

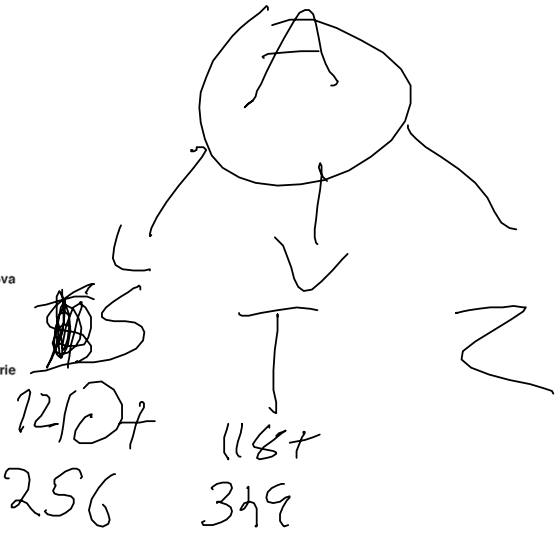
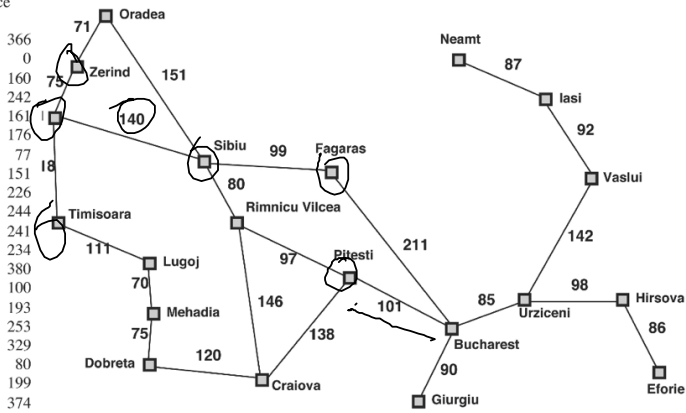
A\* By Brent!

Wednesday, September 14, 2016 9:17 AM

Romania with step costs in km

Straight-line distance  
to Bucharest

|                |     |
|----------------|-----|
| Arad           | 366 |
| Bucharest      | 0   |
| Craiova        | 160 |
| Dobreta        | 242 |
| Eforie         | 161 |
| Fagaras        | 176 |
| Giurgiu        | 77  |
| Hirsova        | 151 |
| Iasi           | 226 |
| Lugoj          | 244 |
| Mehadia        | 241 |
| Neamt          | 234 |
| Oradea         | 380 |
| Pitesti        | 100 |
| Rimnicu Vilcea | 193 |
| Sibiu          | 253 |
| Timisoara      | 329 |
| Urziceni       | 80  |
| Vaslui         | 199 |
| Zerind         | 374 |



Chapter 4, Sections 1-2 5

Open  
~~S(1210)~~, T(118), Z(349)  
Closed  
A, S

## Brent Writing things

Wednesday, September 14, 2016 10:07 AM

A \*  
 - Search based on  $f(c) = g(c) + h(c)$

- Shortcuts

- If  $f_n$  node already on open list and shorter  
<sub>path</sub>  
 - remove old node, append new node (with updated parent), resort

- If  $f_n$  node already on closed list and shorter  
<sub>path</sub>

- Replace that node

- Update children  $f(c)$ , using

DFS

E

## A\* Evaluation

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Completeness? Yes

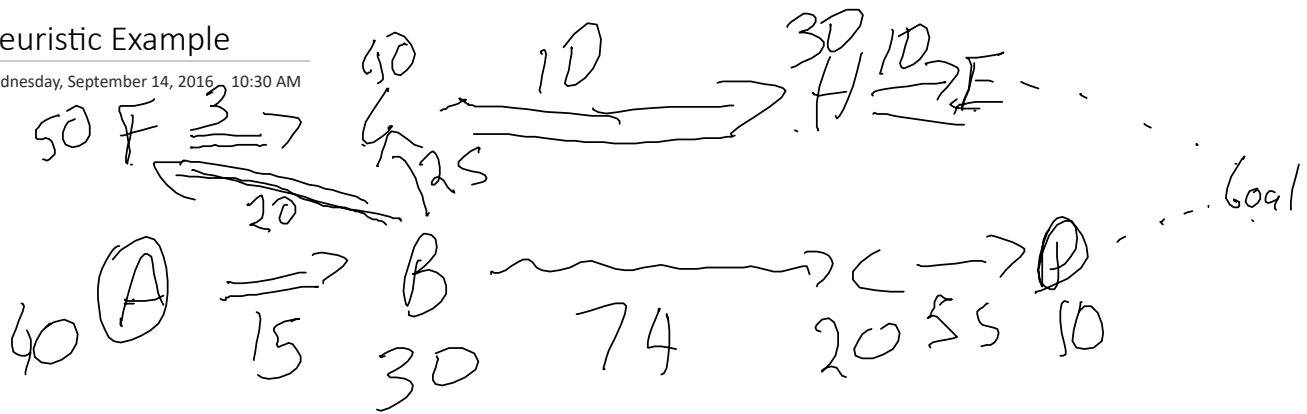
Time complexity? ~~Yes~~ exponential  
average  
with good heuristic

Space Complexity? Exponential

Optimal? It Depends

## Heuristic Example

Wednesday, September 14, 2016 10:30 AM



Open  
 F (35+50) 6 (40+40)  
 85 80  
Closed  
 A, B

-If  $h()$  overestimates  
 $A^*$  may not find shortest  
 path

## Admissibility

Wednesday, September 14, 2016 10:39 AM

-  $A^*$  with admissible heuristic is optimal

- a admissible heuristic never <sup>over</sup>estimates cost

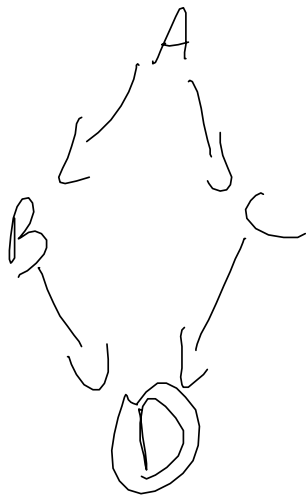
$$f^* = g^* + h^*$$

→  
perfect!

$$h(n) \leq h^*(n) \quad \forall n = \text{admissible!!}$$

## Admissible Example

Wednesday, September 14, 2016 10:42 AM



$$h^*(B) = 2 \quad h(B) = 2$$
$$h^*(C) = 1 \quad h(C) = 0$$

## Heuristic Design

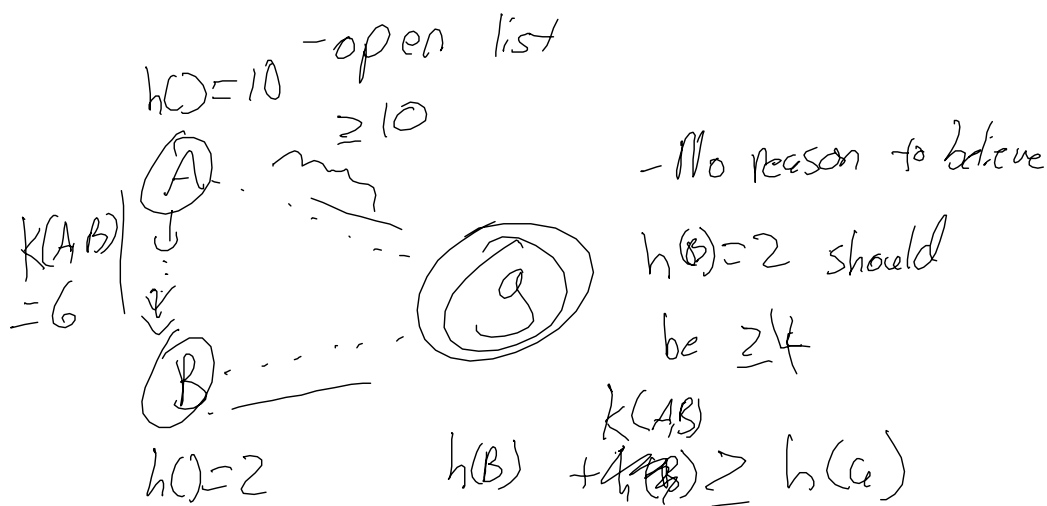
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Many ways to evaluate heuristic

- Admissibility
- Informedness:  $\frac{\text{size of search space}}{\text{number of nodes explored using } h()}$
- Allows direct heuristic comparison
- $h_a(n) \leq h_b(n) \leq h^*(n) \Rightarrow h_b(n) \text{ dominates } h_a(n)$

Consistency

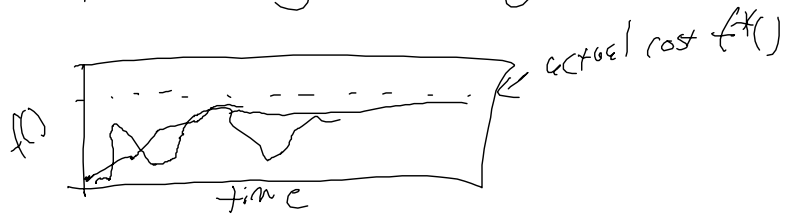
- Overestimation is bad.
- What happens when you grossly underestimate?
  - Shortcuts still happen!



$$h(A) - h(B) \leq K(A, B)$$

Monotonicity

- Always increasing/decreasing





## Review times!

Friday, September 16, 2016 10:03 AM

$A^*$  -  $g()$ ,  $h()$ ,  $g() + h()$  ← admissible

-  $h()$  is not admissible

- Bad things happen

- Shortcuts!, could have to re-insert onto closed list

- DFS

Admissible heuristic

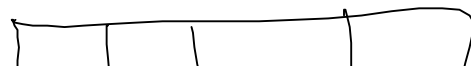
- Never overestimates

Ex 8 puzzle

|   |   |   |
|---|---|---|
| 1 | 2 | 3 |
| 4 | ↓ | 5 |
| 6 | 7 | 8 |

goal →

|   |   |   |
|---|---|---|
|   | 1 | 2 |
| 3 | 4 | 5 |
| 6 | 7 | 8 |



L'  
1 B 3  
4 2 5  
6 7 8

