

# Informed Search

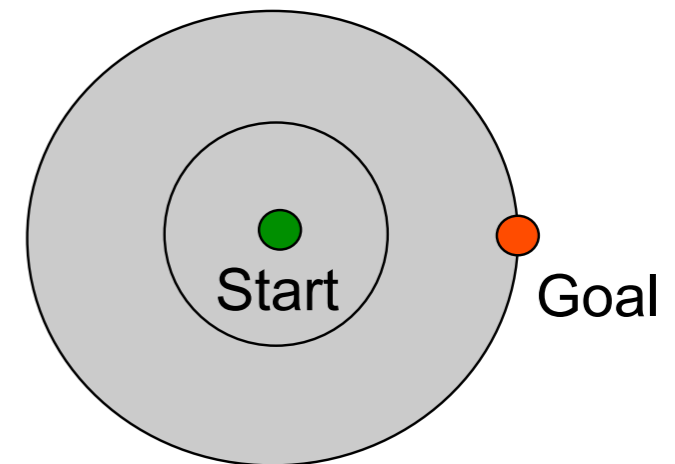
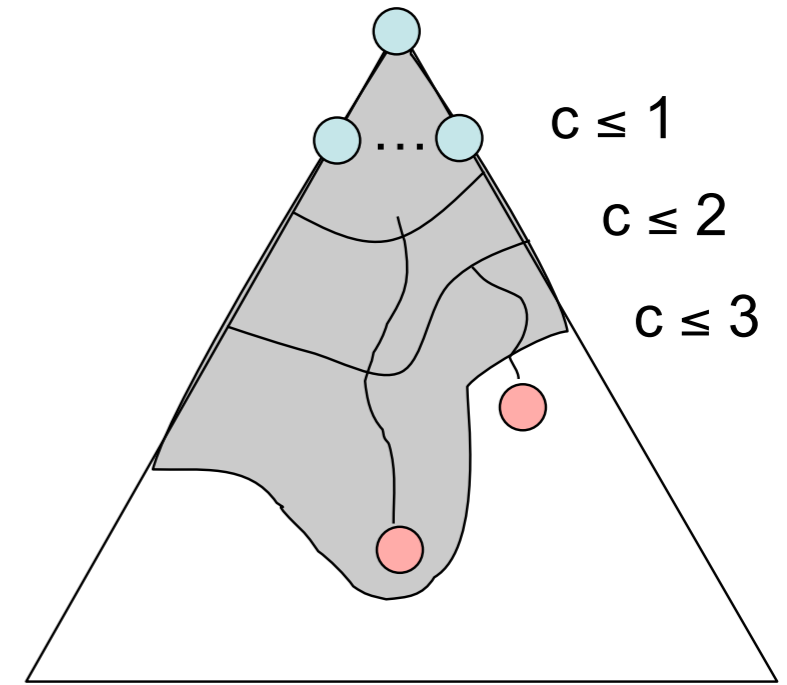
Tomas Svoboda, BE5B33KUI

2017-03-20

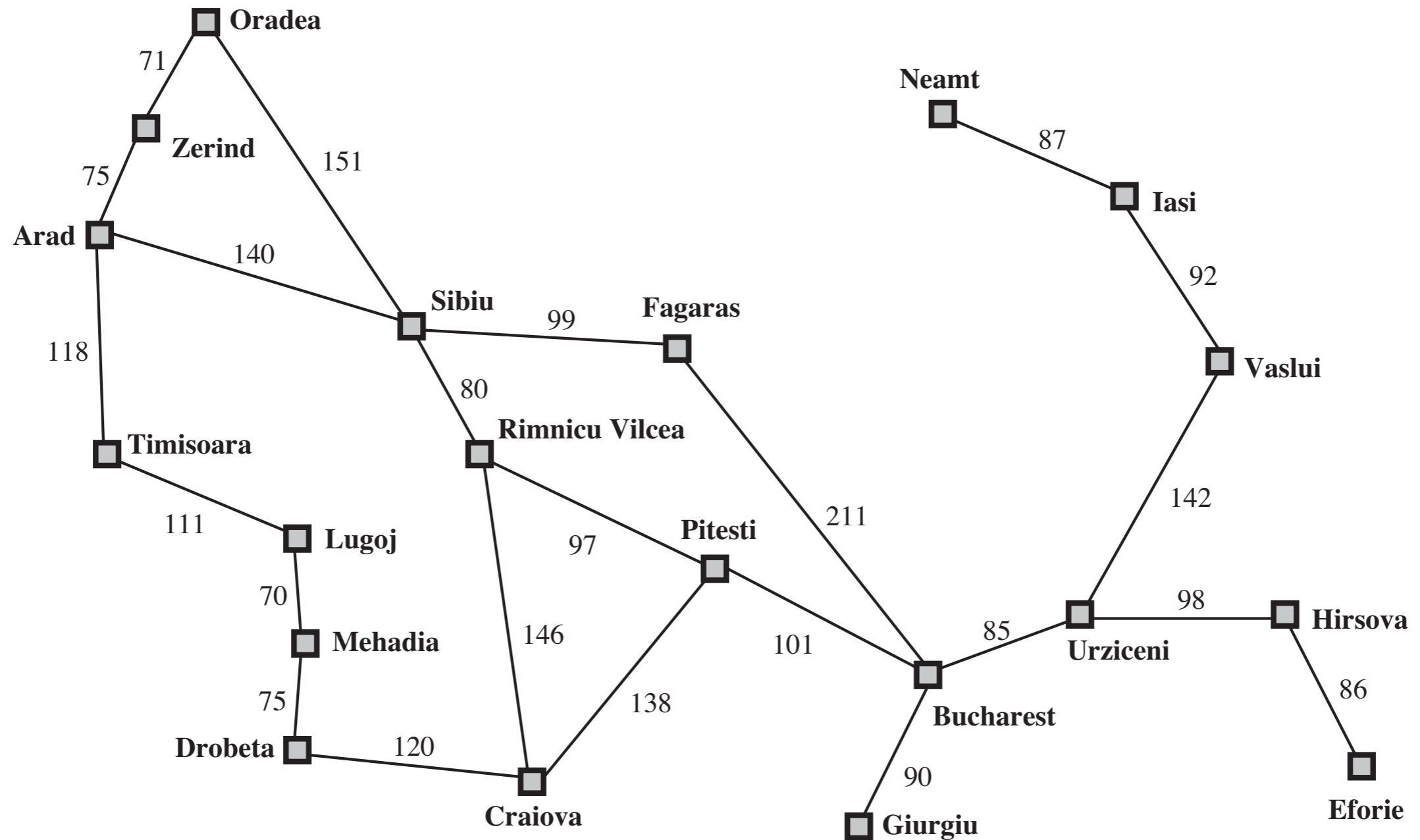
Slide material from CS 188: Artificial Intelligence at UCB  
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# Uniform Cost Search

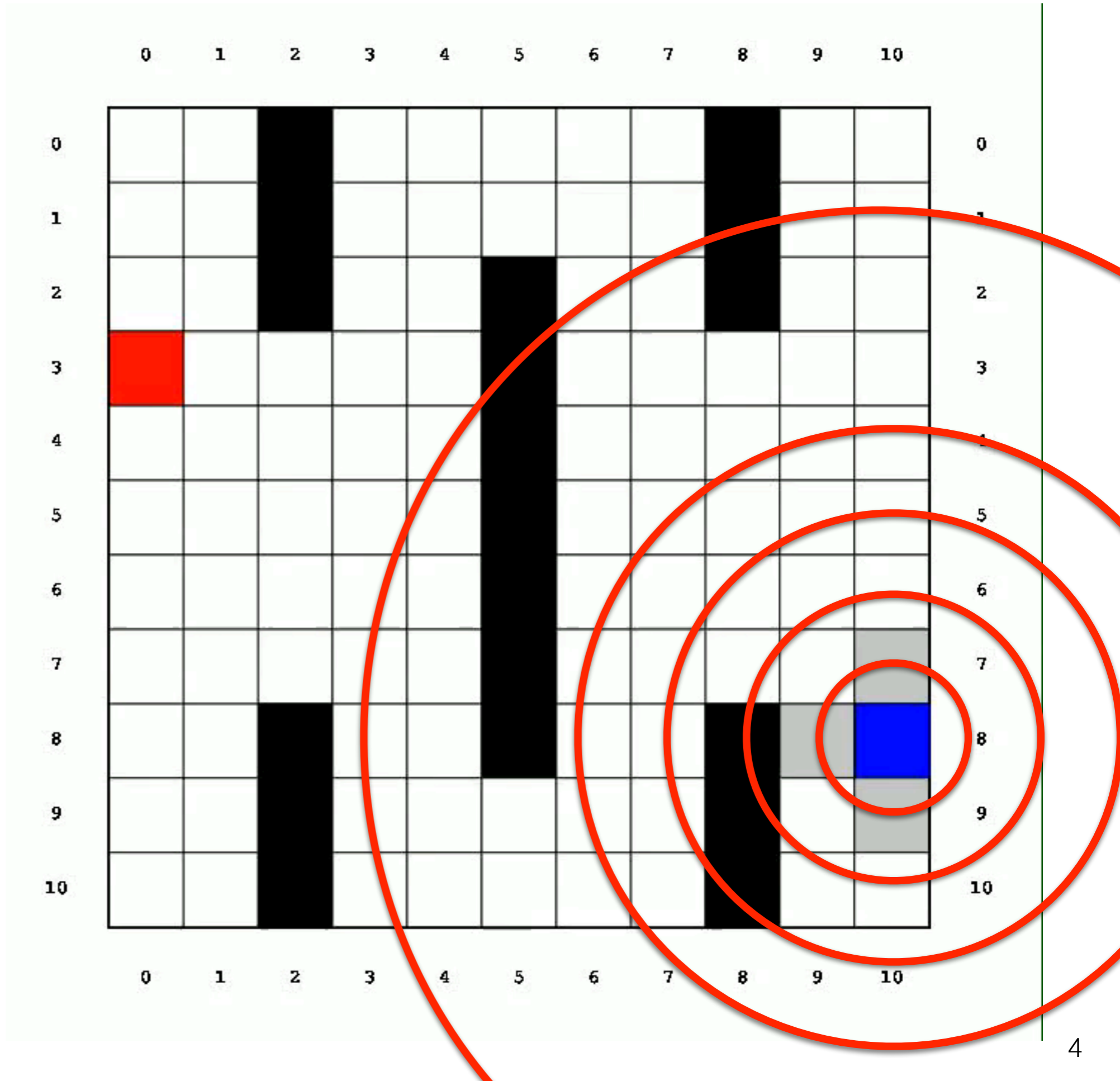
- Strategy: expand the lowest path cost
- UCS: complet and optimal
- but:
  - every direction
  - no info about the goal



# UCS - going blindly in all directions

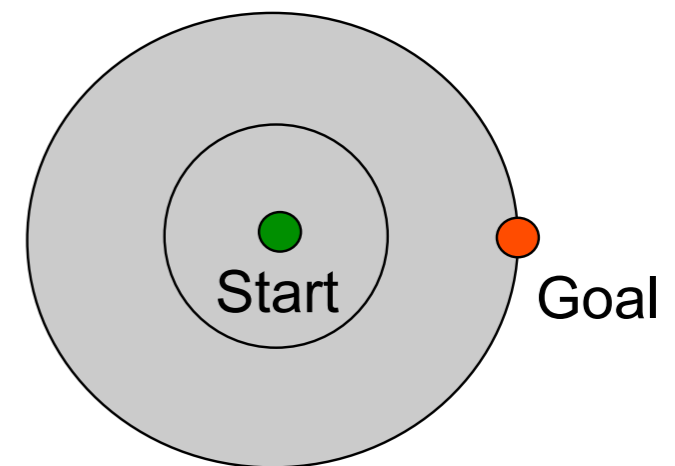
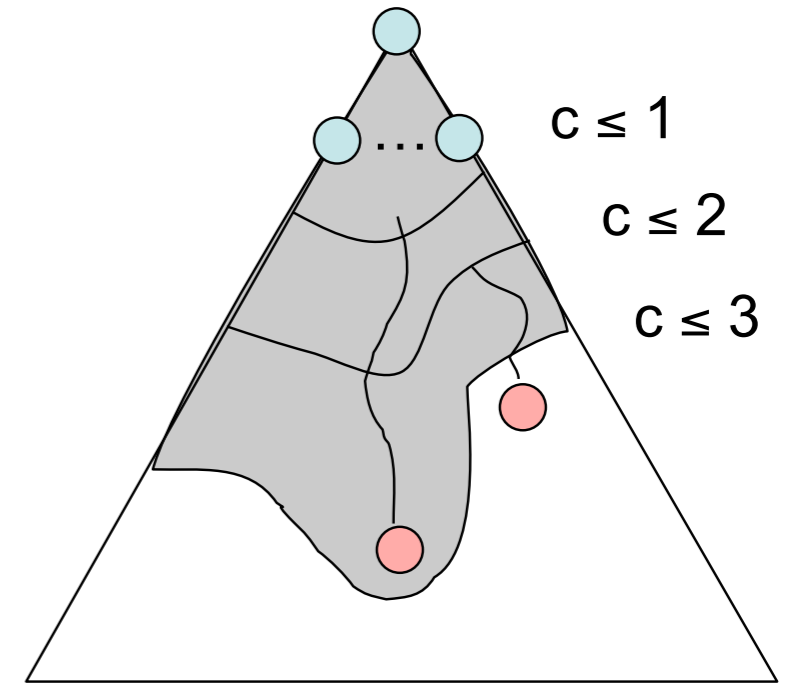


# UCS search in all directions



# UCS strategy - recap

- take node/state closest (cheapest) to the **start**
- $f(n)$  is the sum of all action costs

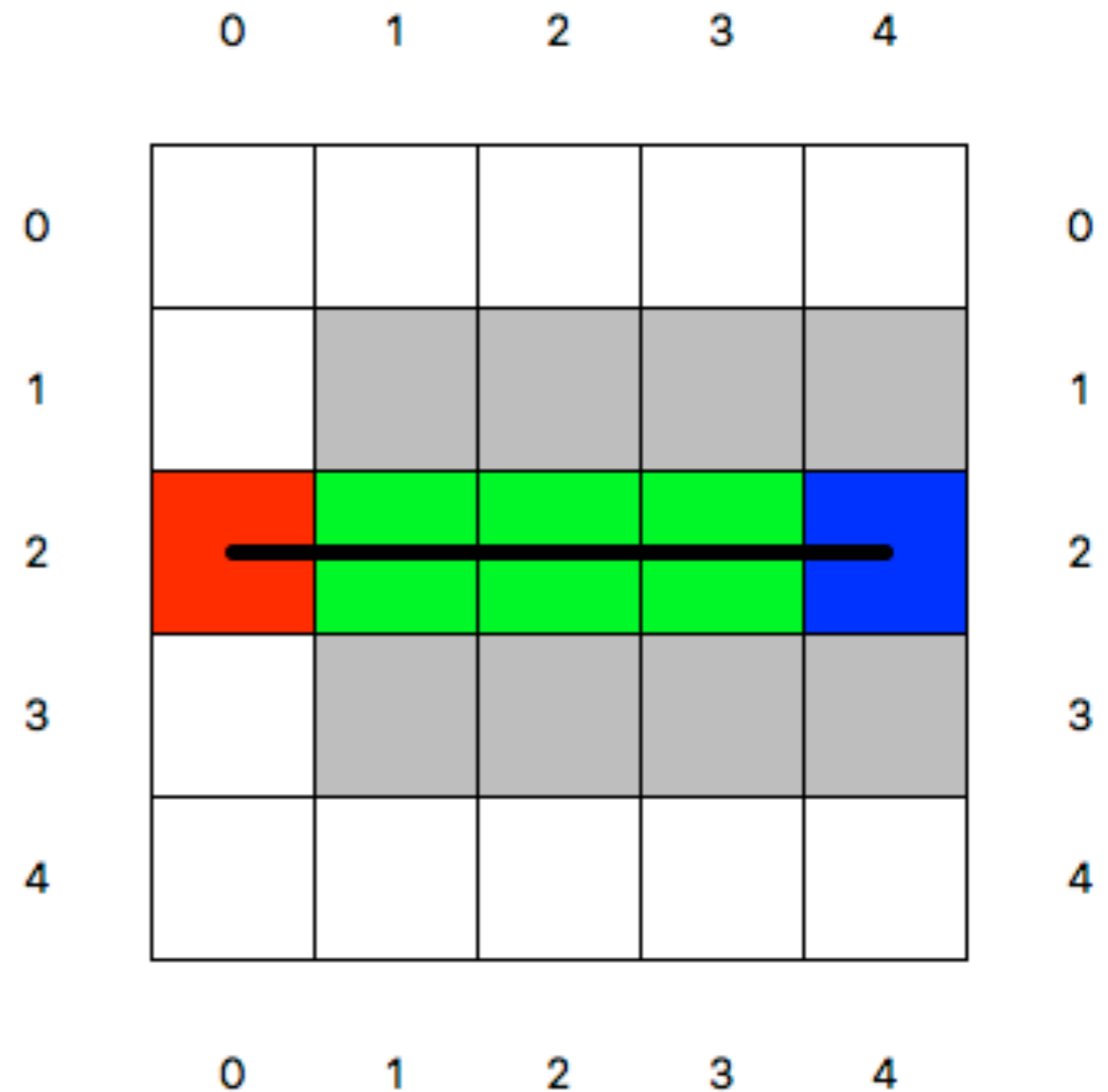


# Informed Search

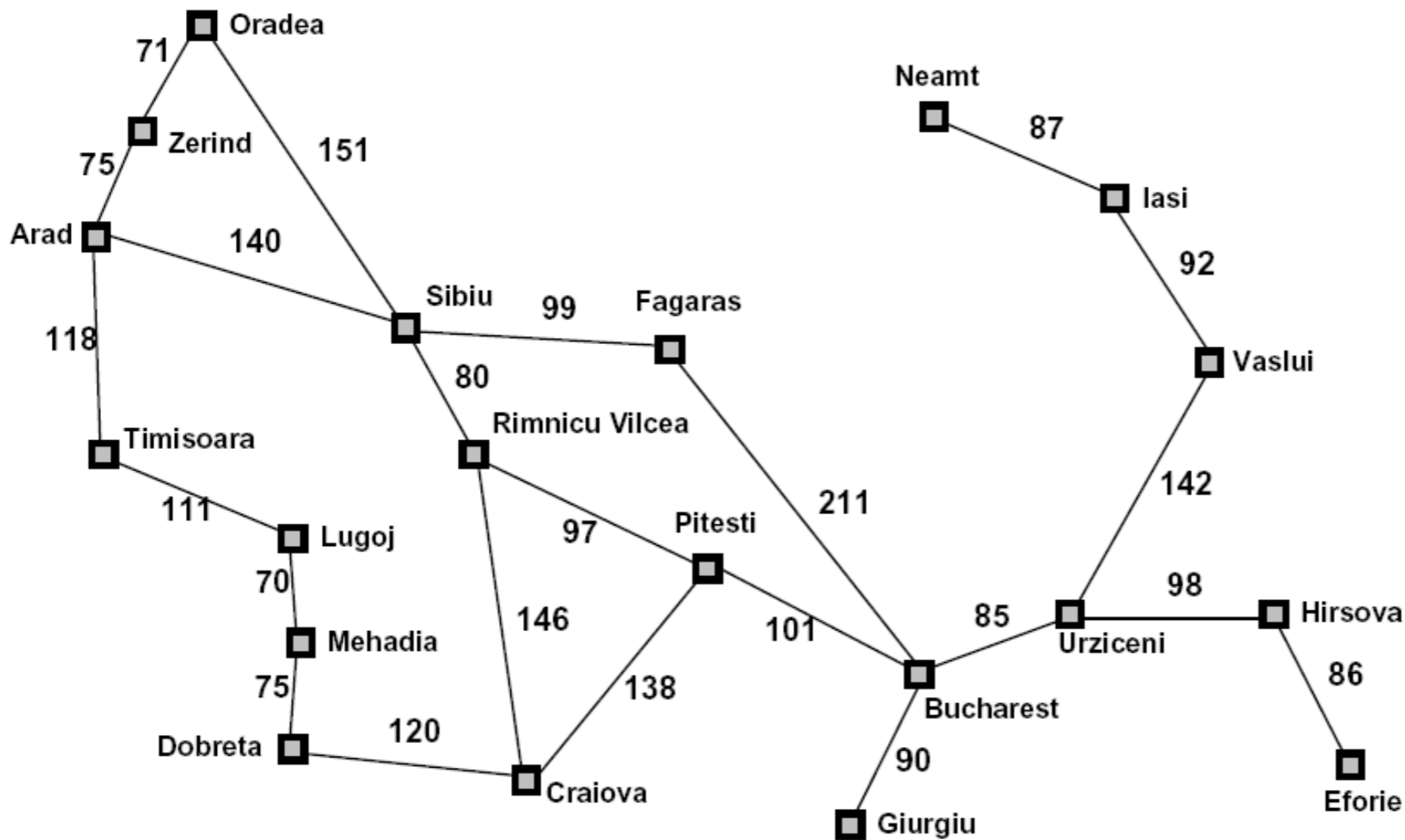
- UCS optimizes backward
- how about forward?

# A Heuristic

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



# GPS Heuristic Function

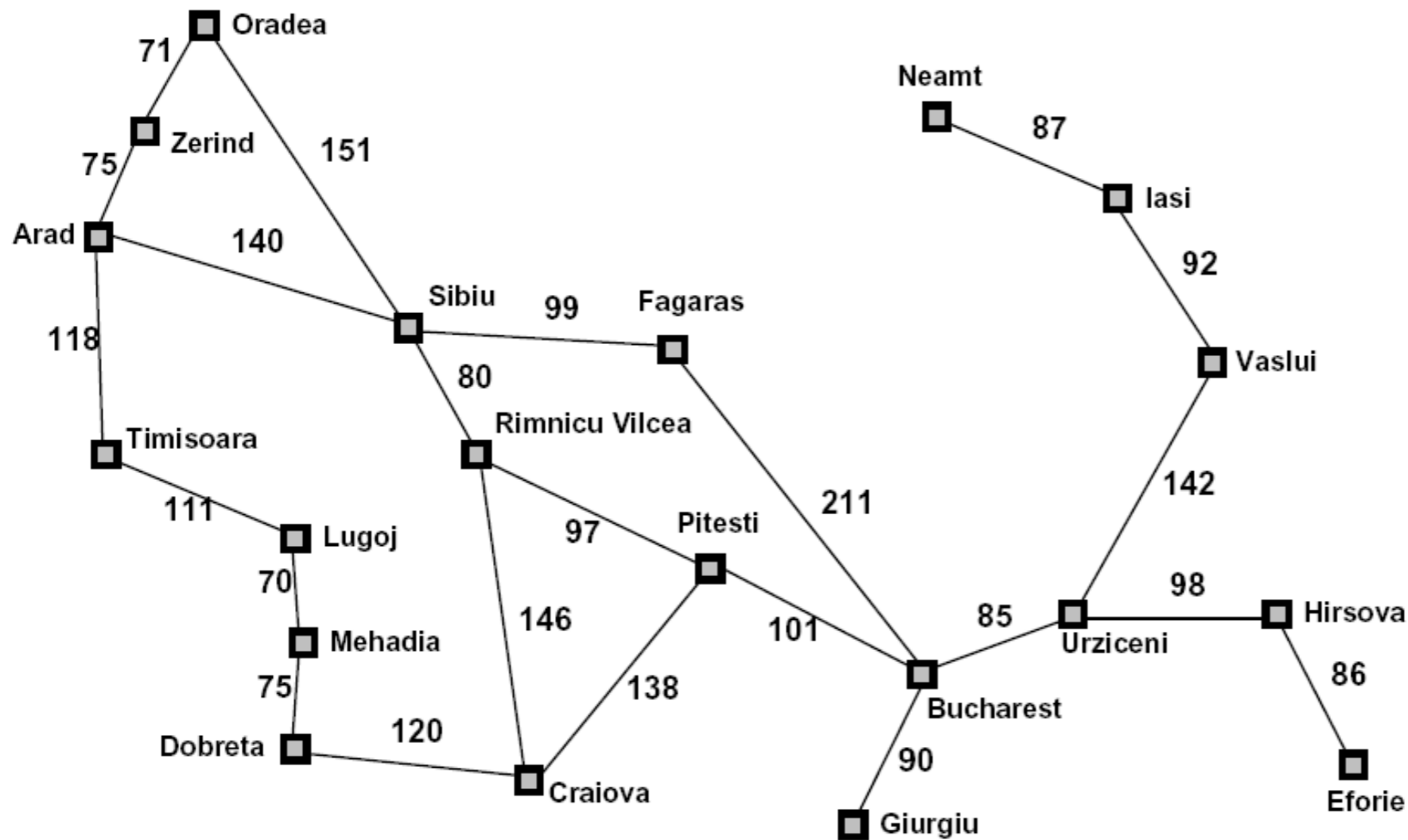


Straight-line distance to Bucharest	
Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	178
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
Mehadia	241
Neamt	234
Oradea	380
Pitesti	98
Rimnicu Vilcea	193
Sibiu	253
Timisoara	329
Urziceni	80
Vaslui	199
Zerind	374

$h(x)$



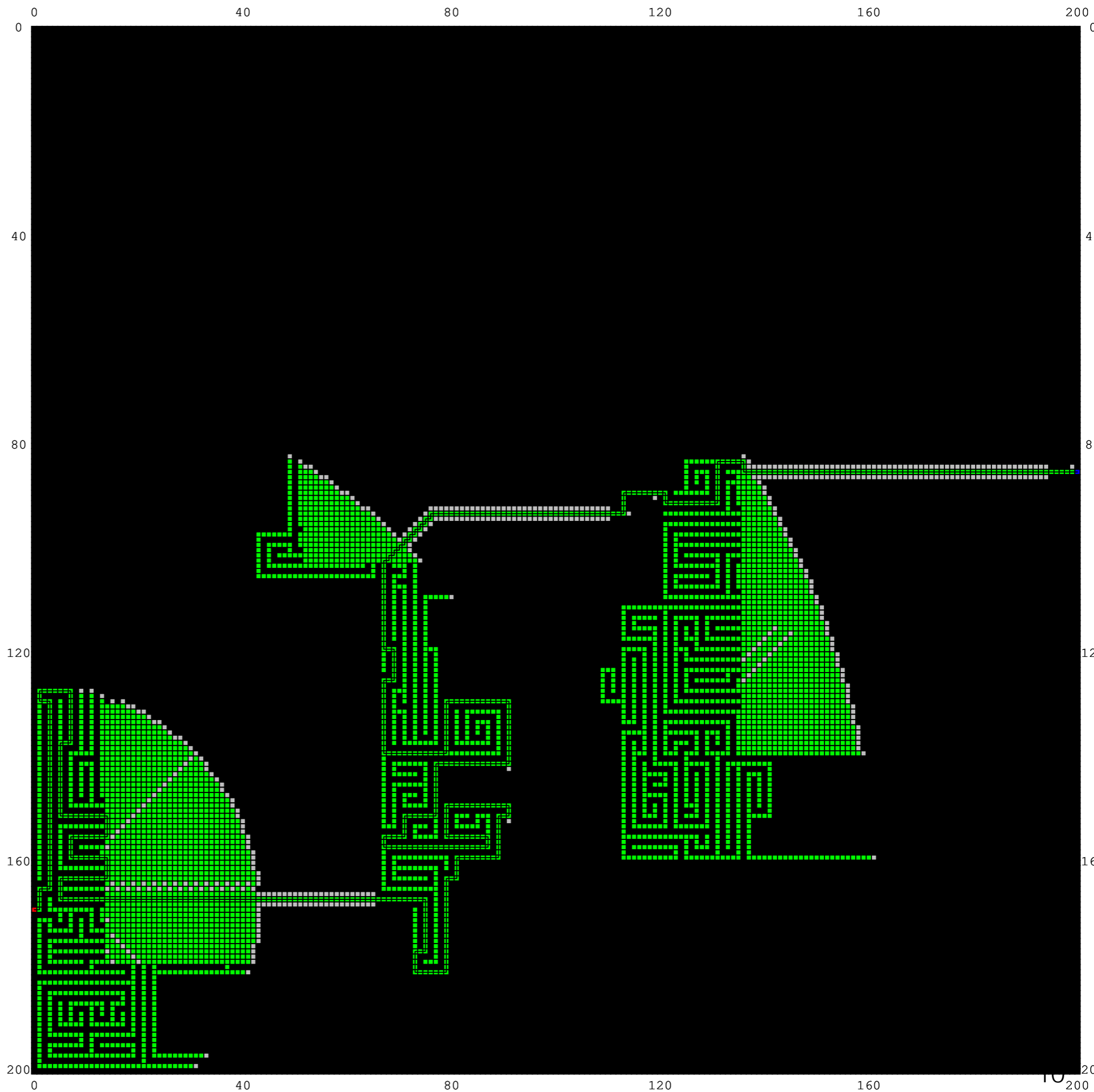
# Greedy Strategy



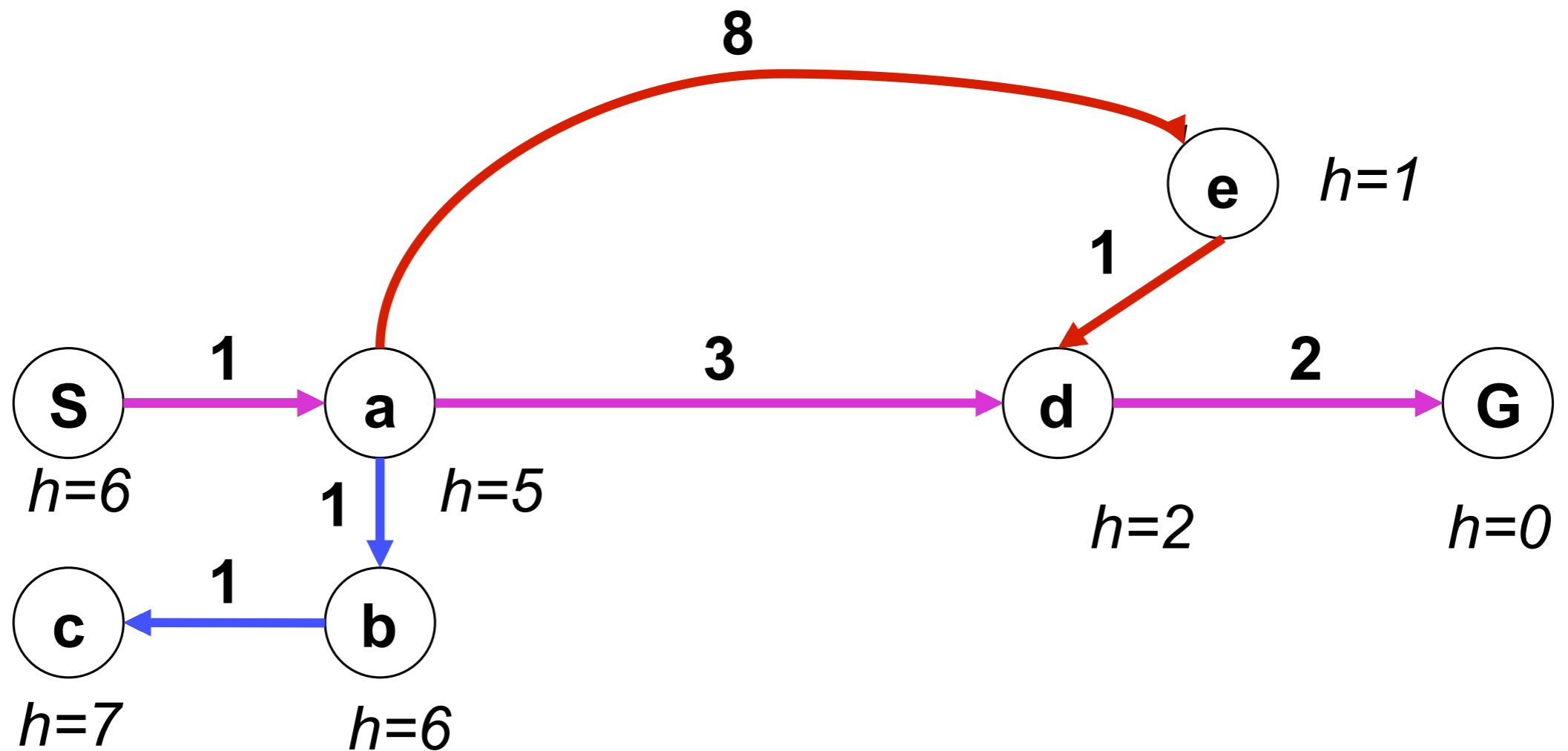
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$h(x)$

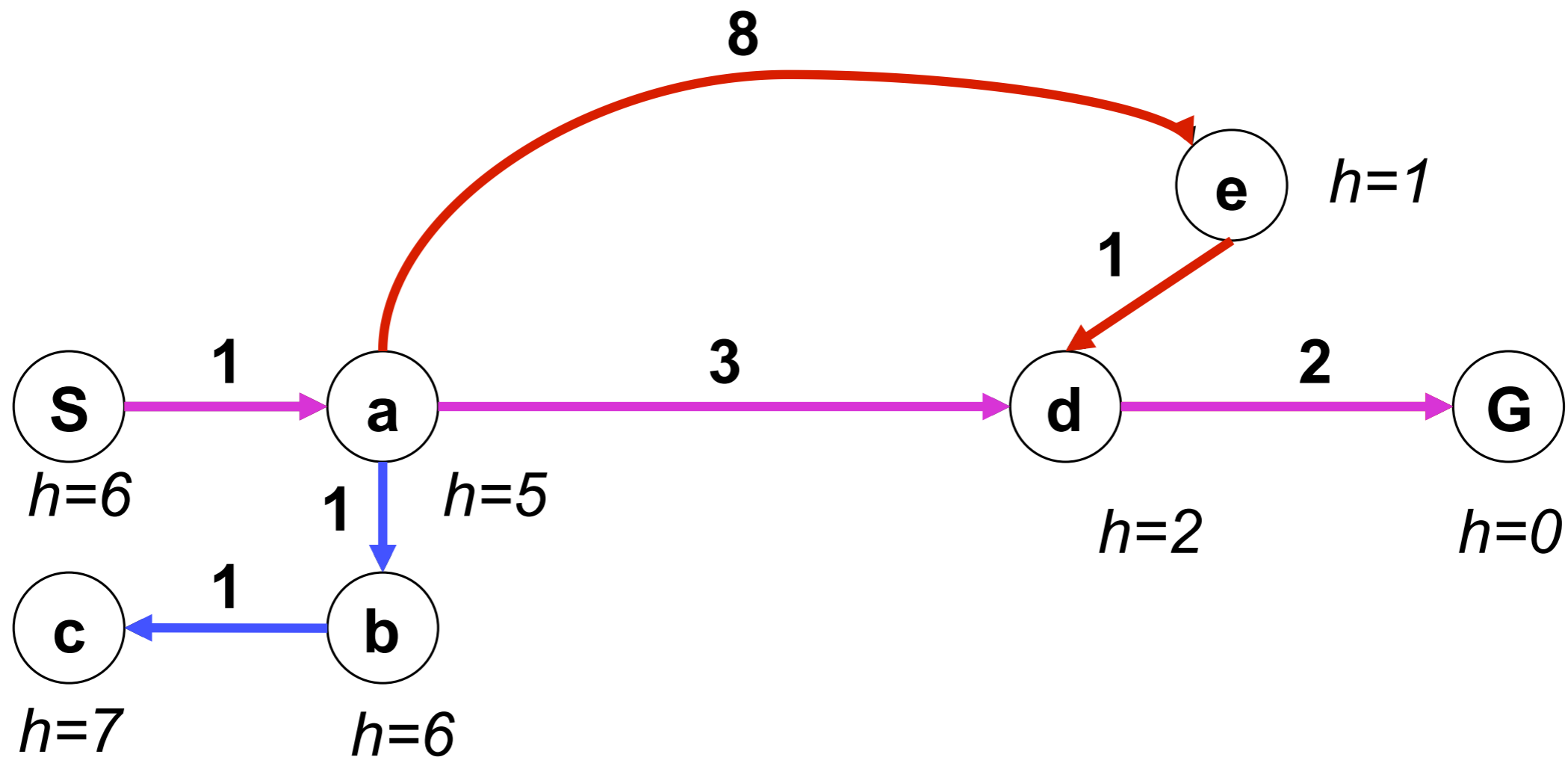
Greedy  
- what  
could  
possibly  
go  
wrong?



# 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**

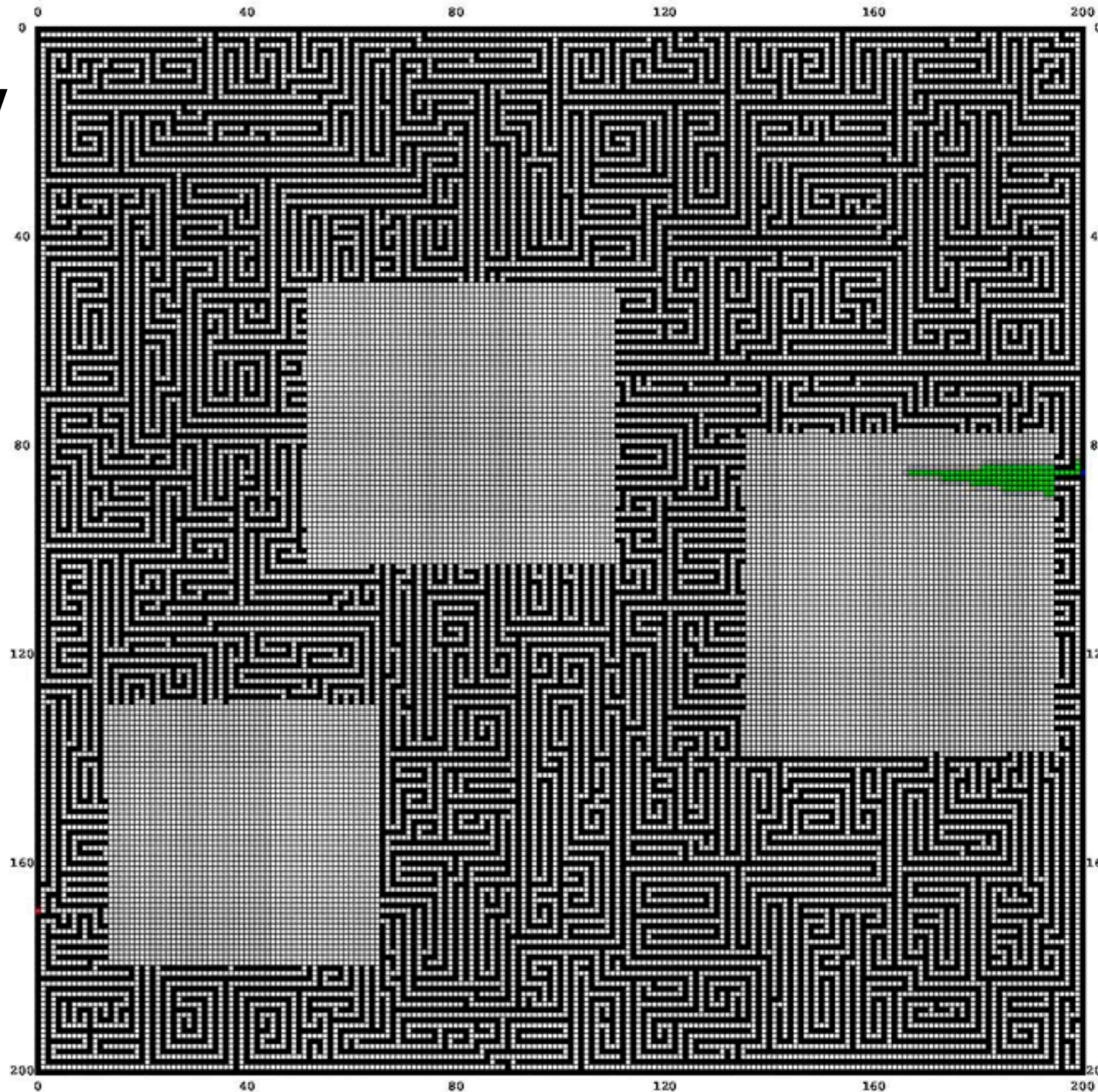
$g(n)$  = sum of costs

$h(n)$  = euclidean dist

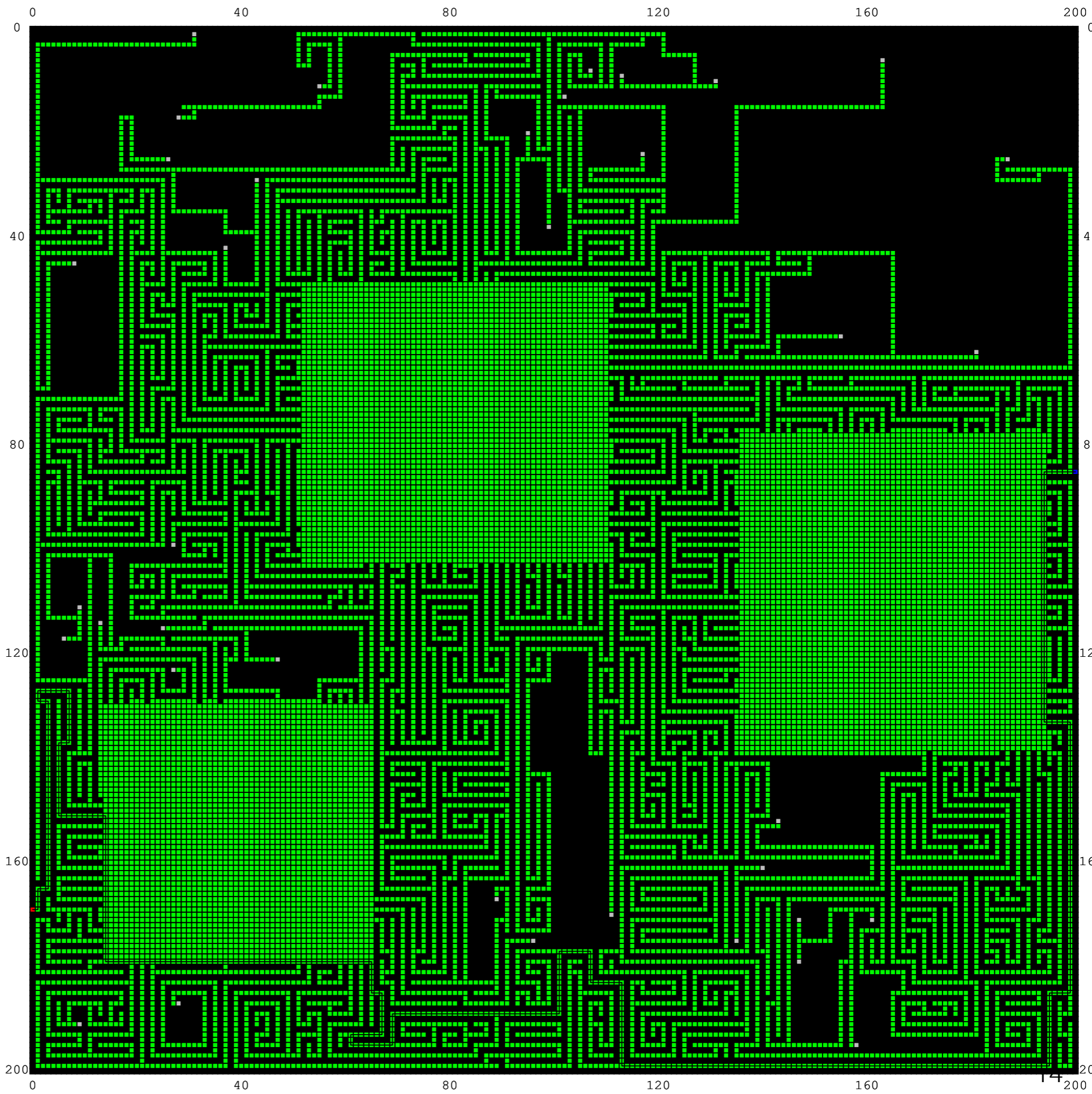
$f(n) = g(n) + h(n)$

takes the min  $f(n)$

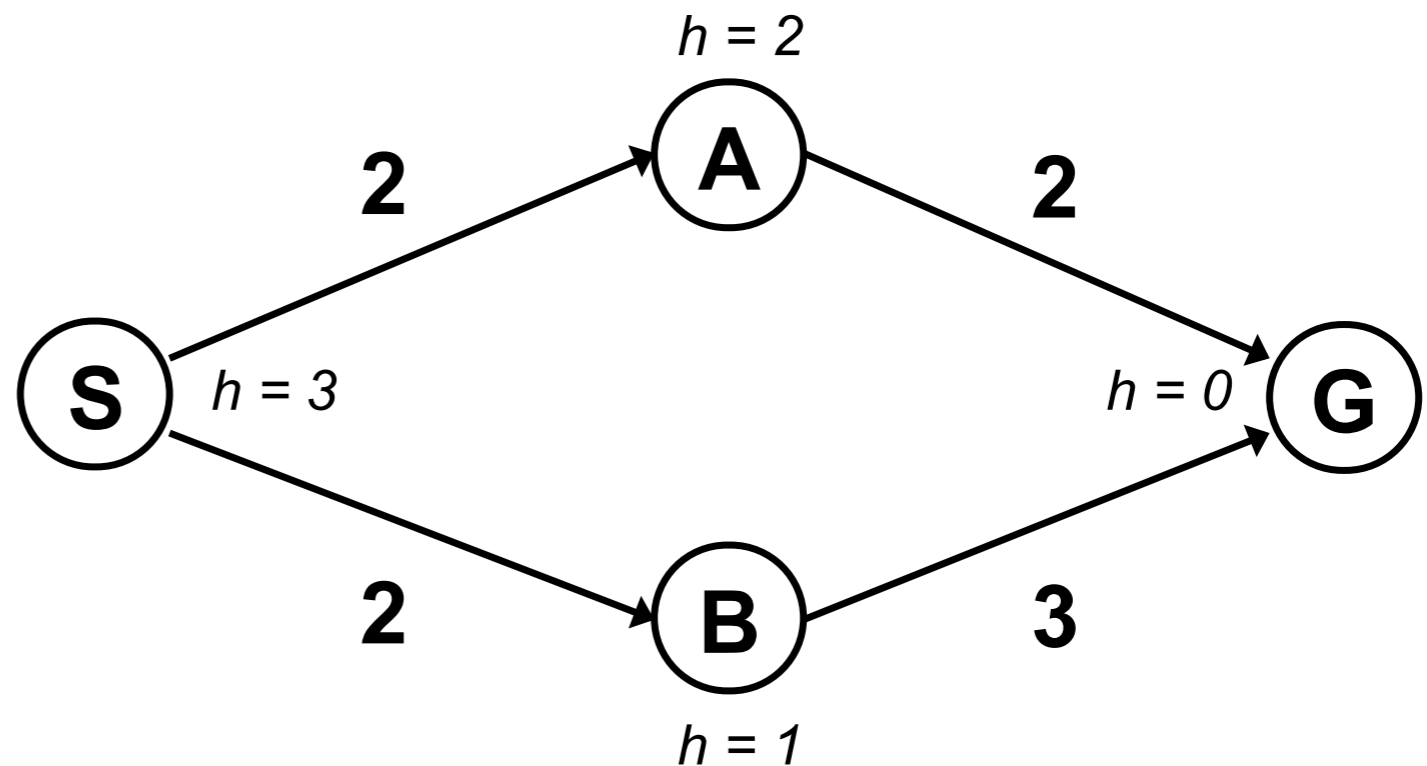
first



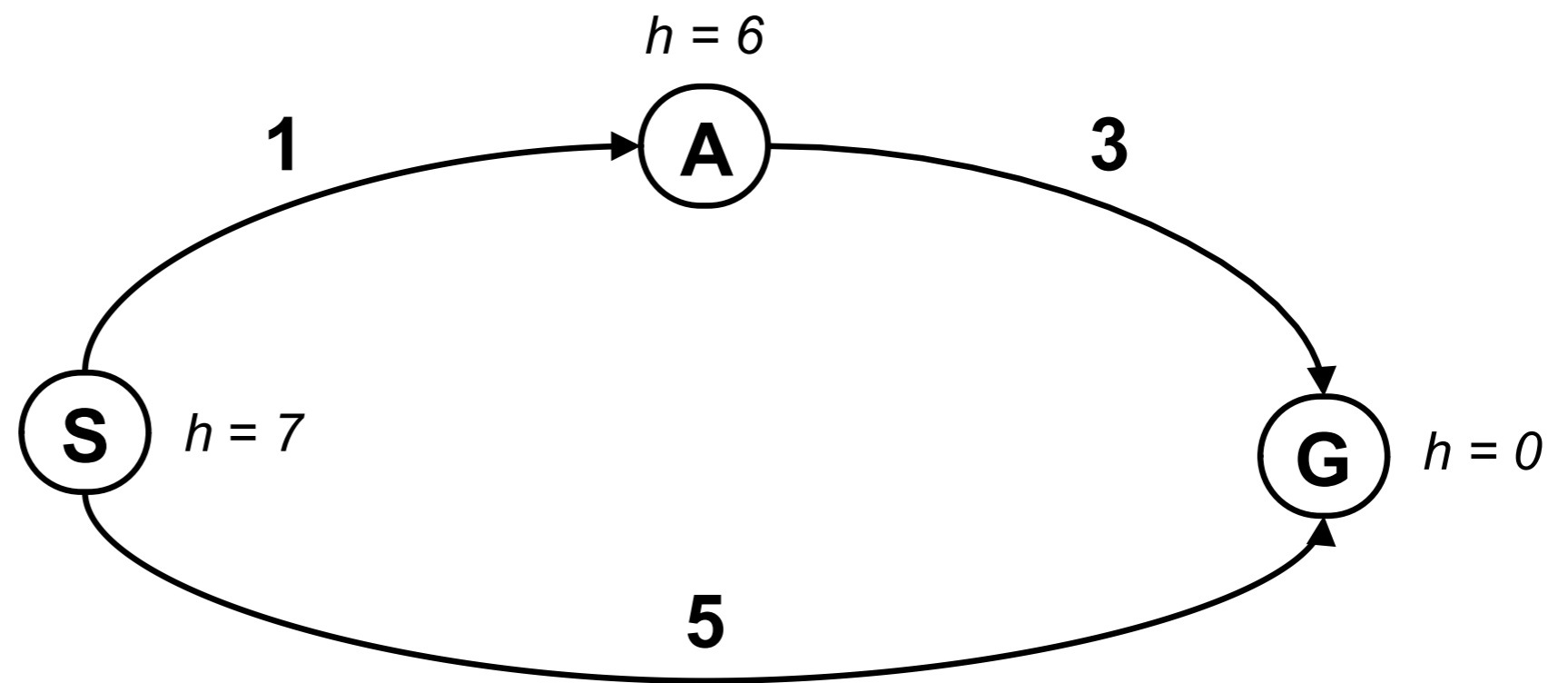
# A\* vs Greedy



# When to stop $A^*$ search?



# Is $A^*$ optimal?



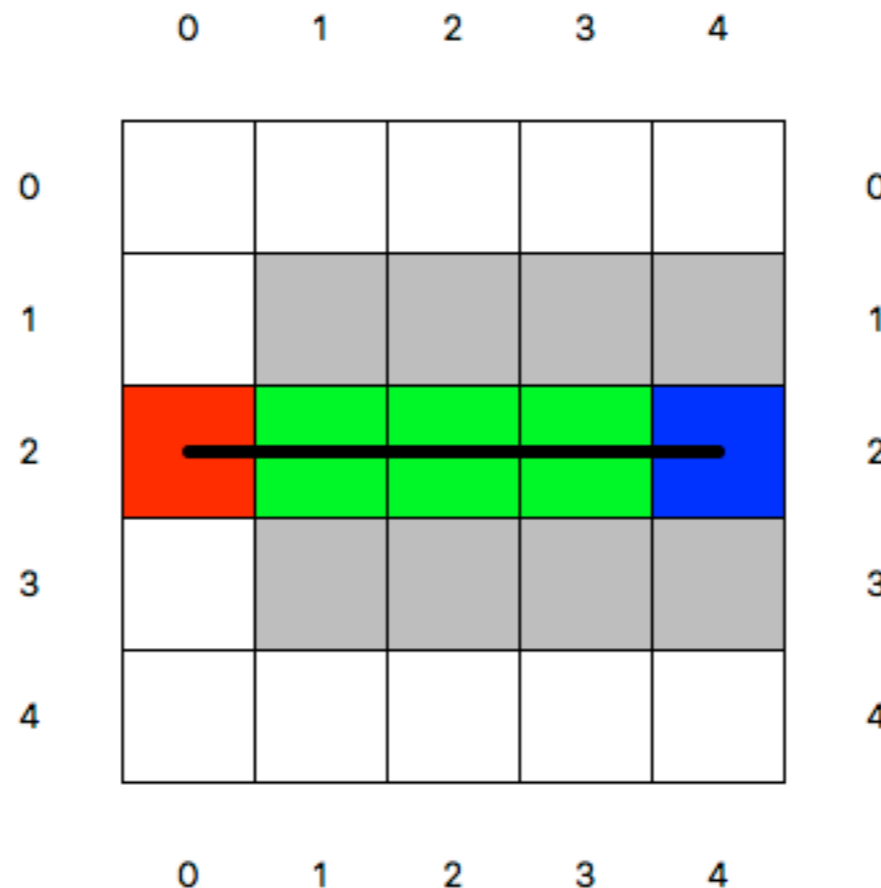


# Admissible heuristics

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

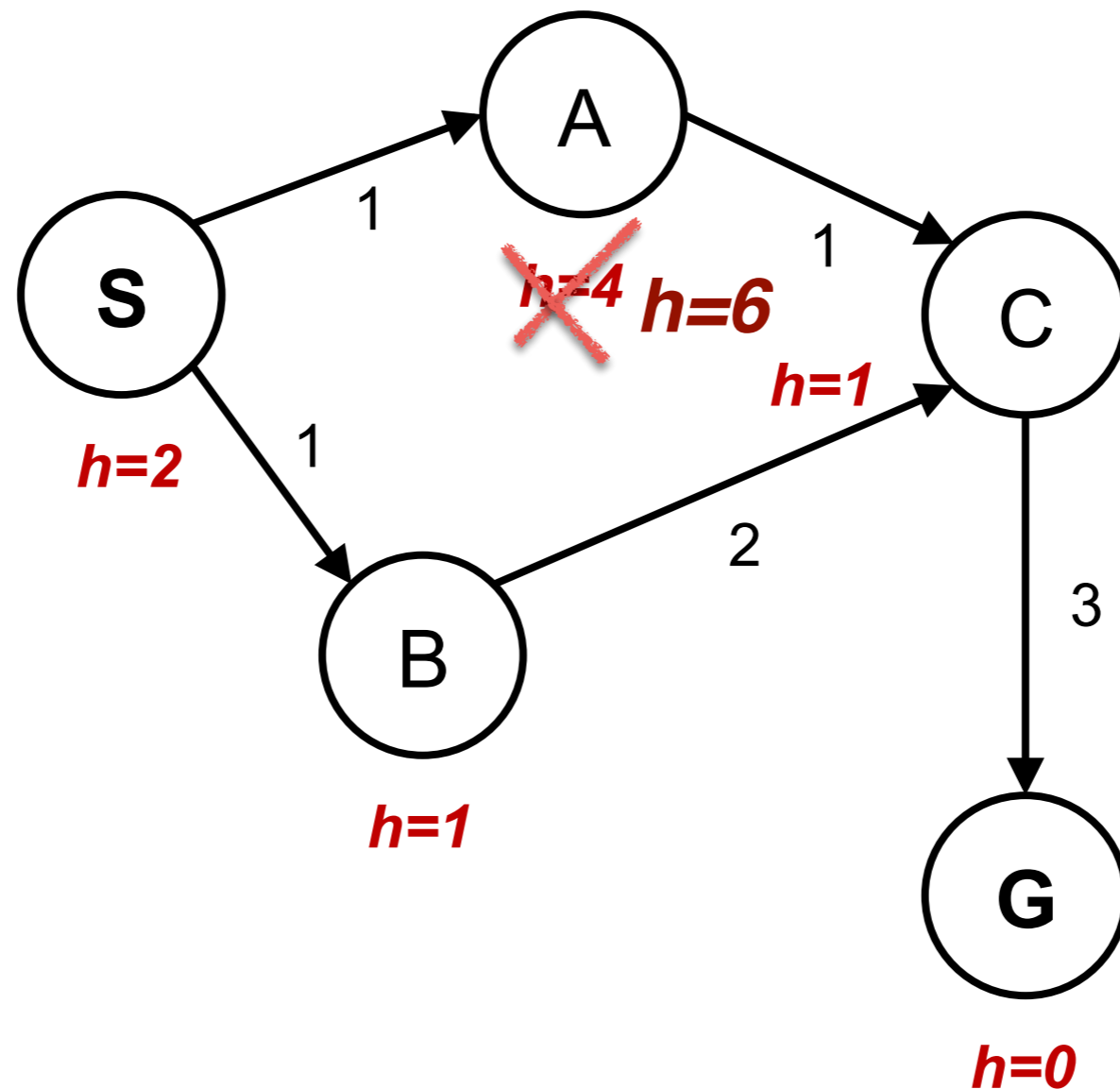
where  $h^*(n)$  is the true cost to the nearest goal.

Examples?



# Is admissible good enough?

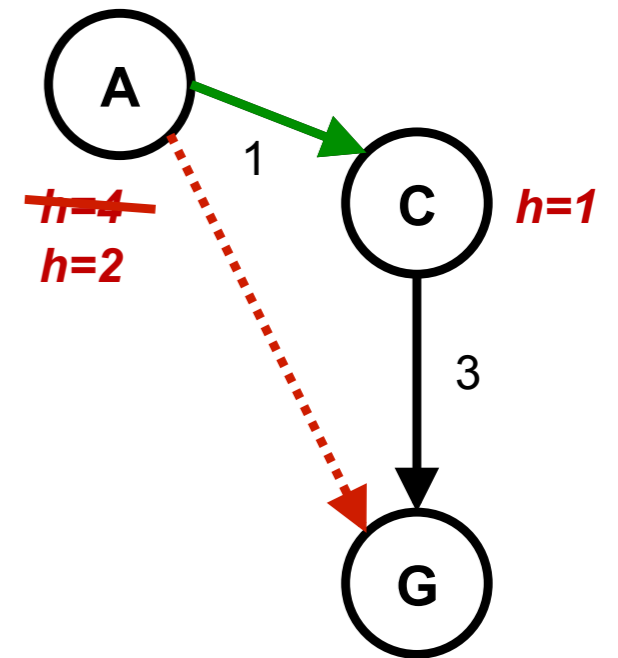
State space graph



# Consistent! heuristic

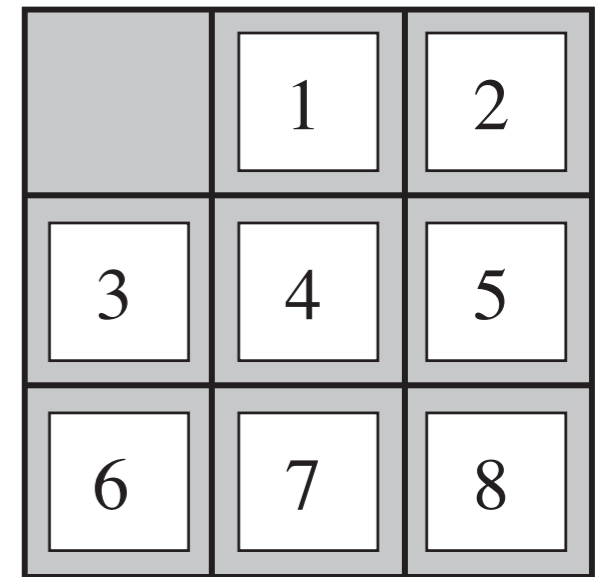
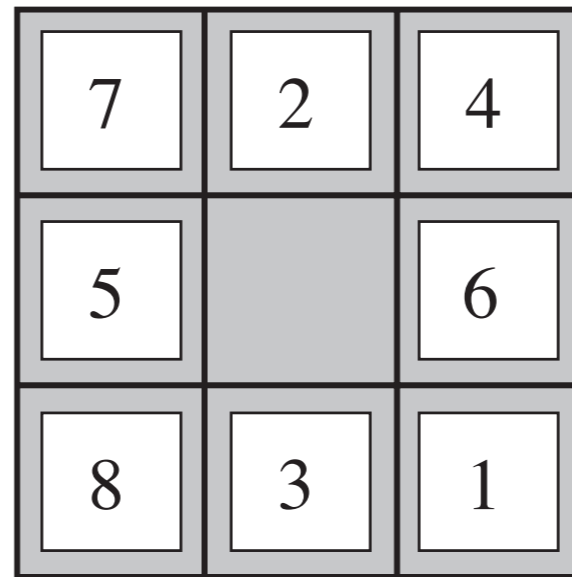
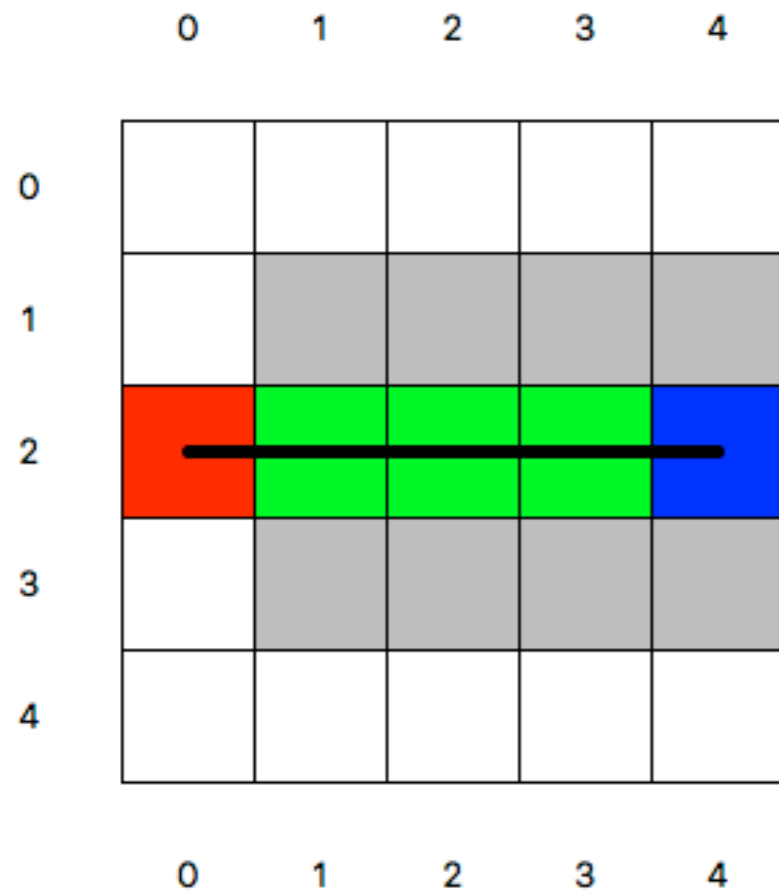
Admissible:  $h(A) \leq \text{actual cost}(A \rightarrow G)$

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.

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

# Heuristic - learning from experience

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