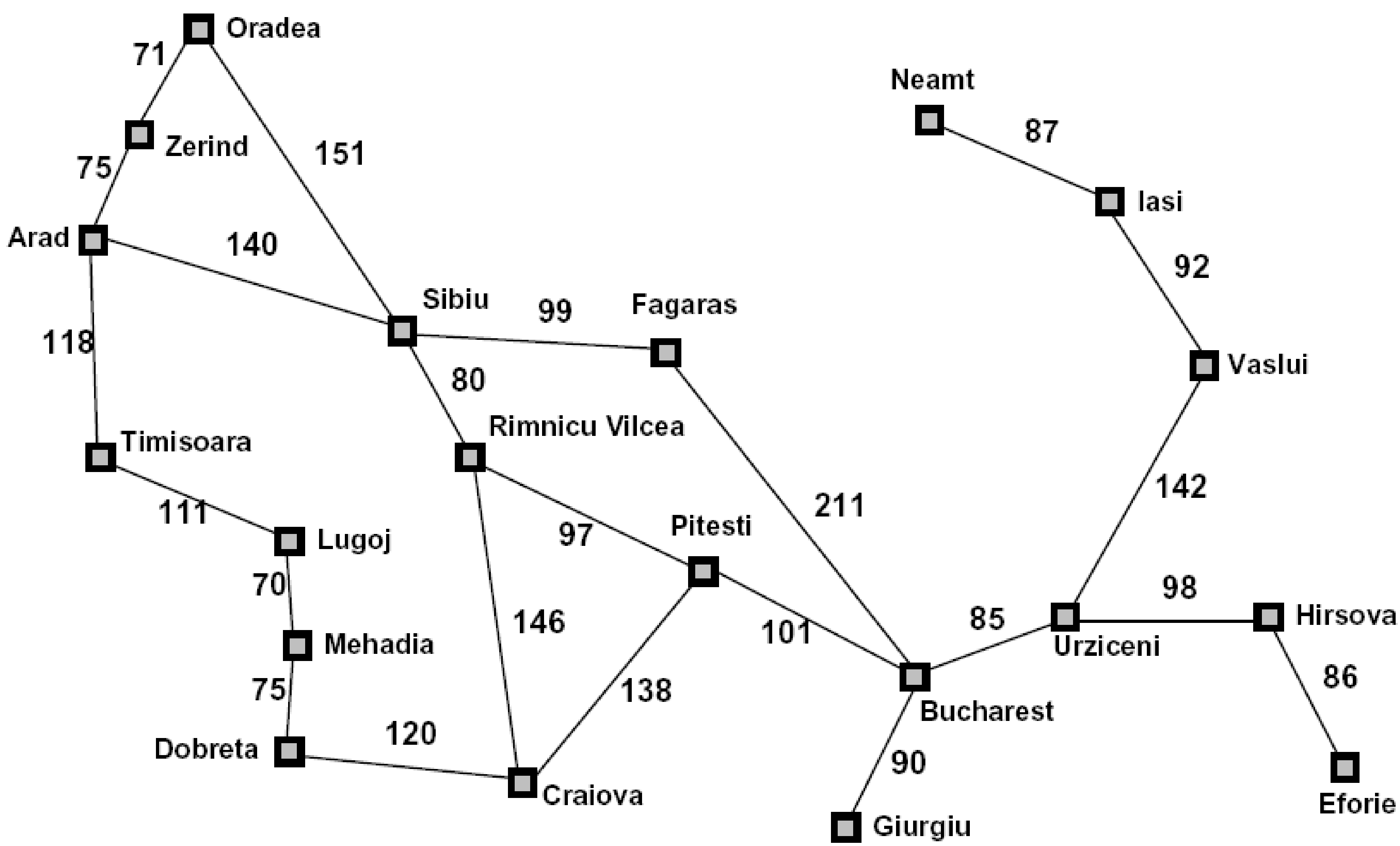
- UCS optimizes backward
- How about forward?

A Heuristic

- A function that estimates how close a state is to the goal
- Designed for a particular problem



GPS Heuristic Function

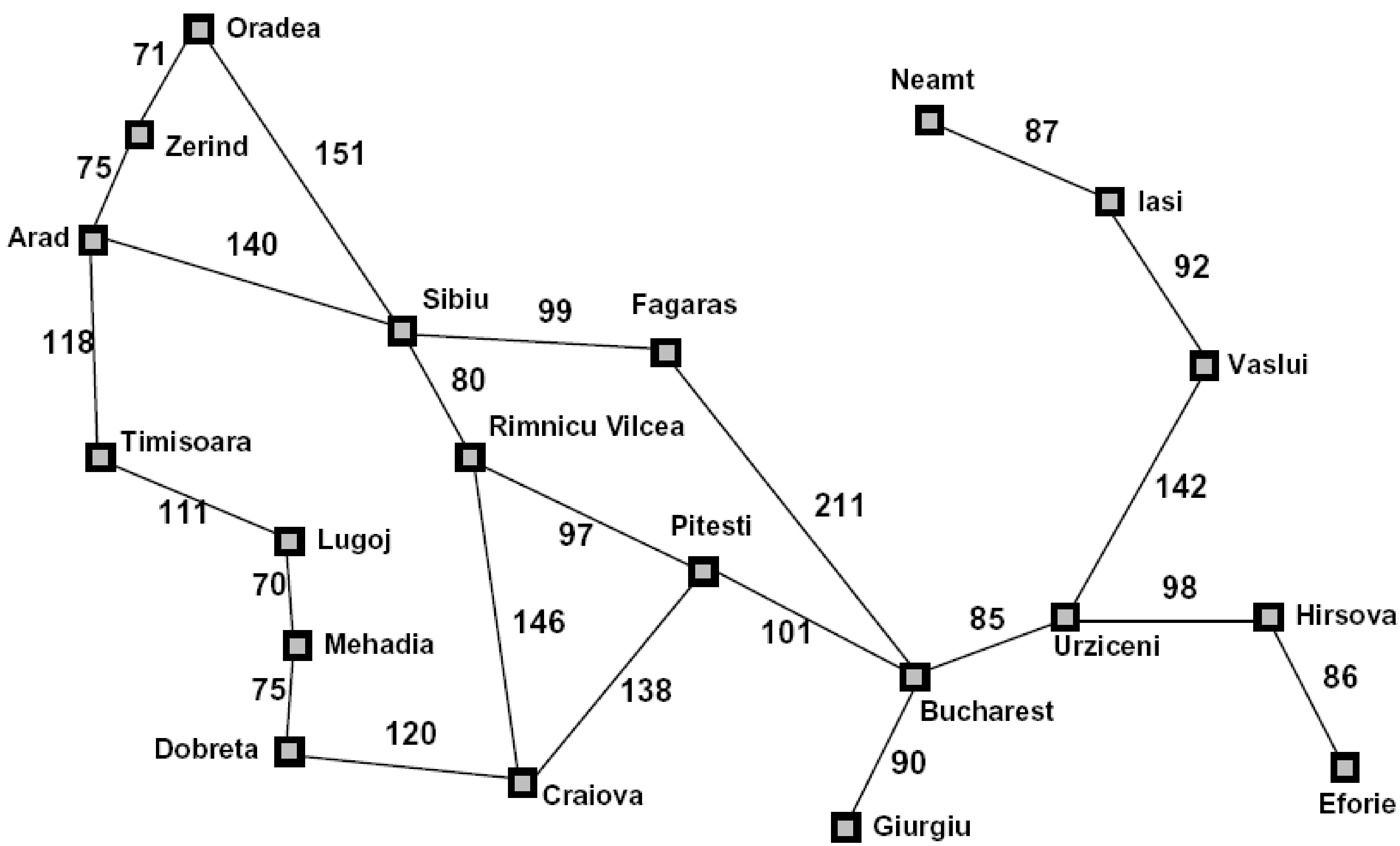


Straight−line distance
to Bucharest

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

h(x)

Greedy Strategy



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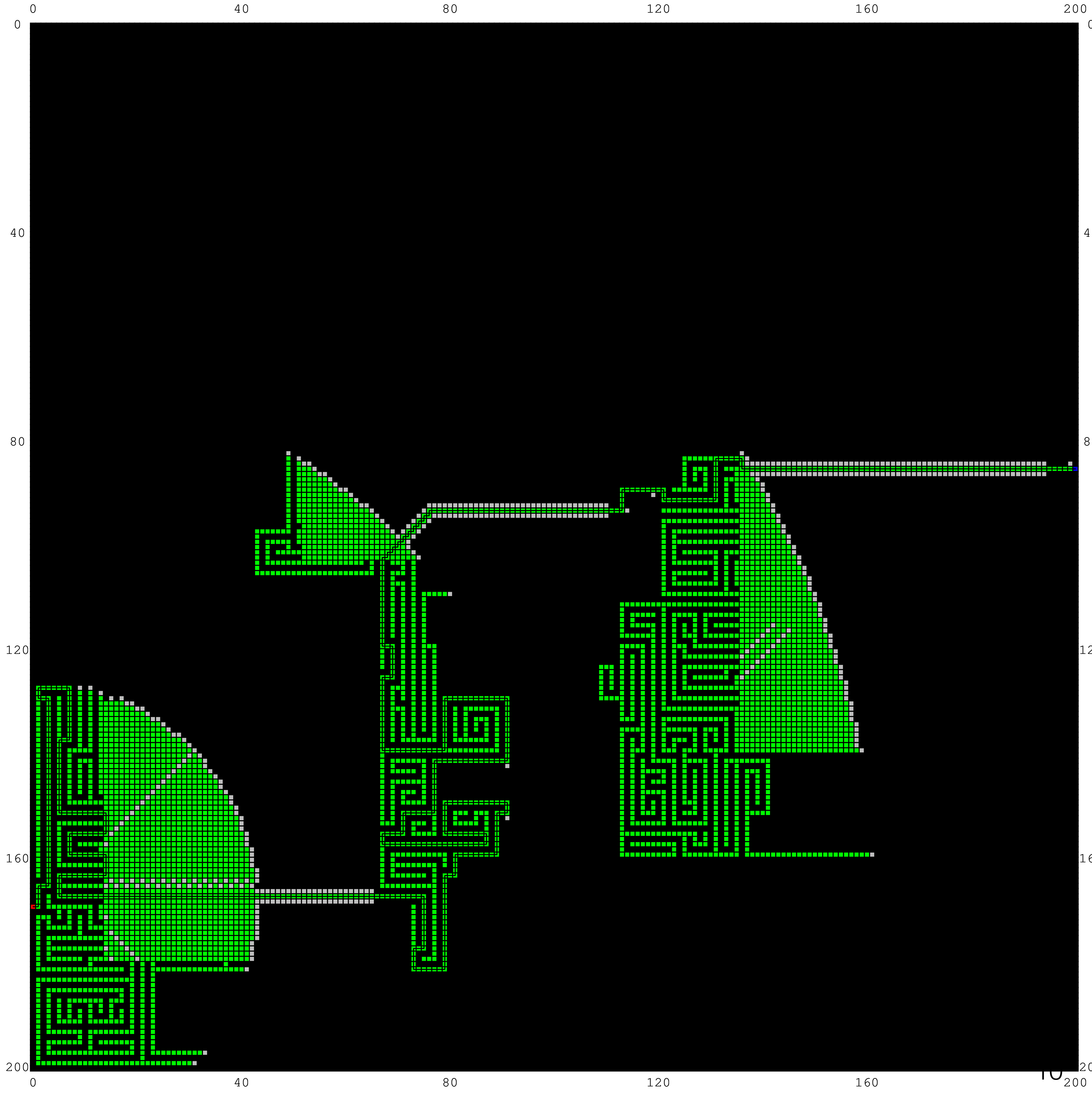
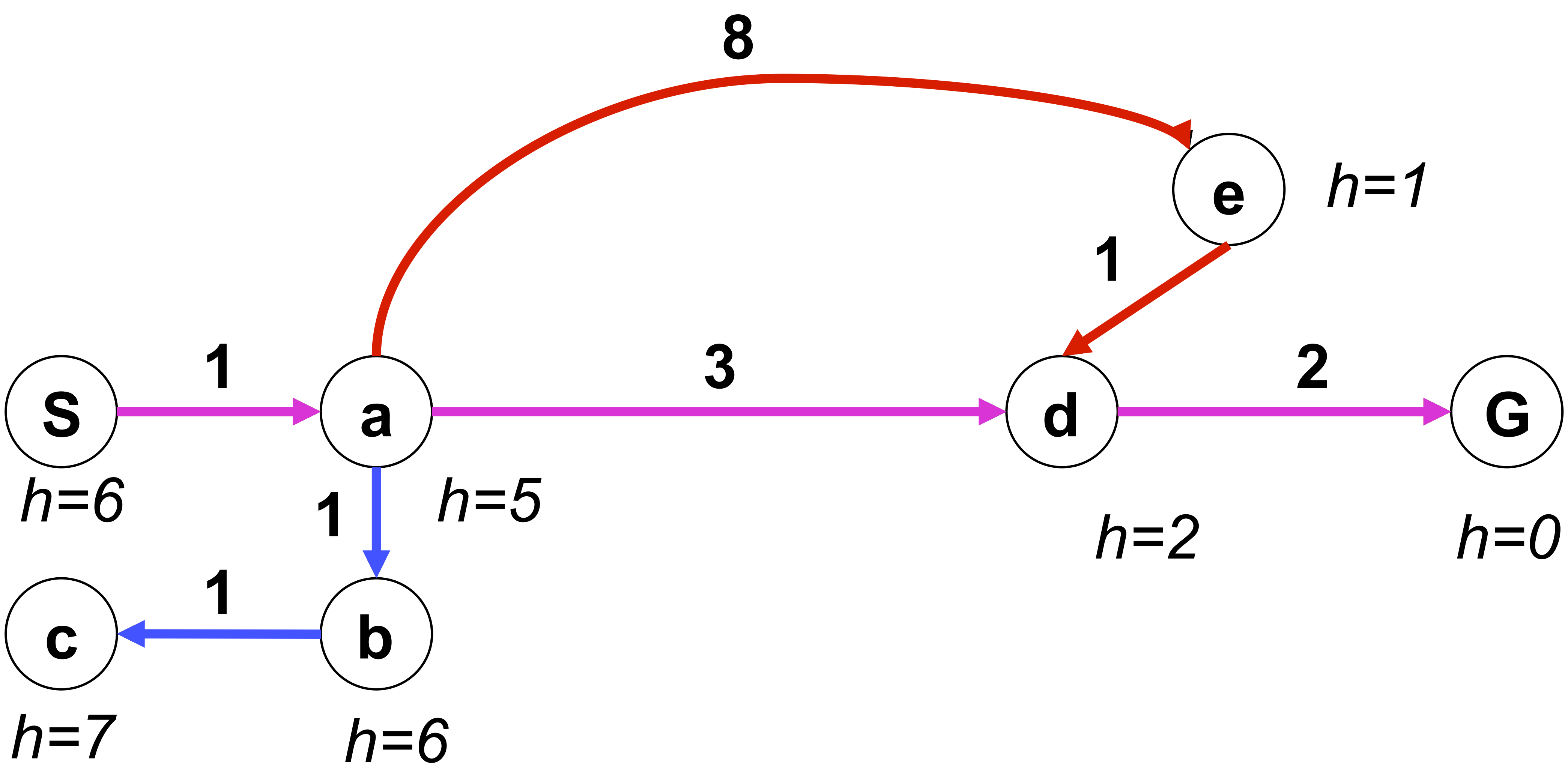
h(x)

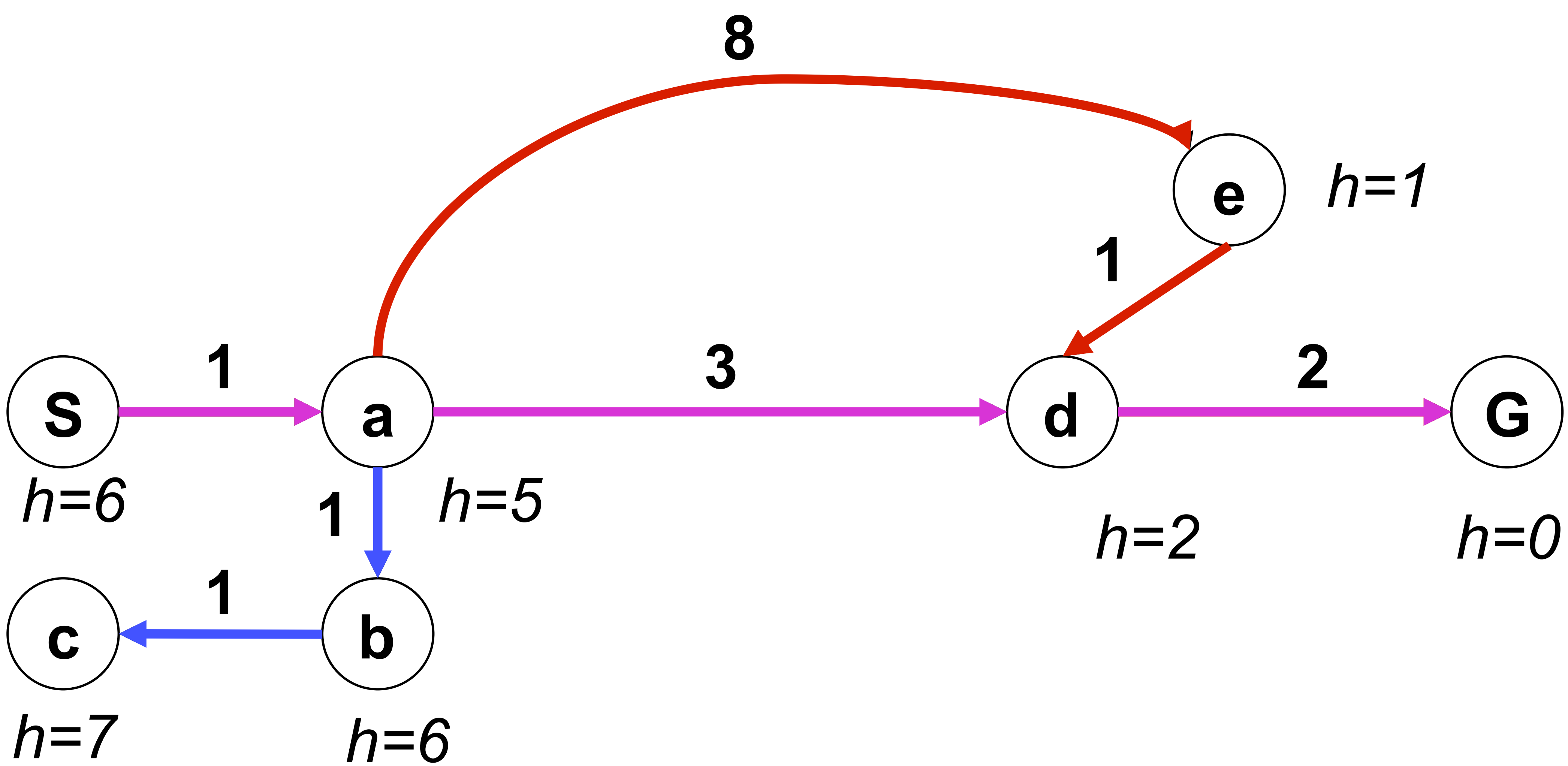
Greedy - what could possibly go wrong?



Greedy Strategy



A* combine UCS and Greedy

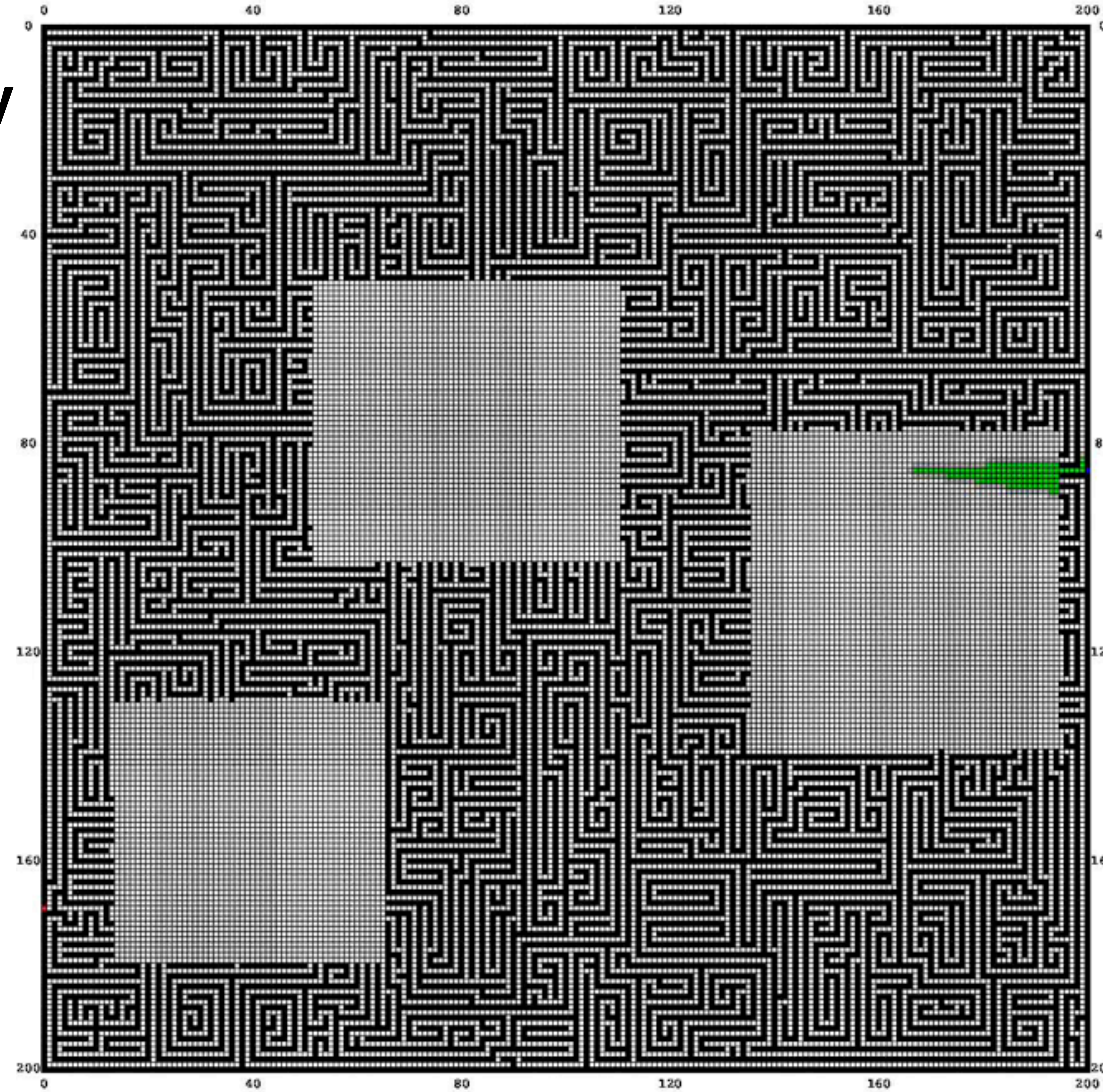


UCS orders by path cost - *backward cost g(n)*
Greedy orders by goal proximity - *forward cost h(n)*

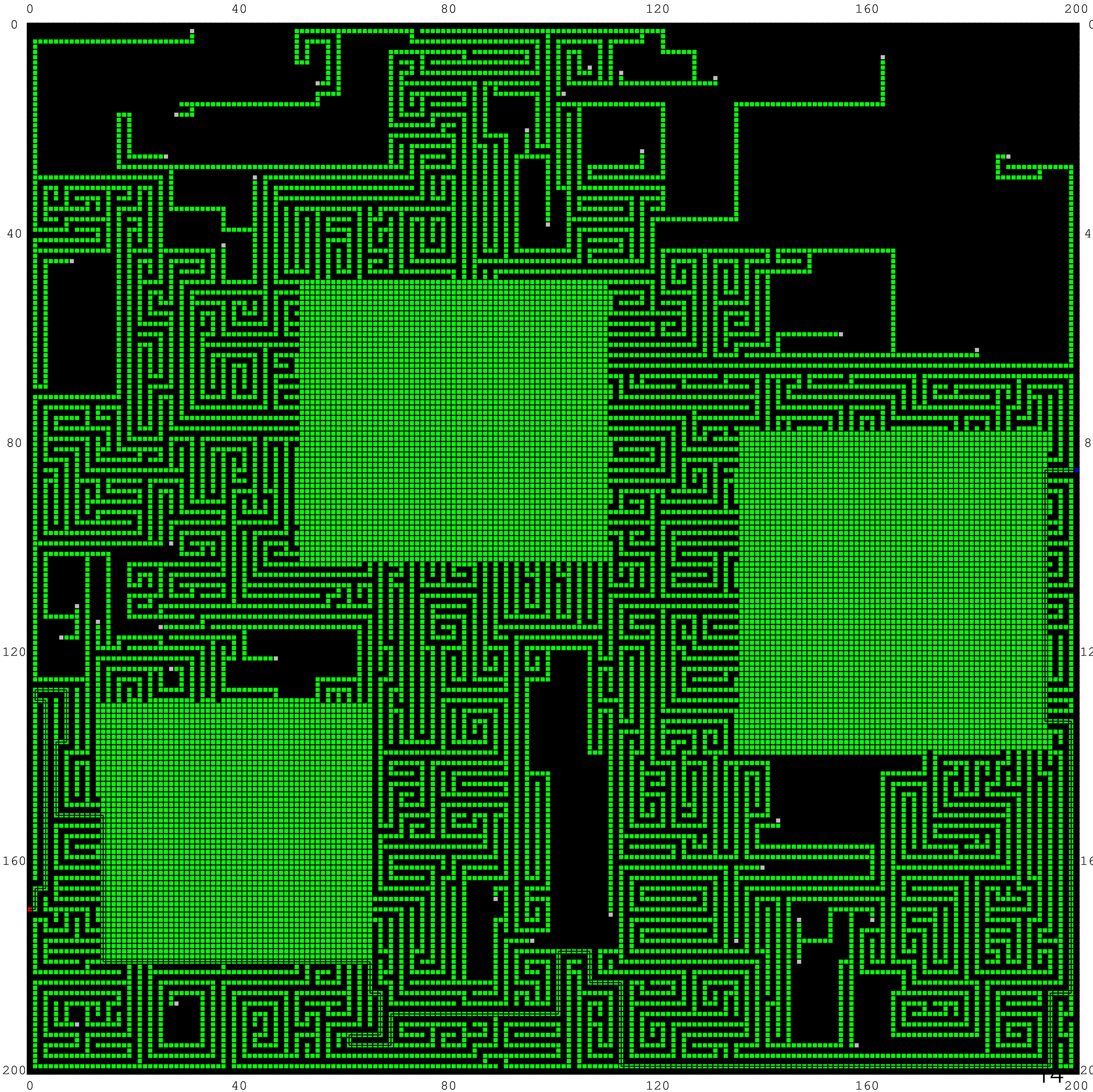
A* orders by the sum: $f(n) = g(n)+h(n)$

A*=UCS and greedy
g(n) = sum of costs
h(n) = euclidean dist
f(n) = g(n)+h(n)

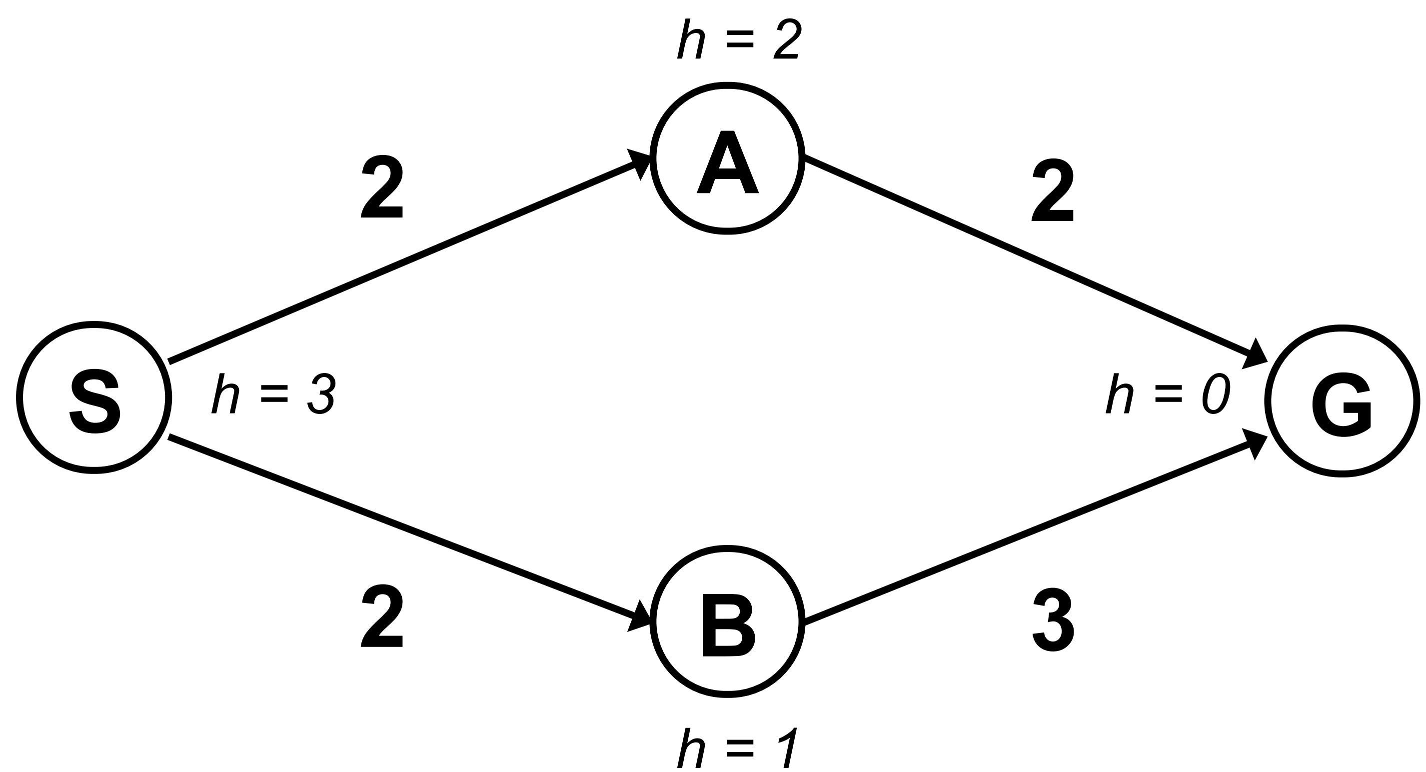
takes the min *f(n)* first



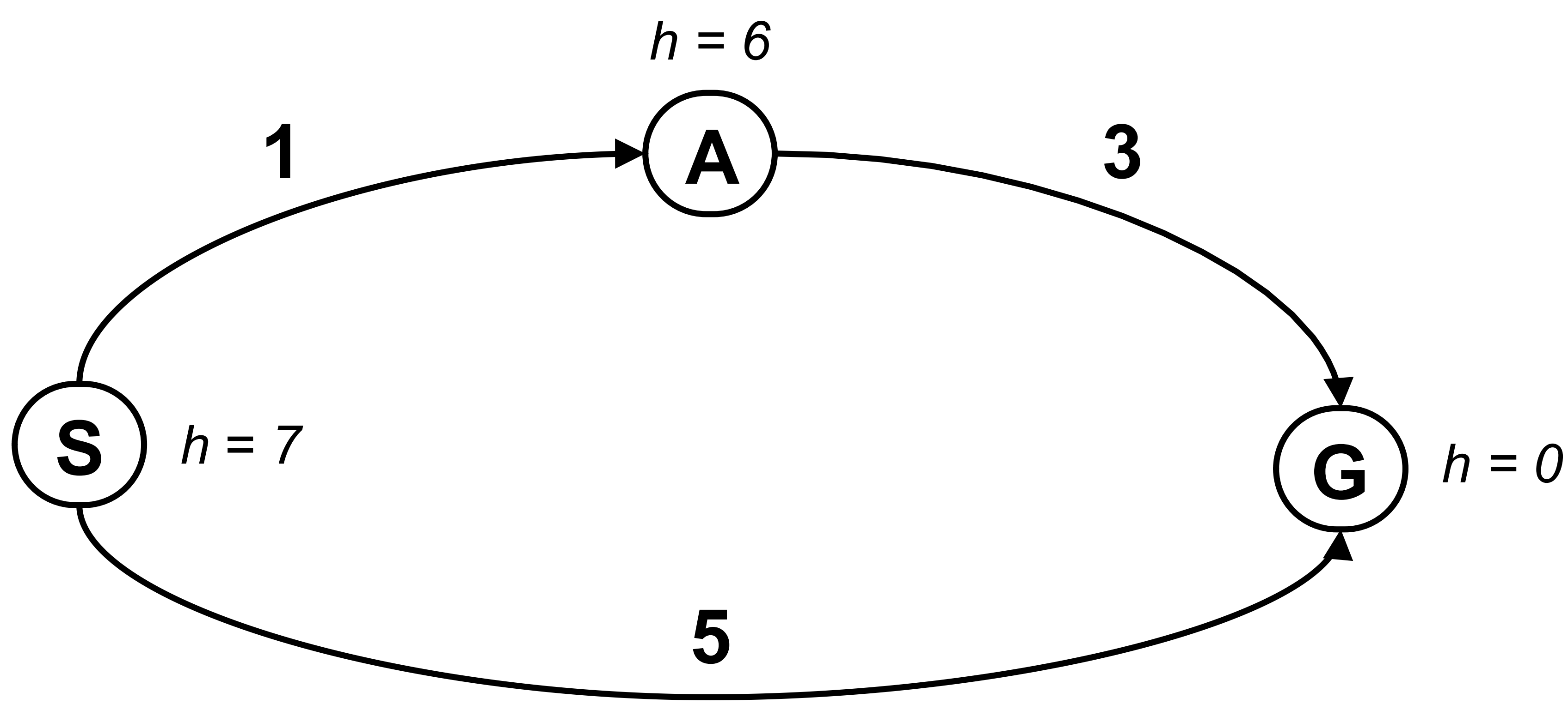
A* vs Greedy



When to stop A* search?



Is A* optimal?

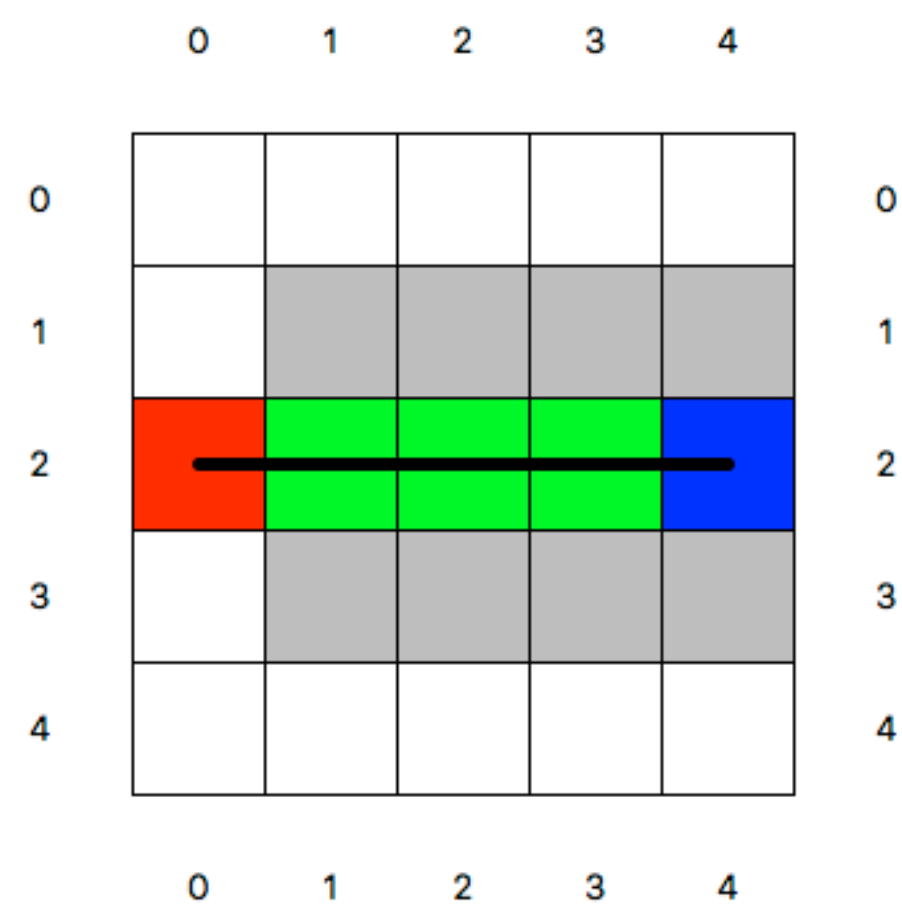


Admissible heuristics

$0 \leq h(n) \leq h^*(n)$

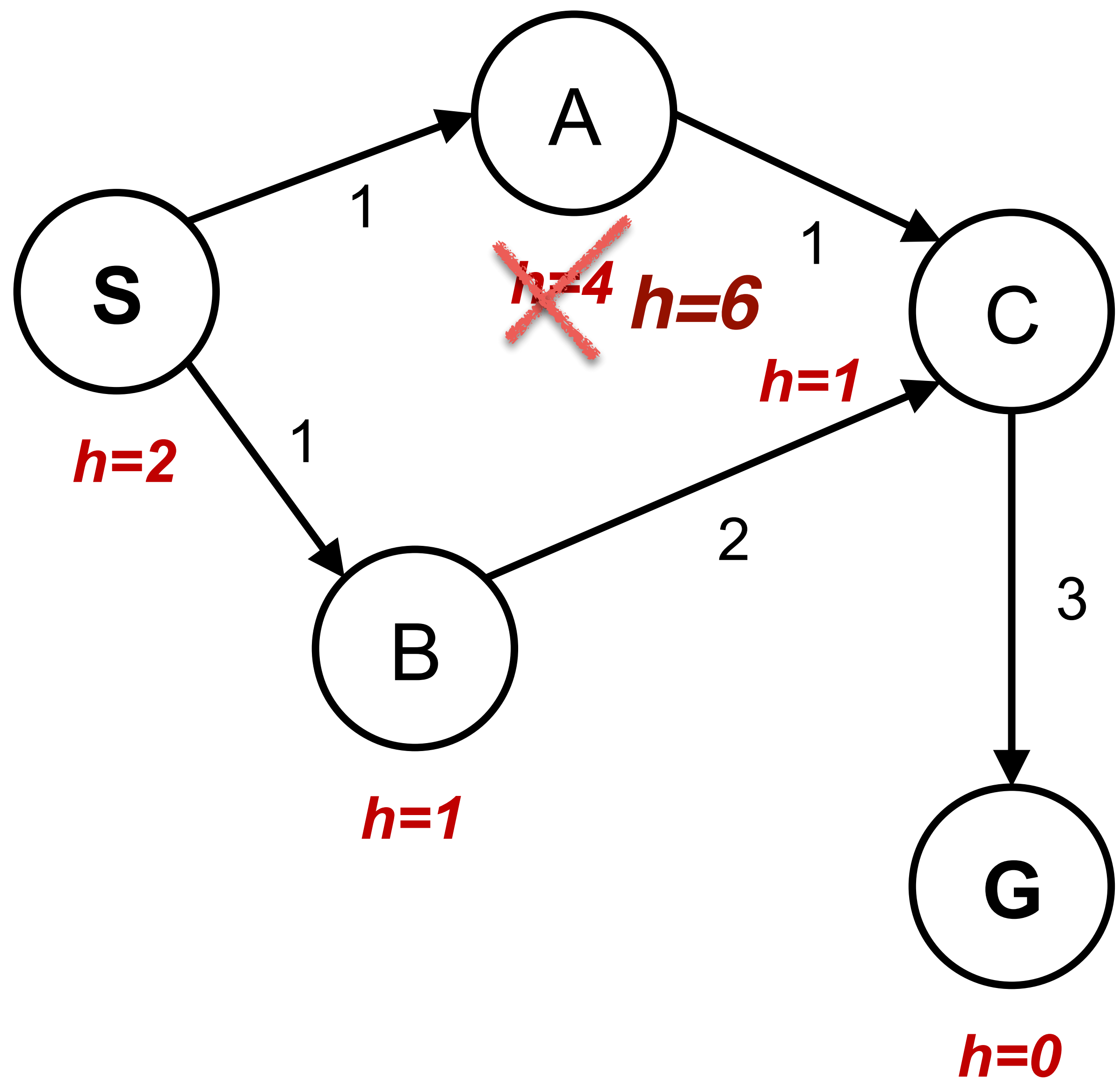
where $h^*(n)$ is the true cost to the nearest goal.

Examples?

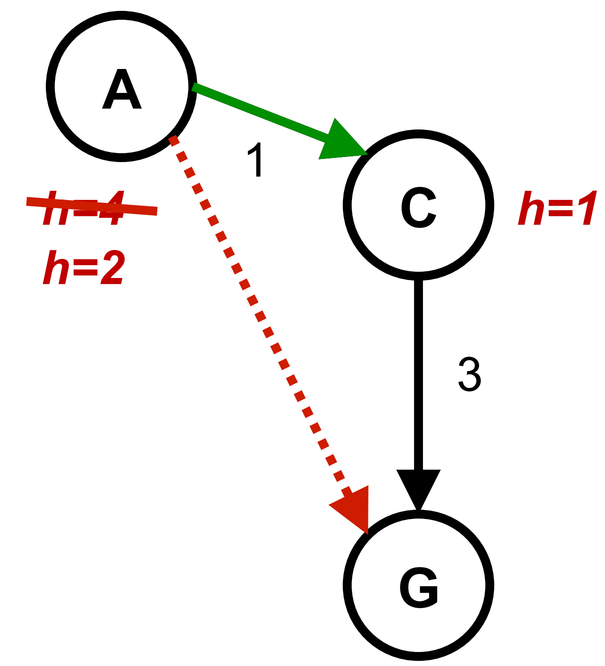


Is admissible good enough?

State space graph



Consistent! heuristic

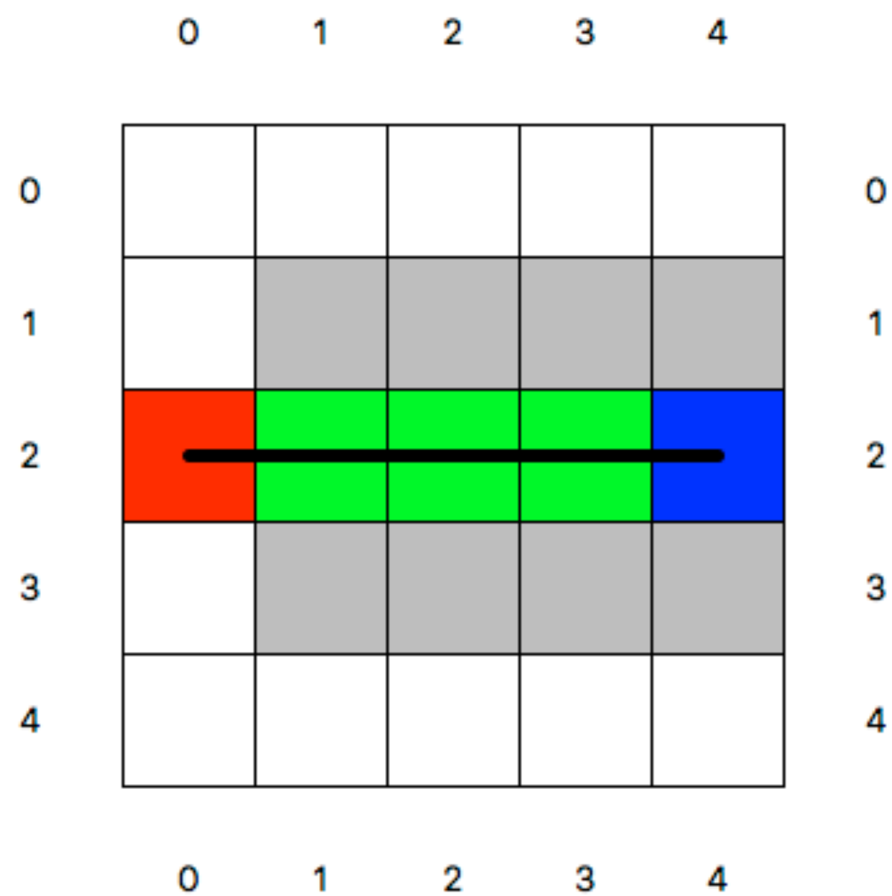


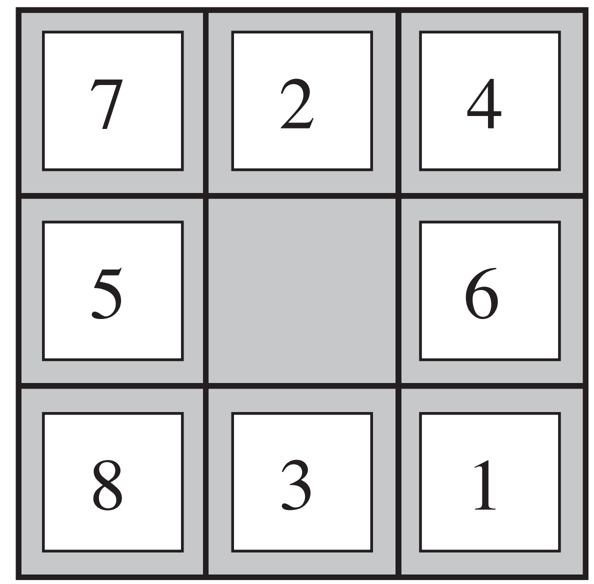
Admissible: $h(A) \leq \text{actual cost}(A \rightarrow G)$

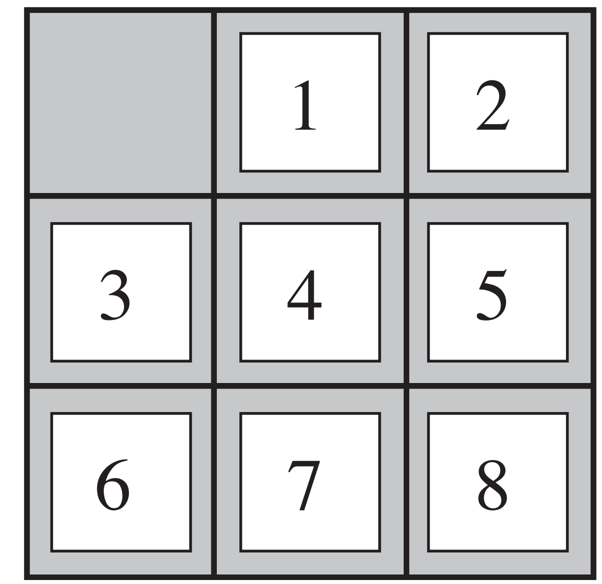
Consistent: $h(A) - h(C) \leq \text{cost}(A \rightarrow C)$

Consequence: the value *f* along a path never decreases.

How to find a heuristic?







What is the best (better) heuristic?

$$0 \leq h_1(n) < h_2(n) < h_3(n) \leq h^*(n)$$

Where $h^*(n)$ is the true cost to the nearest goal.
And all h are also consistent.

$$h^{\mathsf{best}}(n) = \mathsf{max}\{h_1(n), h_2(n), h_3(n) \ldots\}$$

Heuristic - learning from experience

- n-1 puzzle
- Let play - and observe the actual costs (number of moves)
- If too many states? How to generalize?
- …