Advanced Artificial Intelligence

Lab 03

Outline

- A concrete problem
- Implementation of heuristic search algorithms for this problem
  - Greedy Best-First Search
  - A* Search
- Exercise

Remarks of Heuristic Search

- involve domain knowledge

  -- Heuristic Function

- Complete / Optimal

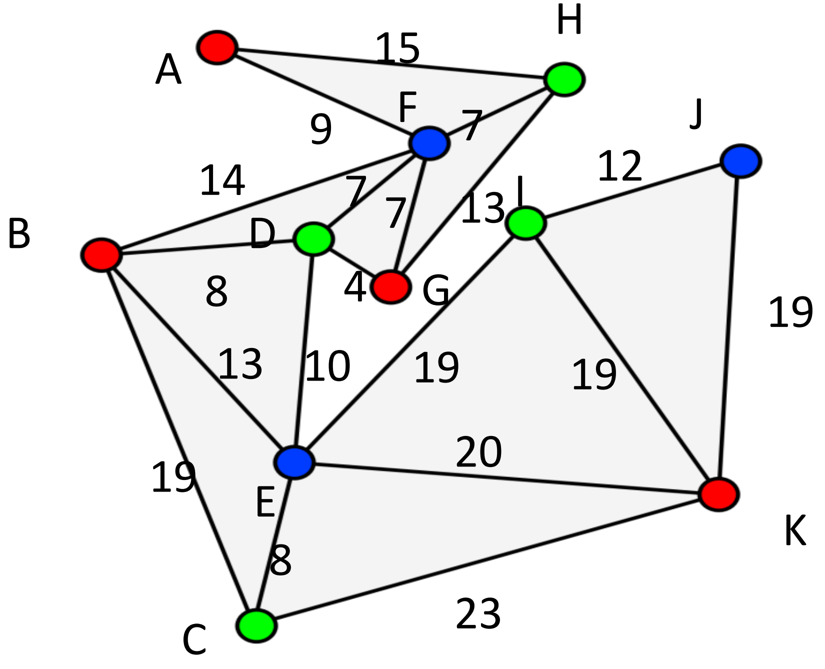
Greedy Best-first Search

Incomplete & Not always optimal

A* Search

Complete & Optimal

A Concrete Problem



Task: Find shortest Path from **H** to **C**

Straight-line dis to C	
A	26
B	19
D	17
E	8
F	24
G	17
H	29
I	25
J	32
K	23

Domain knowledge(Heuristic)
i.e. h(*)

Greedy Best-first Search

Remarks of Greedy Best-First Search

- Idea: Expand the node that seems closest to the Goal.

- Expand node s that has the minimal $f(s) = h(s)$.
- Complete? No, can stuck in loops.

- Optimal? No.
- Time? $O(b^m)$, but good heuristics can give drastic improvement.
- Space? $O(b^m)$, keep all nodes in memory.

Greedy Best First Search

Node	SLD to C
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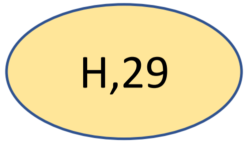

H,29

Greedy Best First Search

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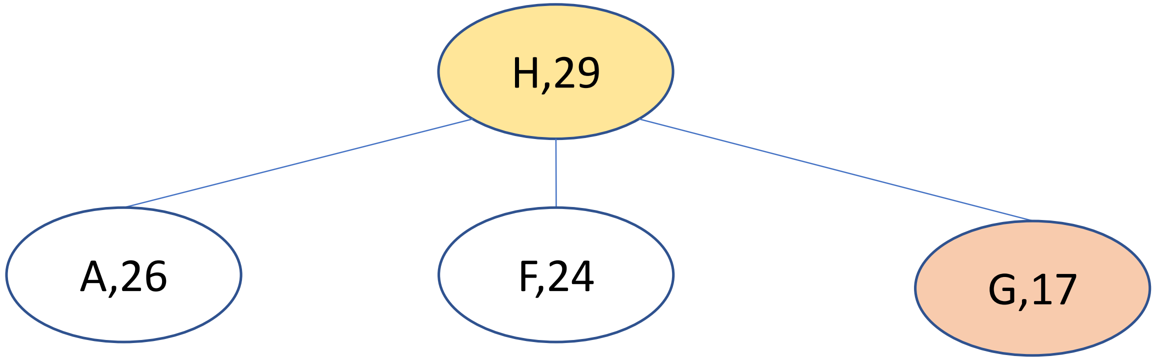
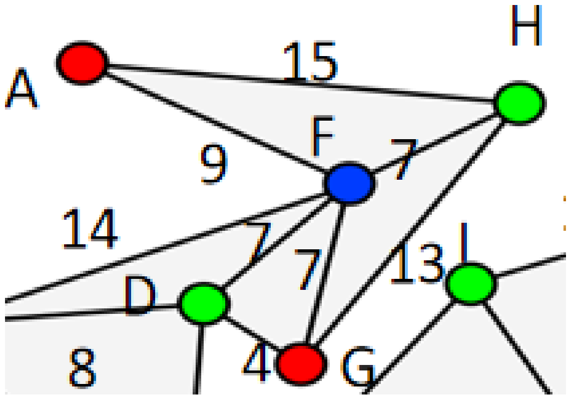


H,29

A,26

F,24

G,17



Greedy Best First Search

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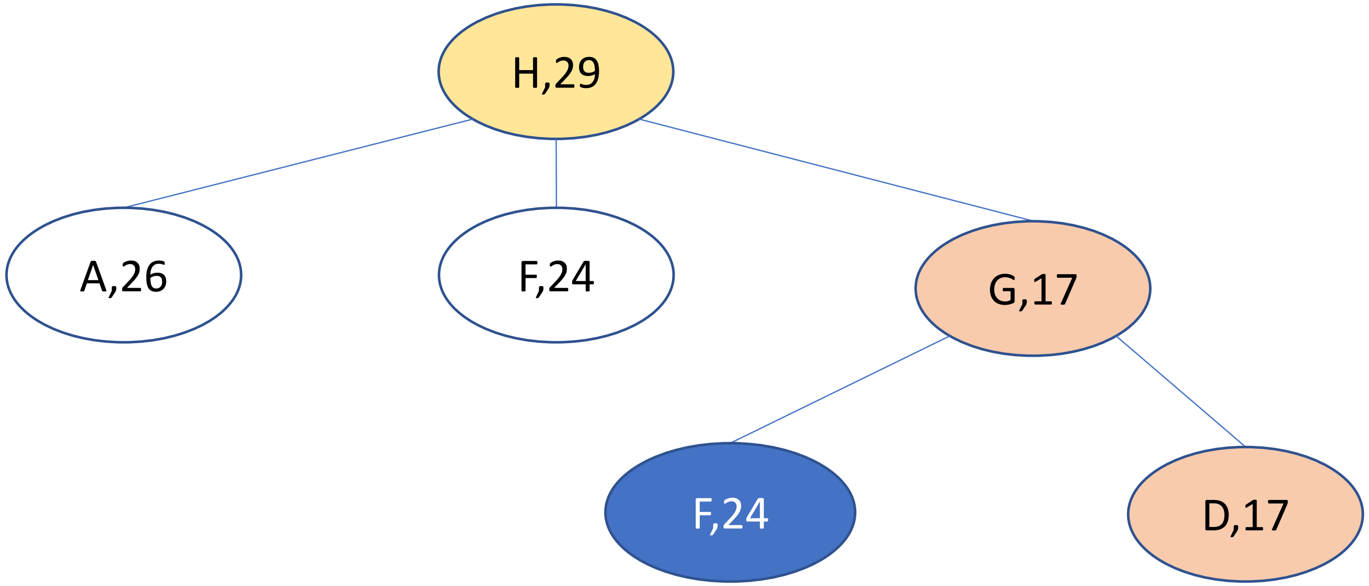

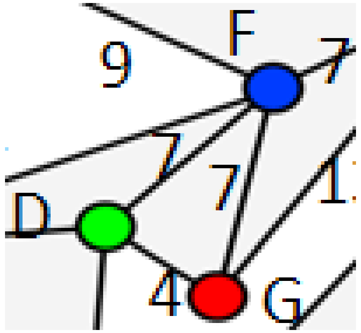

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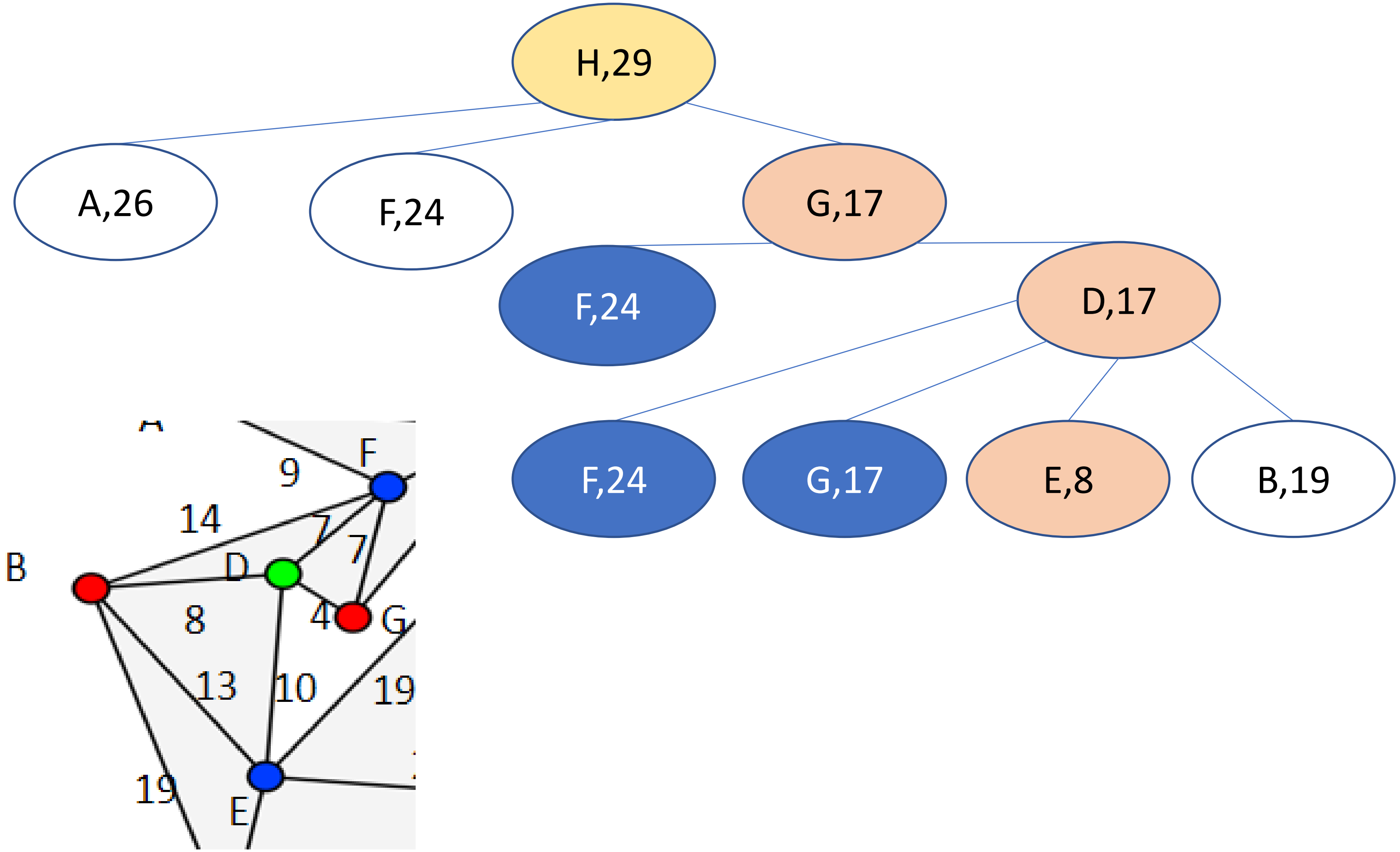

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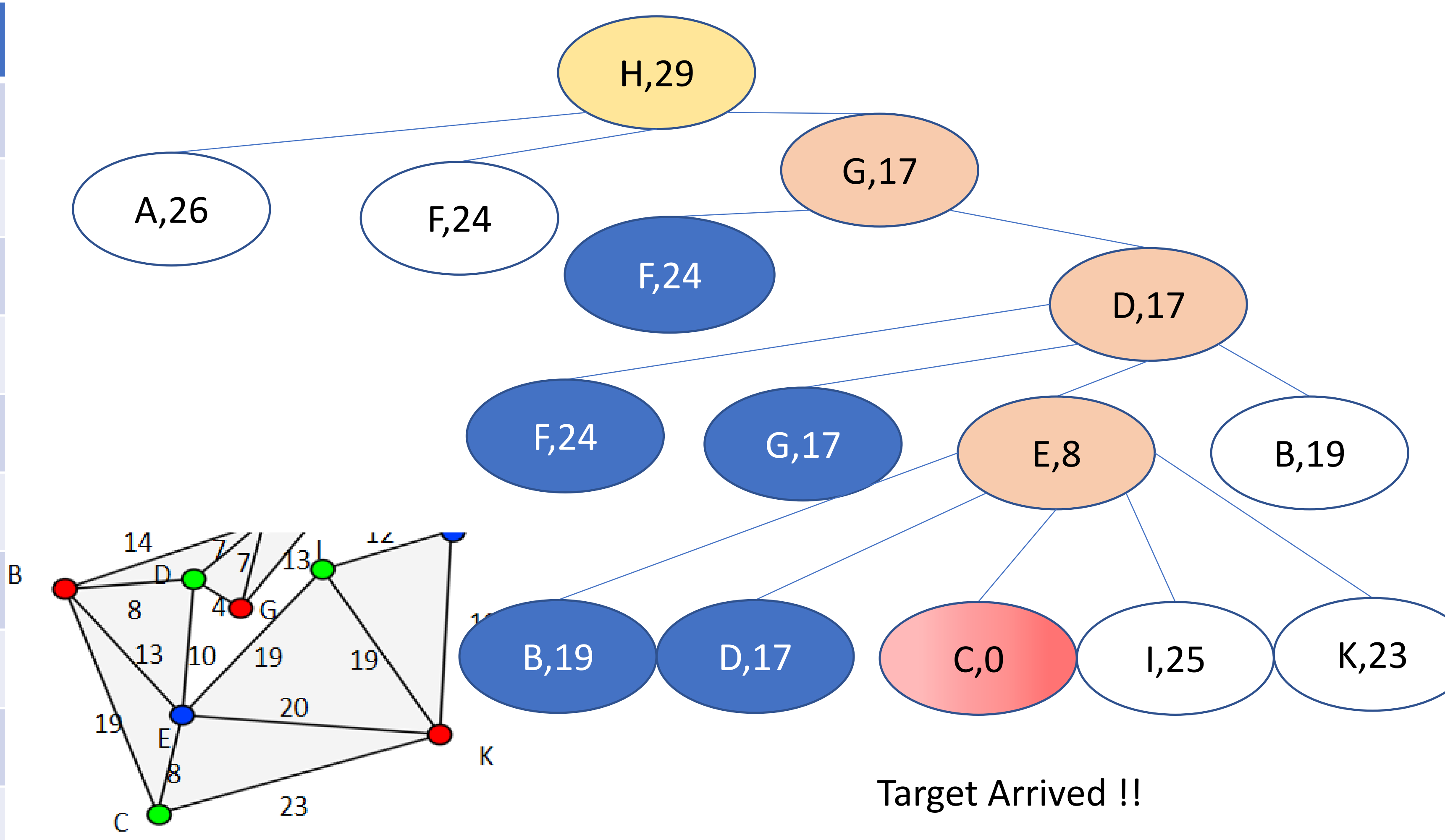
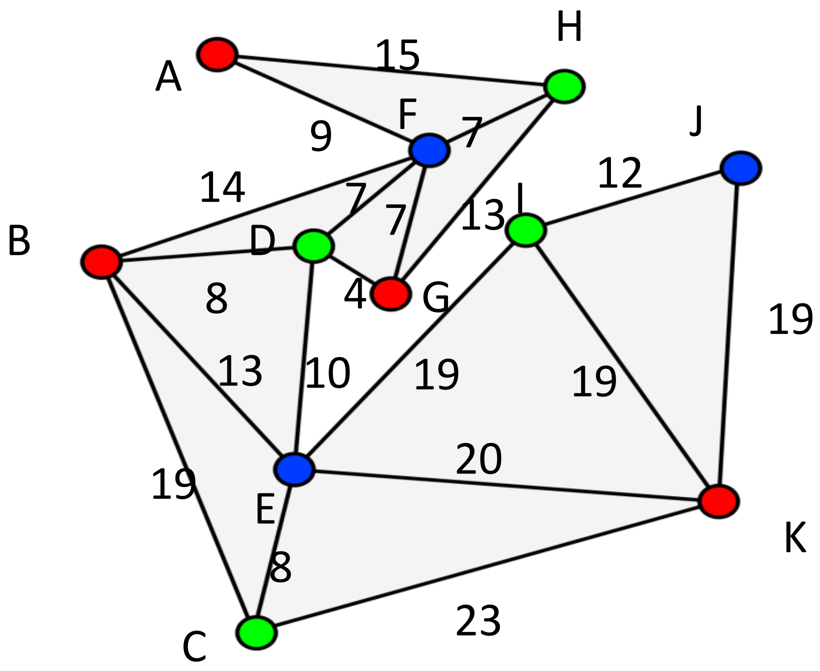


Target Arrived !!

Greedy Best First Search



- **Solution**:
  H -> G -> D -> E -> C

- $\boldsymbol{\mathit{Distance}} = 13 + 4 + 10 + 8$
  $= 35\ m$

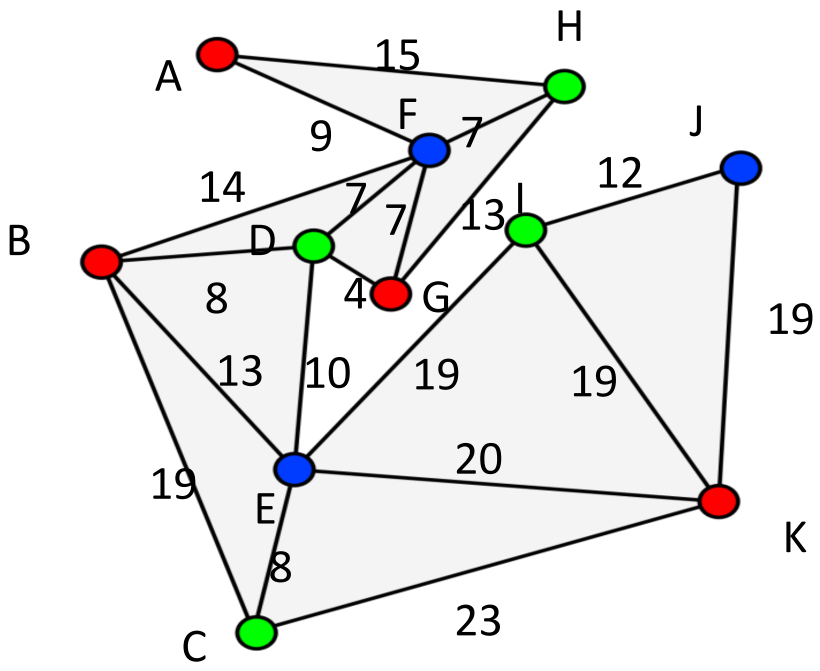
But it is not an optimal solution!

A* Search

Remarks of A* Search

- Idea: avoid expanding paths that are already expensive.
- Expand the node s that has the minimal $f\ (s) = h(s) + g(s)$
  - $g(s)$: cost from *Start* to s.
  - $h(s)$: estimated cost from s to *Goal*.
  - $f\ (s)$: estimated total cost of path from *Start* through s to *Goal*.
- Theorem: A* with h is optimal if h is admissible
  - Here we set h: SLD to C h(s) is admissible
  - A* is complete and optimal in this case.

A* Search Illustration



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H

29 = 29 + 0

$$f\ (s) = h(s) + g(s)$$

A* Search Illustration

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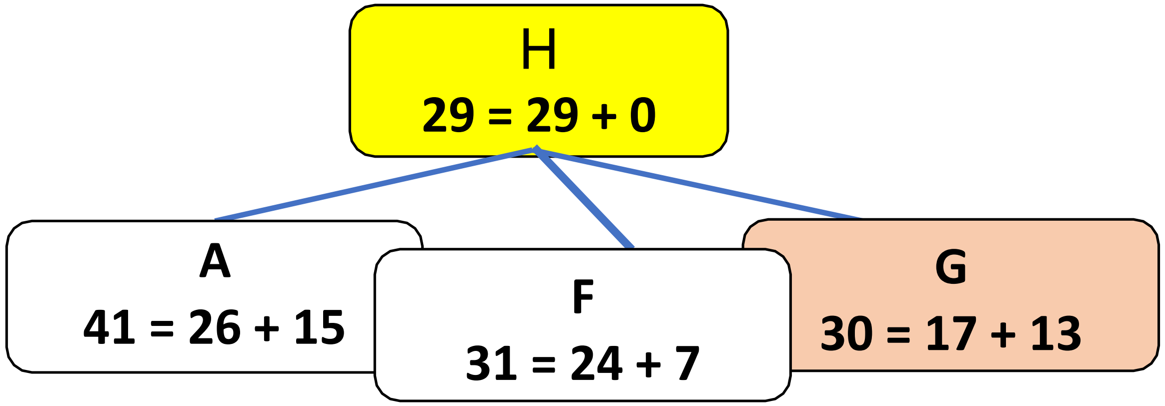
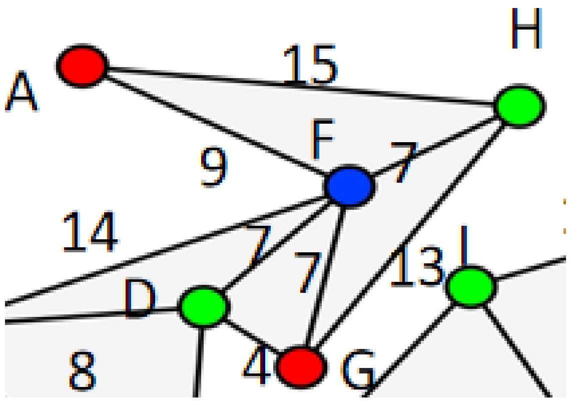


H
29 = 29 + 0

A
41 = 26 + 15

F
31 = 24 + 7

G
30 = 17 + 13



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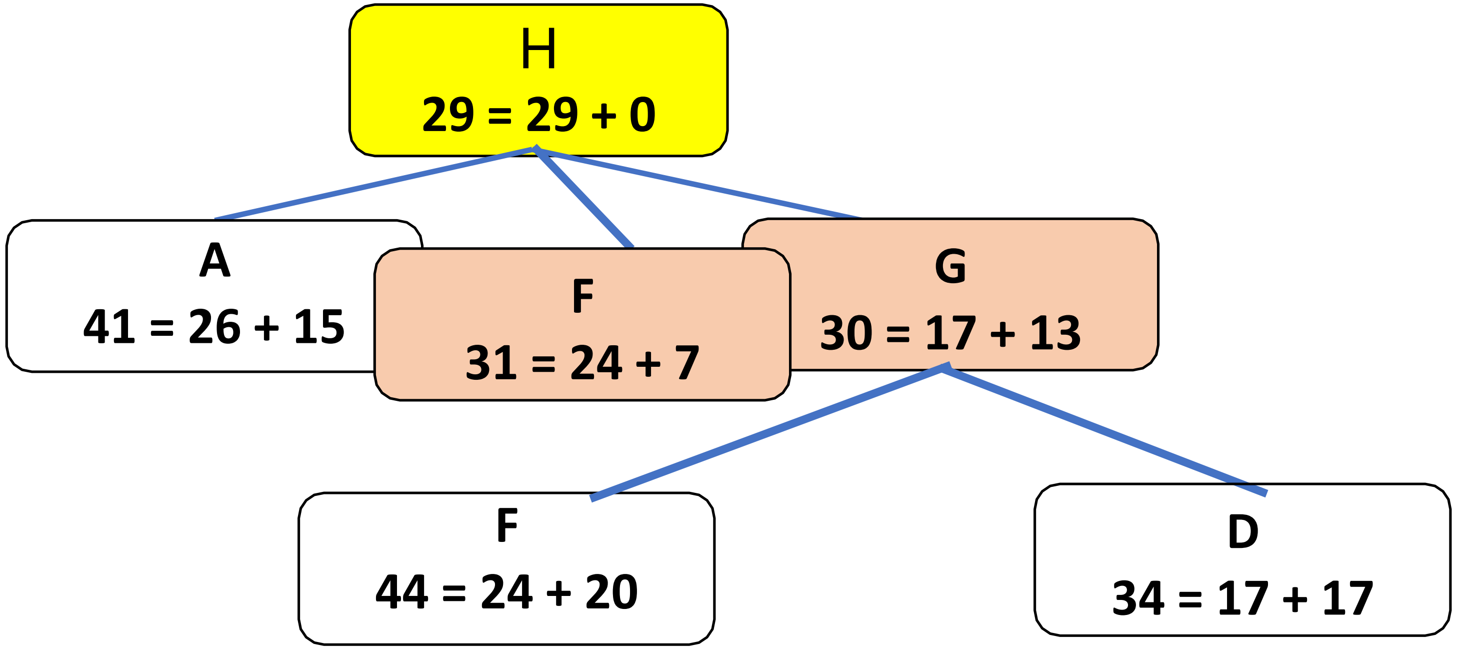


H
29 = 29 + 0

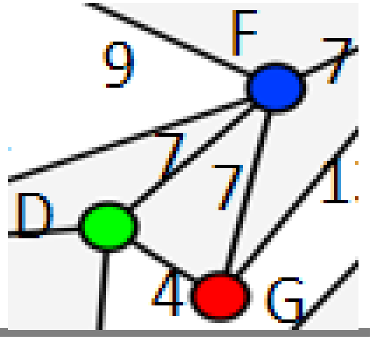
A
41 = 26 + 15

F
31 = 24 + 7

G
30 = 17 + 13

F
44 = 24 + 20

D
34 = 17 + 17



A* Search Illustration

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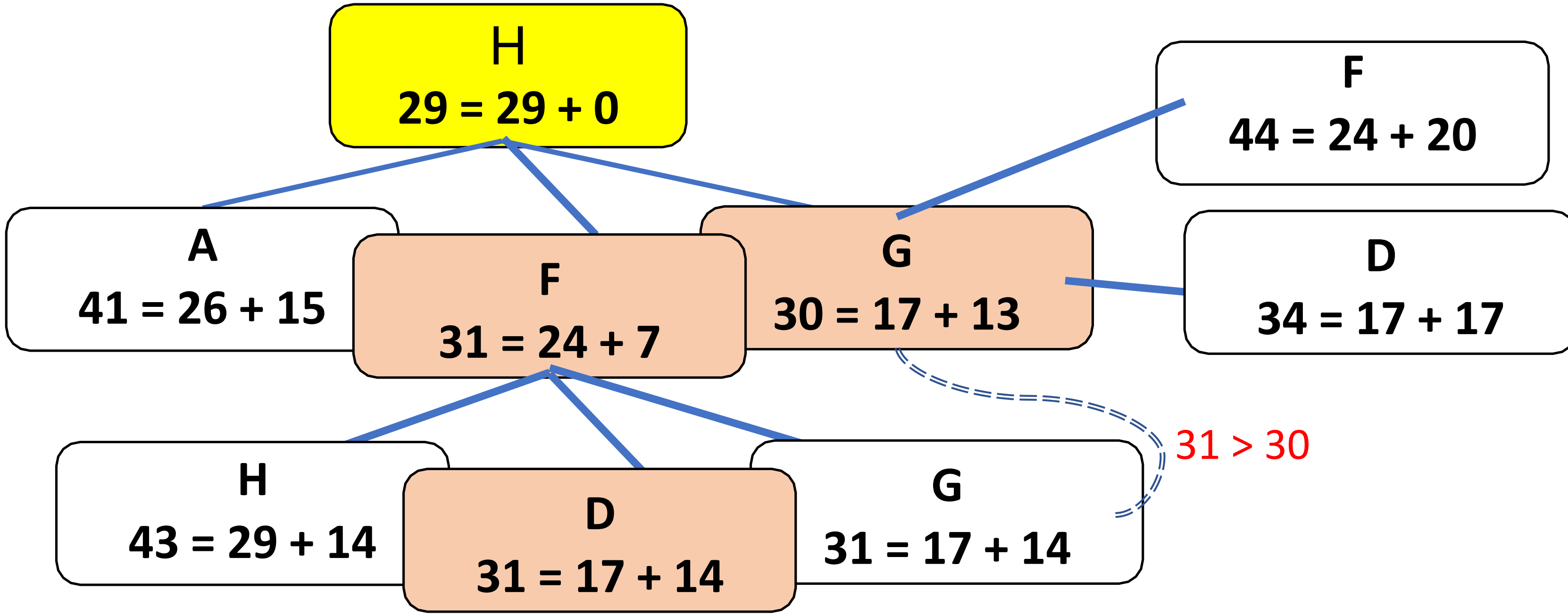


H
29 = 29 + 0

A
41 = 26 + 15

F
31 = 24 + 7

G
30 = 17 + 13

F
44 = 24 + 20

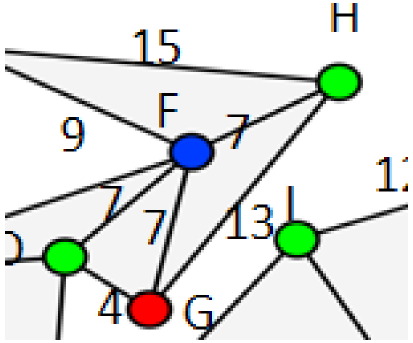
D
34 = 17 + 17

H
43 = 29 + 14

D
31 = 17 + 14

G
31 = 17 + 14

31 > 30



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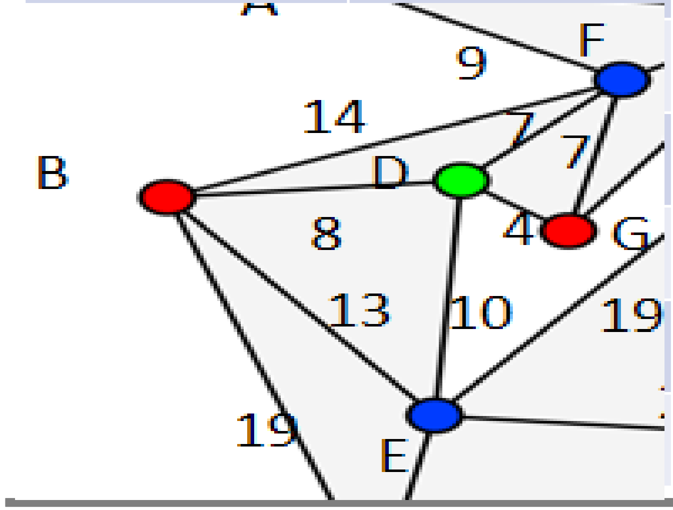
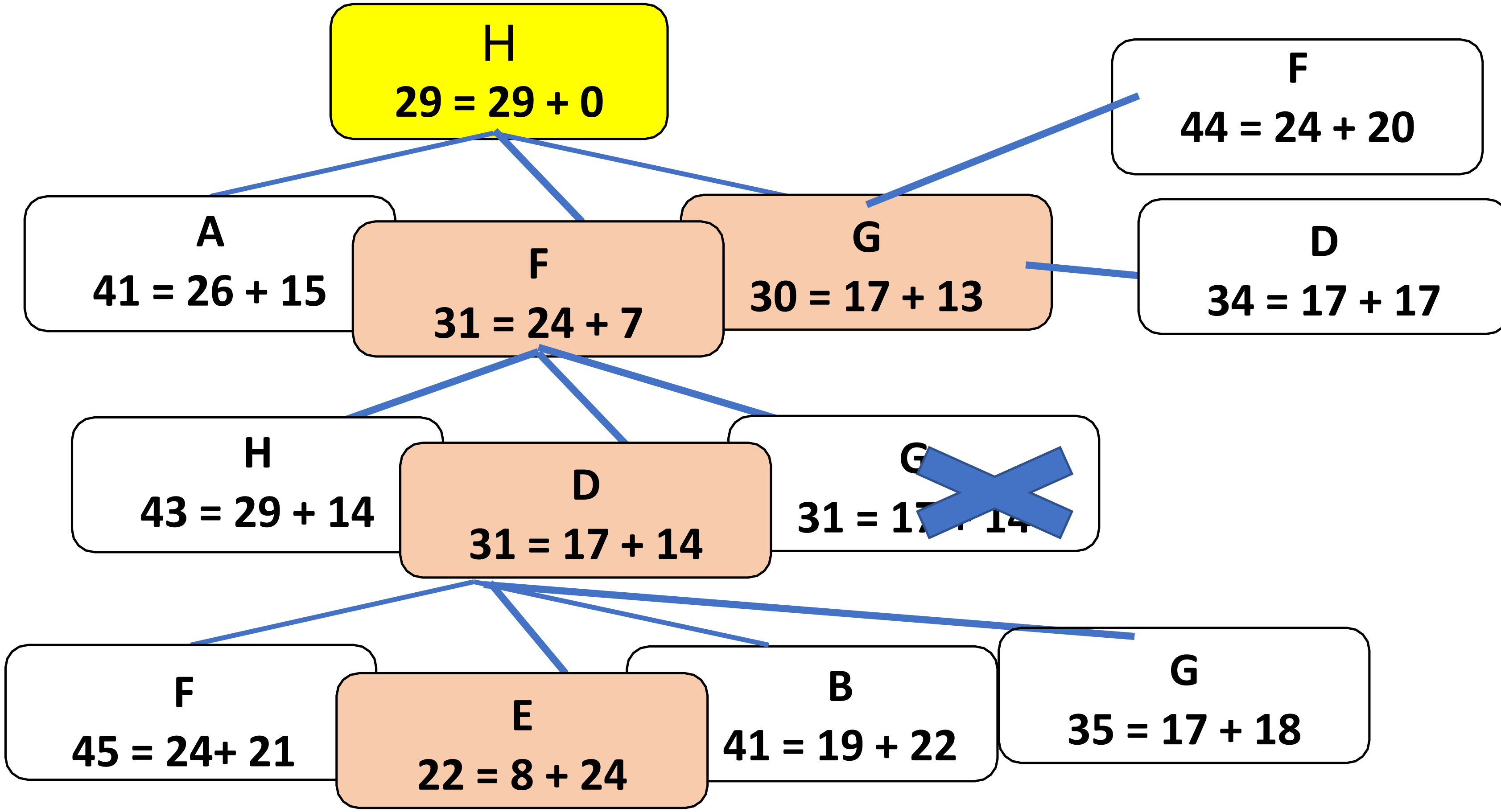




H
29 = 29 + 0

A
41 = 26 + 15

F
31 = 24 + 7

G
30 = 17 + 13

F
44 = 24 + 20

D
34 = 17 + 17

H
43 = 29 + 14

D
31 = 17 + 14

G
31 = 17 + 14

F
45 = 24+ 21

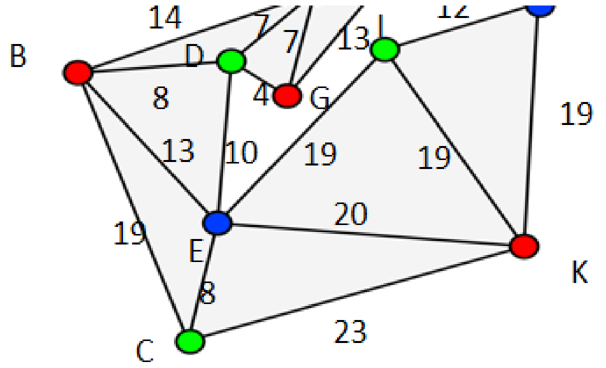
E
22 = 8 + 24

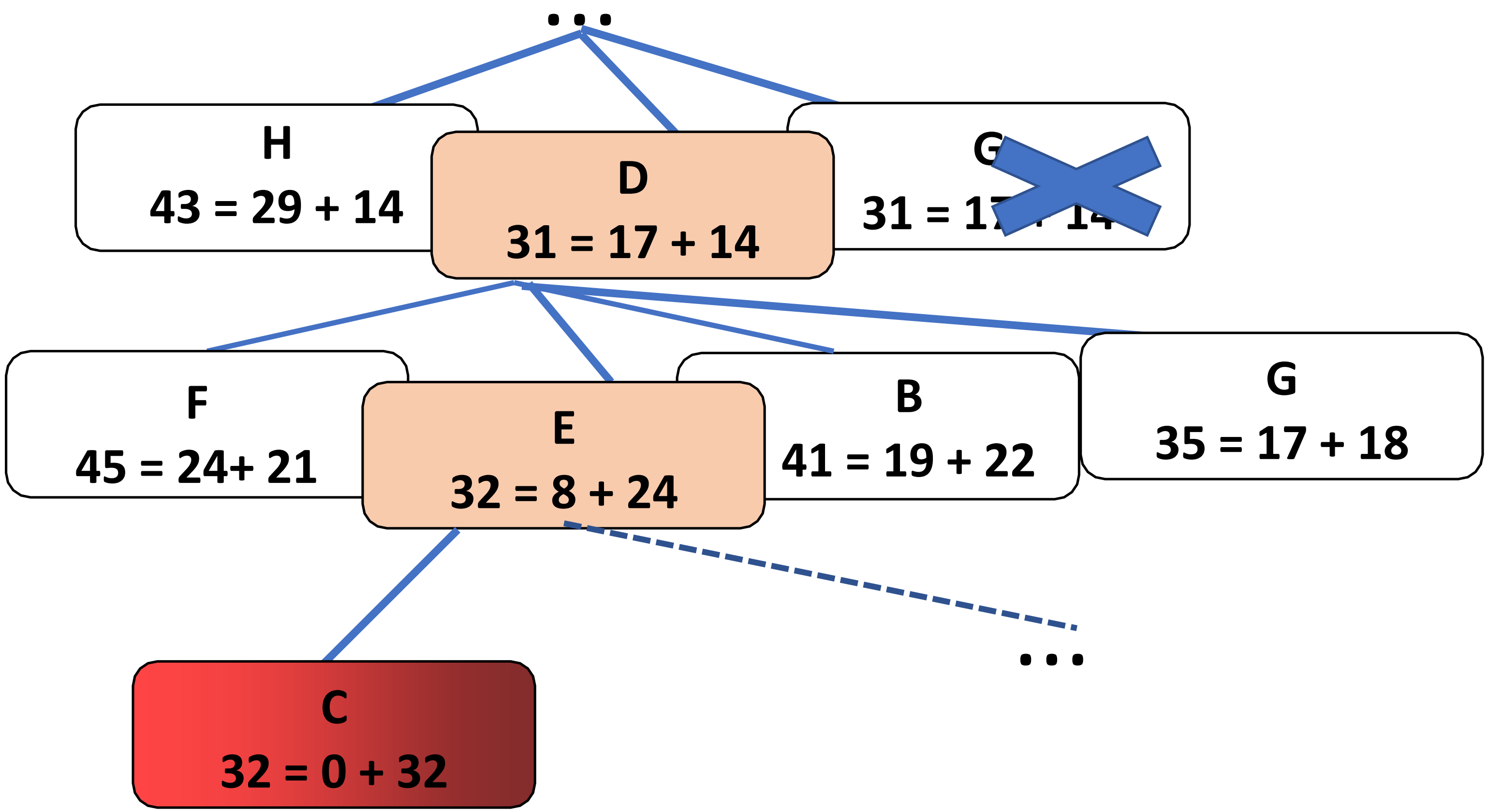
B
41 = 19 + 22

G
35 = 17 + 18

A* Search Illustration

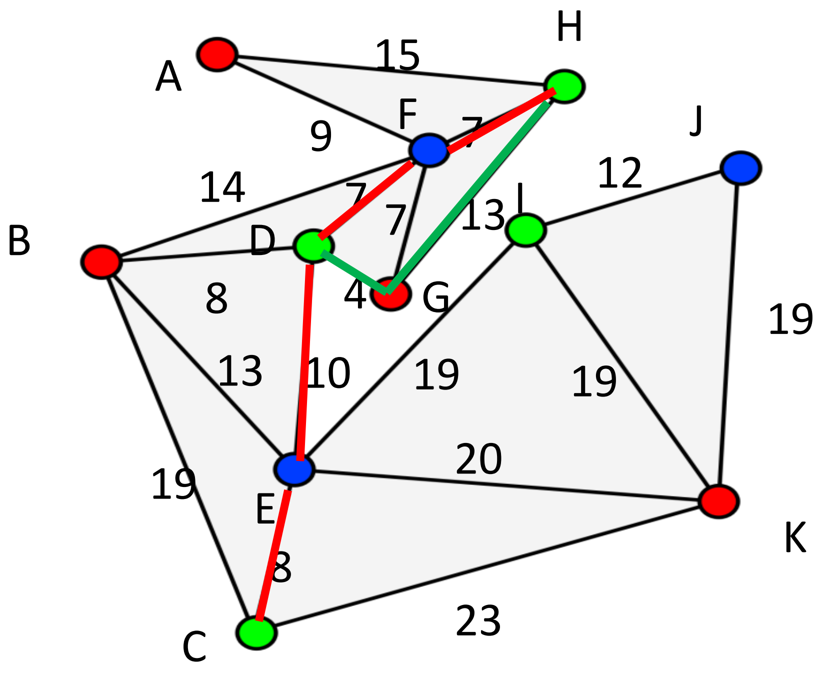
Node	SLD to C
B	19
D	17
I	25
K	23
C	0





Target Arrived ！

A* Search Illustration



- **Solution**:
  H -> F -> D -> E -> C

- $\boldsymbol{Distance} = 7 + 7 + 10 + 8$
  $= 32\ m$

- Solution by Greedy Search: 35m

Brief Summary

Summary: Heuristic Search

- Core idea: expand the path that seems most promising.
- Node s with lowest $f(s) \rightarrow$ the most promising.
- Usually $f(s) = h(s) + ?$.

- Greedy: Incomplete & Not always optimal
- A*: Complete & Optimal

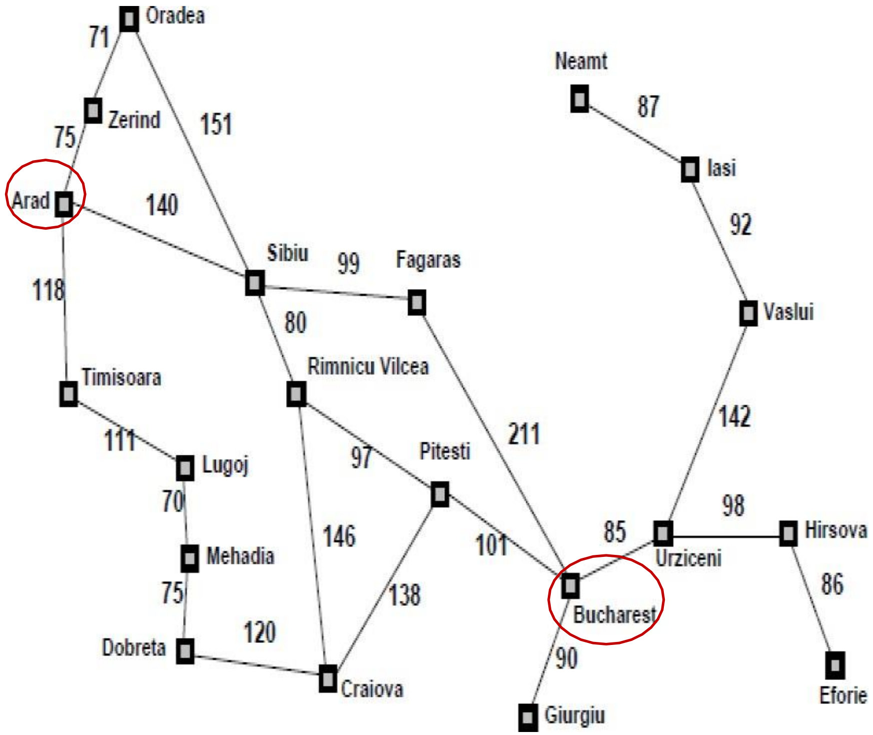
Summary: Search Methods with $f(s)$

- The choice of f determines the search methods.
- Uniform-cost search: $f(s) = g(s)$.
- Greedy best-first search: $f(s) = h(s)$.
- A* search: $f(s) = g(s) + h(s)$.

- $g(s)$: the path cost from Start to node s.
- $h(s)$: the estimated cost from node s to Goal.

Exercise

Exercise 1



Use A* Search with the straight-line distance heuristic to solve the shortest path from Lugoj to Bucharest.

Please give the order of the node expansion with f(s), g(s), and h(s) for each node.

Exercise 2

Heuristic Path Algorithm is a type of Best First Search and its evaluation function is f(n) = (2-w)g(n) + w*h(n).

1) Suppose h is admissible. how to set w to make it optimal?

2) When w=0, w=1, and w=2, which search algorithm does it represent? Explain your answer.