AI Search (BFS DFS A*)

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(Teacher Mode)

2 Lessons - BFS and DFS one day, A* the next

EQs: What is Artificial Intelligence? How do computers make decisions?

Objectives:

Day 1: SWBAT emulate a BFS and DFS on a given data set and compare/contrast BFS and DFS.

Day 2: SWBAT emulate an A* search on a given data set and compare/contrast informed vs uninformed search.

Key Vocabulary - informed vs. uninformed, cost, heuristic, optimal

Extra Materials for extension/support: GeeksforGeeks article, videos

Day 1 - **BFS vs DFS**

Searching for Treasure

Hook: Looking for treasure in a cave system and analyzing the approach

What information would be valuable to have about each path?

Efficiency Considerations - Cave Diving in Search of Treasure


A
B
C


D
E


DEAD END
Lava pops
Water flows


F
G

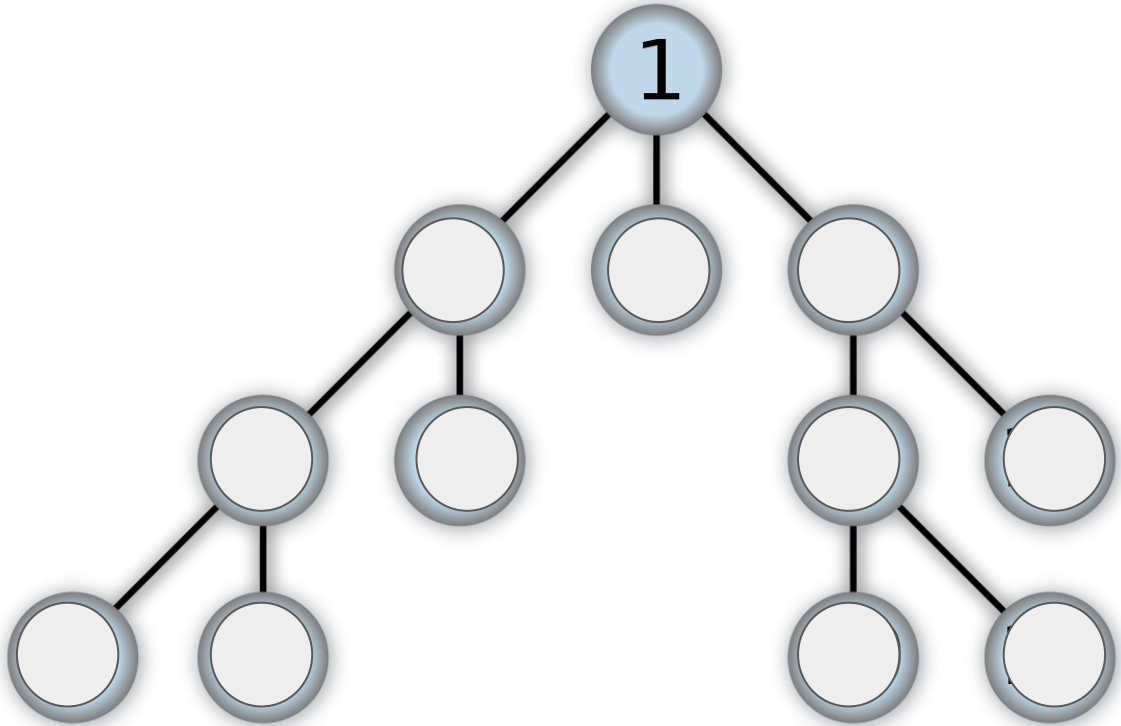
Strategies for Exploring and Mapping the Cave?

3 minutes → On a KtS, write down or diagram a strategy for exploring the cave.

2 minutes → Discuss your strategy with your partner.

1 minute → Adjust your strategies with input from your partner.

Map of the Cave

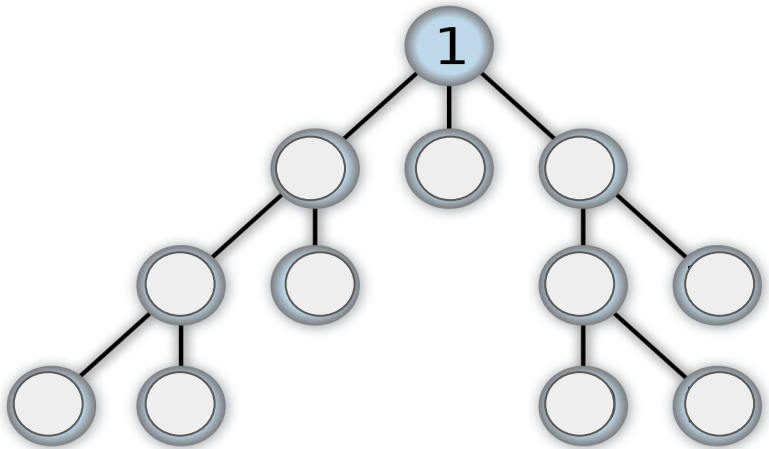


Exercise: Depth First Searching

Explore each branch IN ITS ENTIRETY before moving on to another.

DFS Rules:

1. From the starting node, GO LEFT!
2. Continue going left until you reach a dead end (there are no children).
3. Backtrack to the most recent path not chosen. Go down it and repeat steps 2-3.



DFS and Tree Traversal

(If you've taught Tree Traversal)

Which type of tree traversal does DFS most resemble:

pre-order?

in-order?

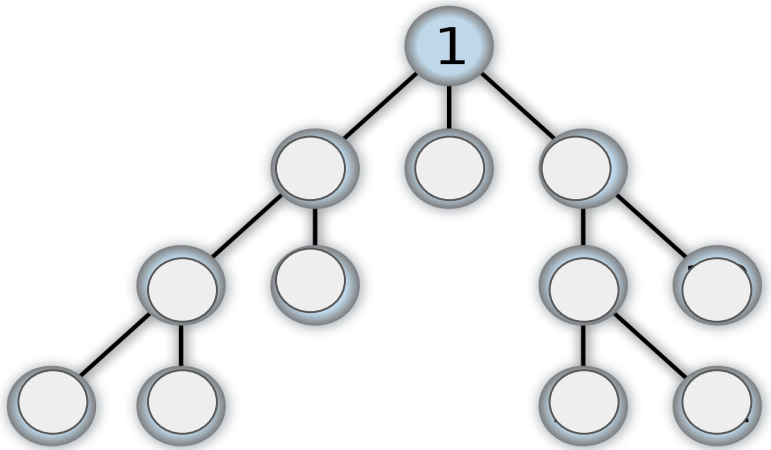
post-order?

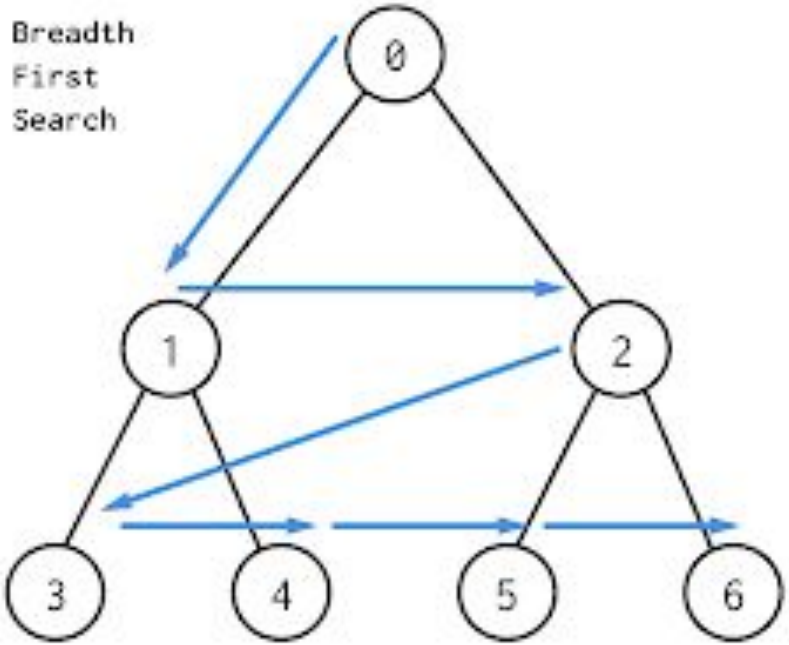
Exercise: Breadth First Searching

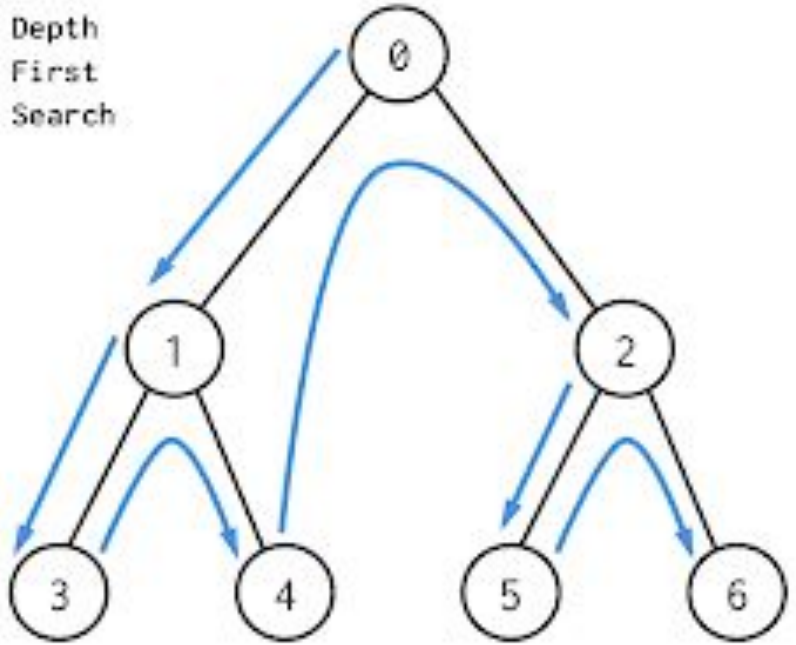
Check each entire level of options before moving to the next.

BFS Rules:

1. Check every option that is 1 step away from the starting node from left to right.
2. Check every option that is 2 steps away from the starting node from left to right.
3. Check every option that is 3 steps… you get the idea...




Breadth
First
Search
0
1
2
3
4
5
6


Depth
First
Search
0
1
2
3
4
5
6

How does this relate to Artificial Intelligence?

Decision Tree

Imagine each node is a chess move.

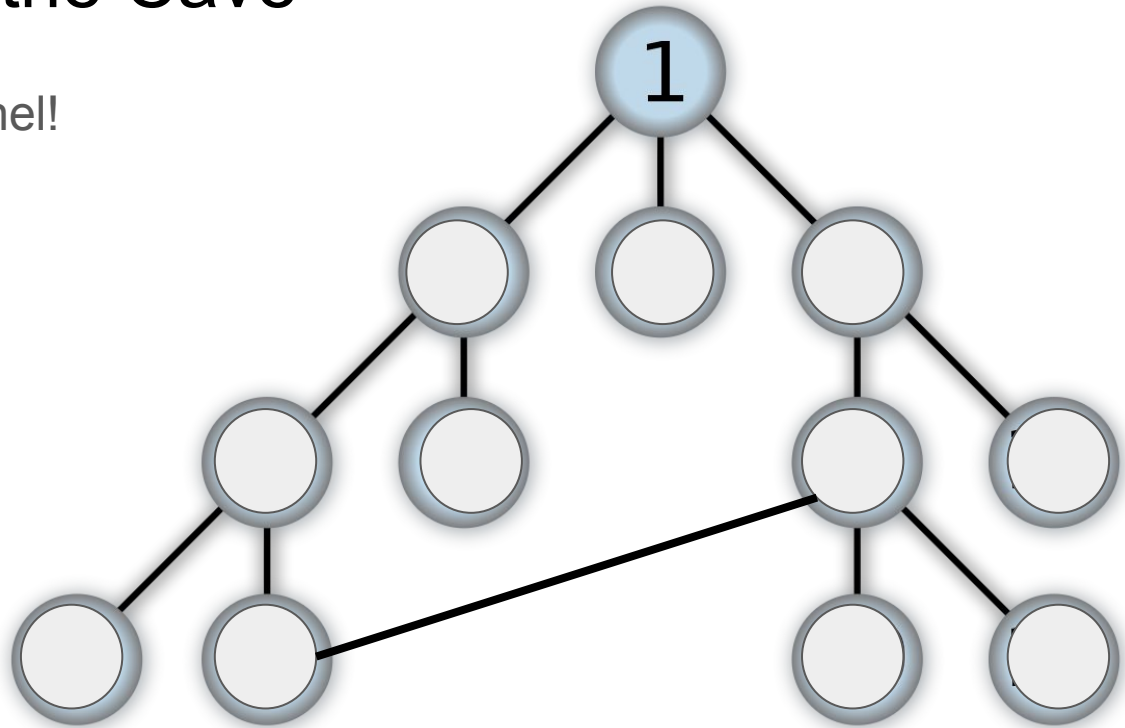
Do a Depth First Search to find a move, SOMEWHERE down the line, that results in checkmate.

Take that first move…

What issues might arise?

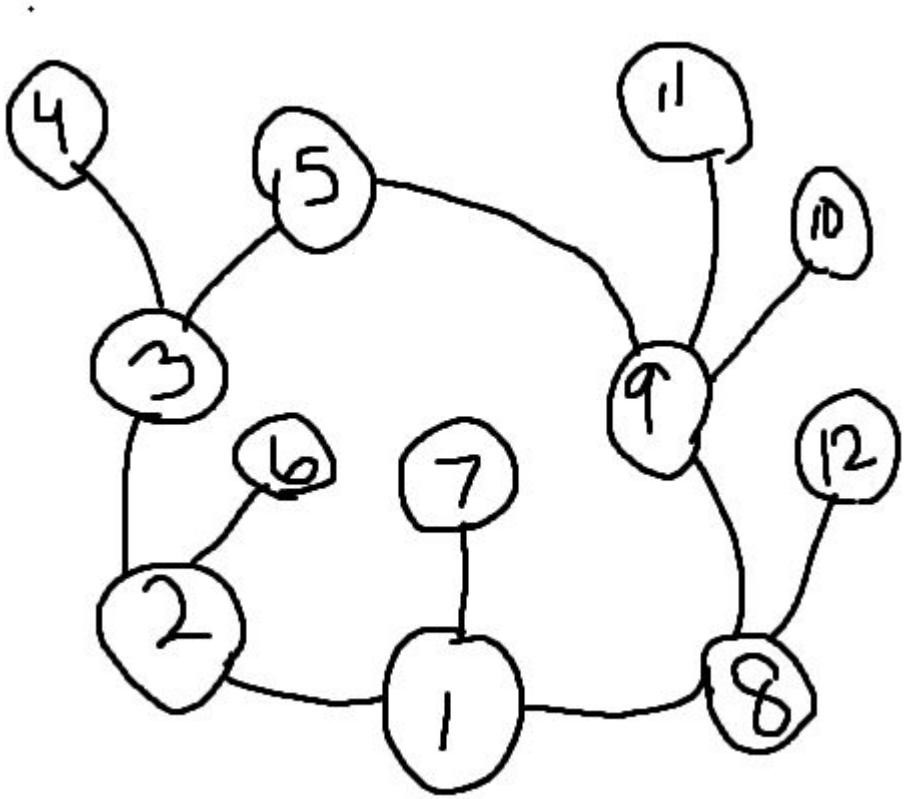
Map of the Cave

Secret Tunnel!



Non-tree Structure

Choose your next node arbitrarily.



Find the Shortest Route

How do we know that the route we found to the treasure is the OPTIMAL route?

How could we find a shorter route to treasure?

Day 1 - **Coding Exercise**

Subgoal Label the Depth First Search and anticipate/design any helper methods in the CaveMap class.

Extension: Code the Depth First Search in the CaveMap class. [Print the path]

Day 1 - **Wrap Up Discussion Questions**:

- Describe the difference between BFS and DFS. Which one is better in your opinion, and why?

- What is not ideal about both BFS and DFS?

Final Thought - reflect on for tomorrow:

Is there a way that we could have a more informed (intelligent) approach to searching? If so, what might we need in regard to the data tree?

Day 2 - **A* Search**

A* (A star) Search

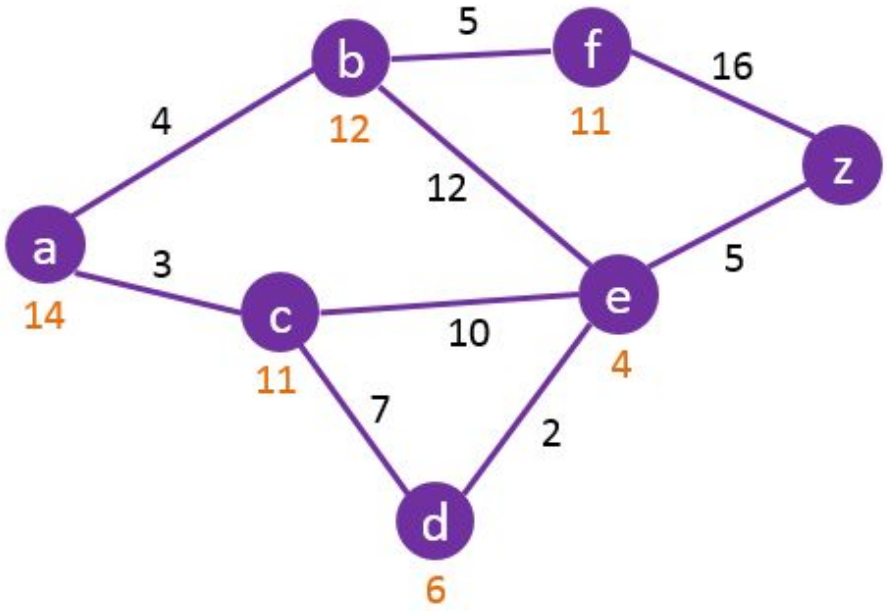
Hook: Looking for treasure in a cave system, which path will you take with a radiation detector? [with cost path analysis]

A* Search: always analyzes path options with a heuristic and picks the route that is the best path forward with consideration of cost of each path (computing space, difficulty, physical distance, literal dollar cost, etc.)

Efficiency Considerations [Elicit from class - from previous day's activity]

Informed vs Uninformed Searches

*Real world example(?) Google Flight Matrix - (decision making about Node - cities with cost path analysis)



A* Search Algorithm

What is the shortest path to travel from A to Z?

Numbers in orange are the heuristic values, distances in a straight line (as the crow flies) from a node to node Z.


h = the node’s closeness to the goal(treasure)
g = the cost of traveling to that node
f = h + g
h = 12
g = 1
f = 13
h = 3
g = 8
f = 11
h = 7
g = 3
f = 10

g-values and h-values overview

The g-value is the **actual** cost of traveling from one node to another directly.

- G stands for G-money, because it's the cost.

The h-value is an estimate of the total cost to travel from that node to the goal node.

- H stands for heuristic, a problem solving technique that involves approximating (by drawing pictures or quickly estimating)
- H also stands for wHole cost from this node to the goal.

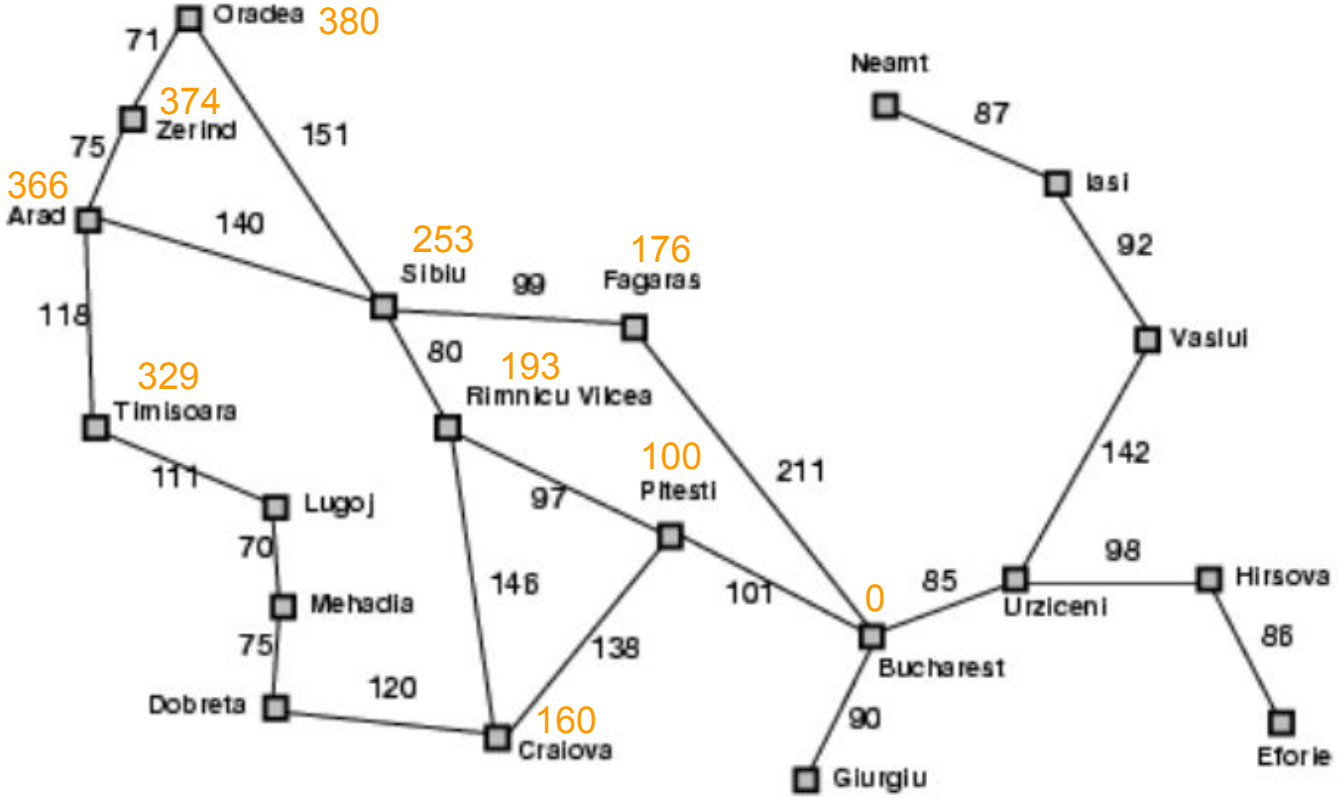
What should the h-value of the goal node be?

Admissible - an h-value is admissible (usable) only if it is less than or equal to the actual cost. Therefore, a heuristic can be seen as a MINIMUM total cost from one node to the goal.

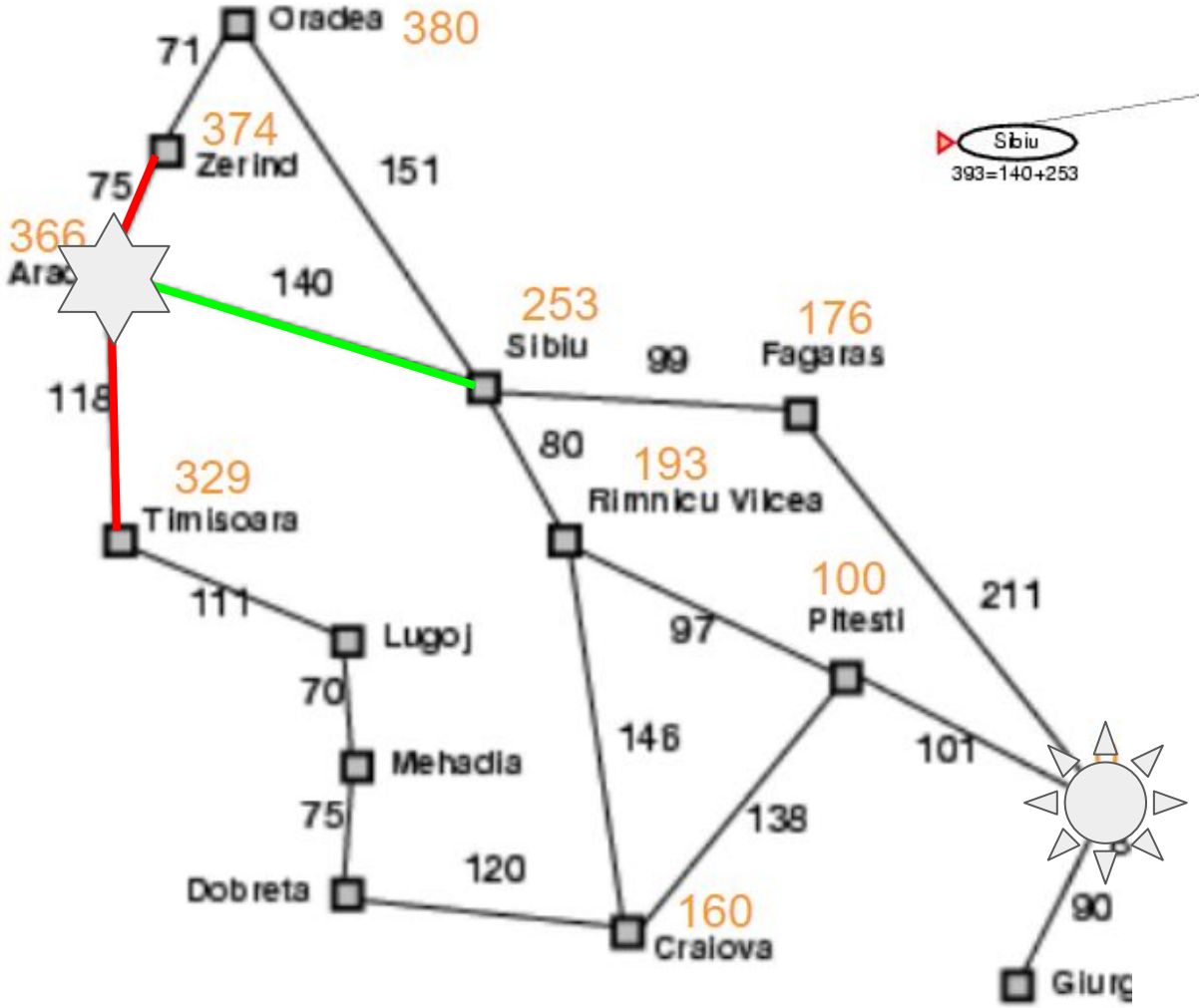
A* search algorithm

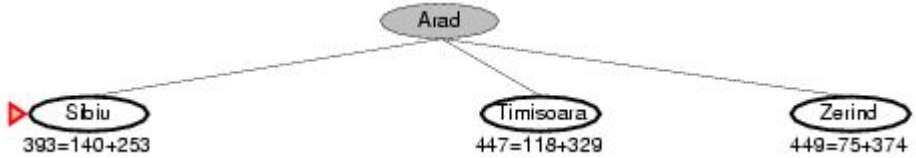
1. From the current node, for each connected node, add the h-value and the TOTAL cost of traveling to that node from the starting node.
2. Choose the unexplored node with the lowest sum of ALL unexplored nodes to move to next.
3. If not the goal node, repeat steps 1-2.
4. If the current node is the goal node, add up the total cost of traveling there and compare it to the minimum value of all unexplored paths. If the cost is lower, you have found the OPTIMAL path.

Romania with straight-line dist.

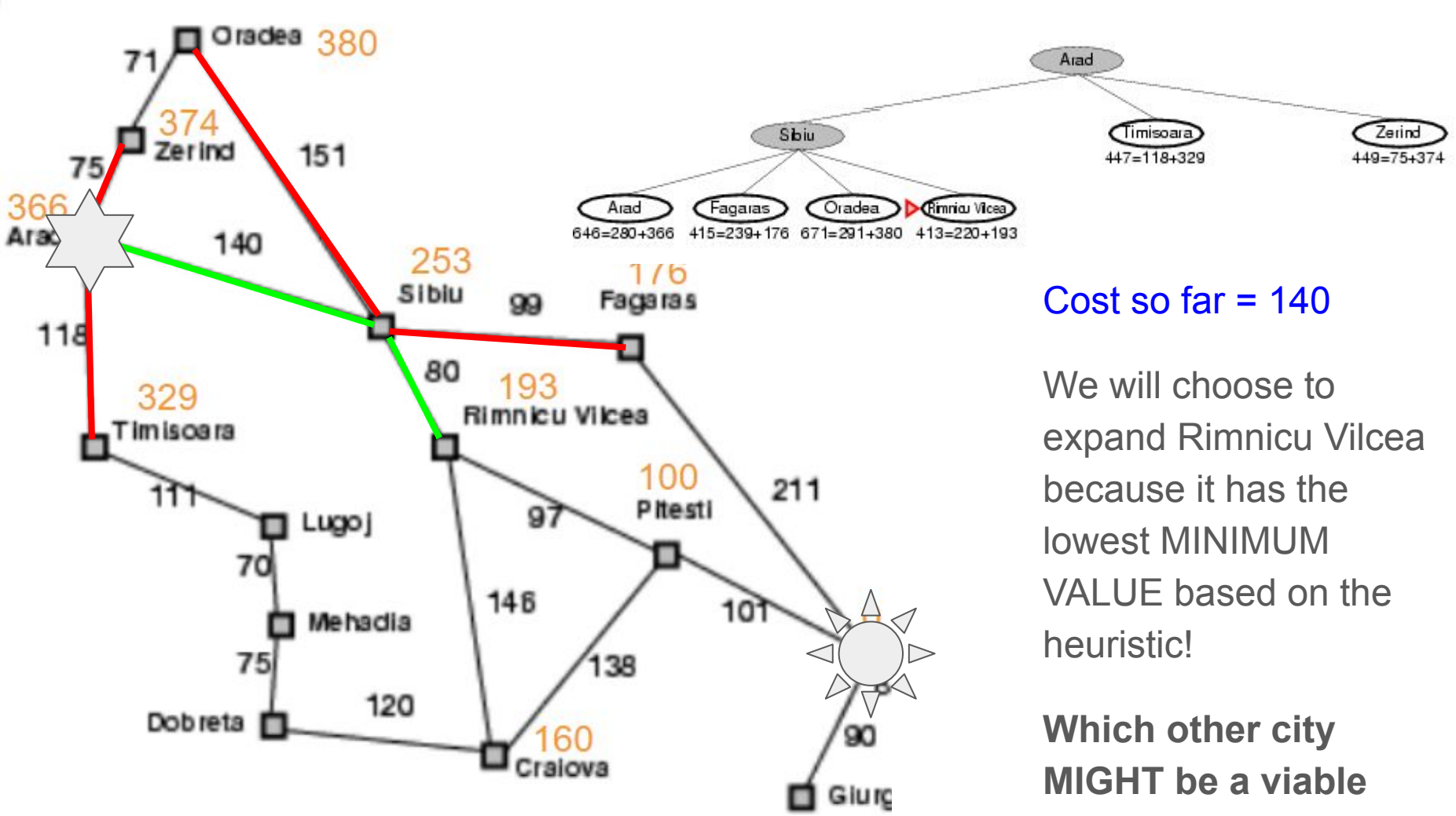


Straight–line distance to Bucharest	
Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	176
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
Mehadia	241
Neamt	234
Oradea	380
Pitesti	10
Rimnicu Vilcea	193
Sibiu	253
Timisoara	329
Urziceni	80
Vaslui	199
Zerind	374





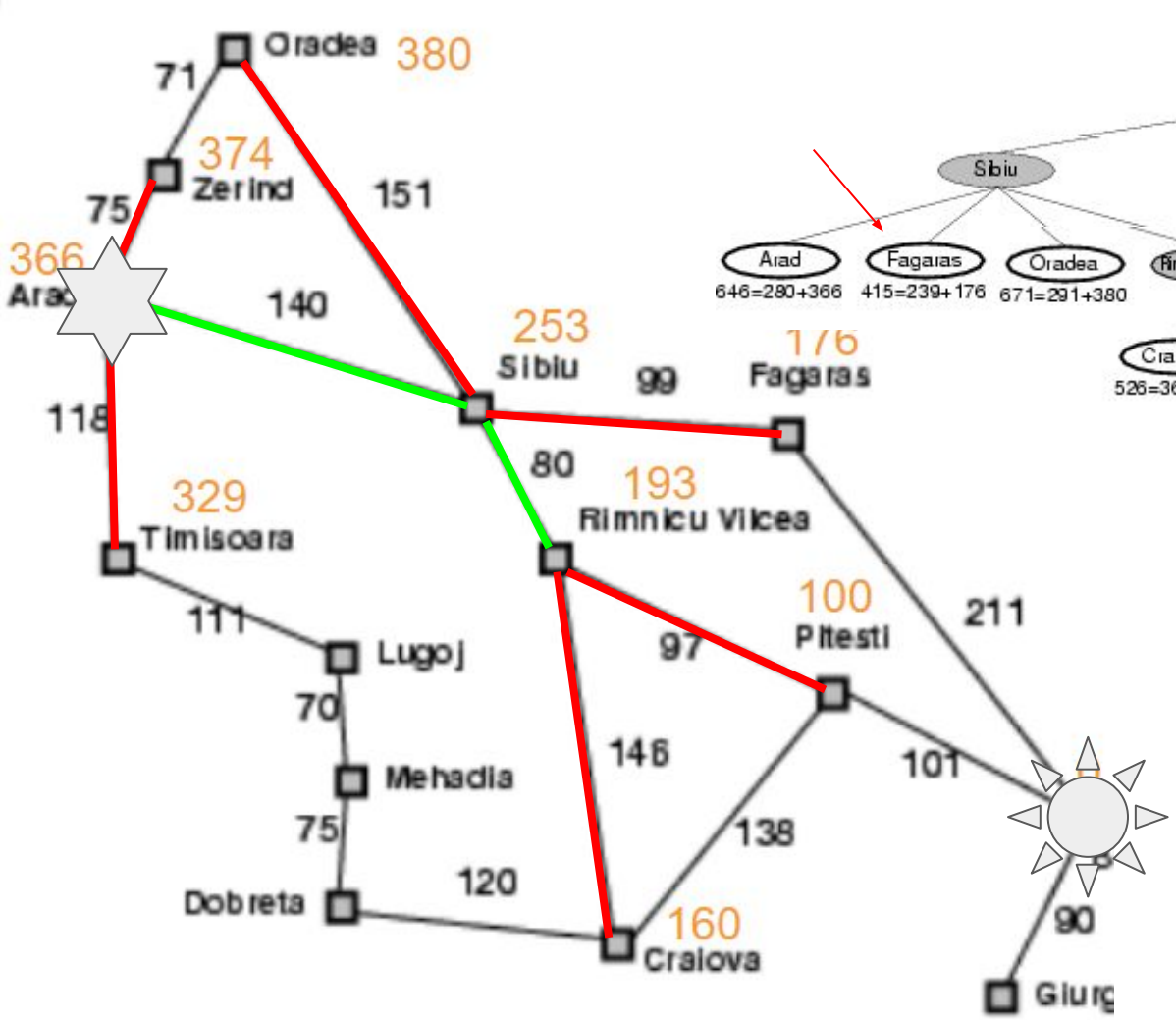
Even though Sibiu is farther away (higher g-value) than Timisoara and Zerind, it ultimately puts us much closer to Bucharest (h-value of 253). The sum of g and h is the lowest, so its minimum overall cost from Arad to Bucharest is lower than the others, and we will explore that first.

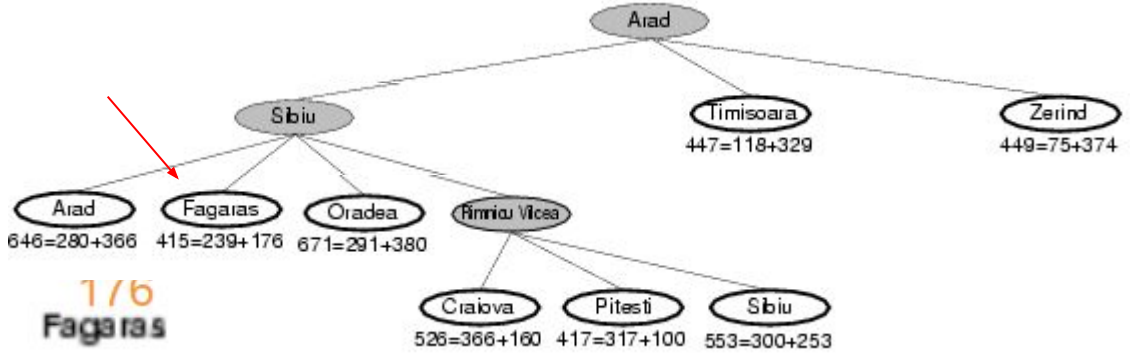


Cost so far = 140

We will choose to expand Rimnicu Vilcea because it has the lowest MINIMUM VALUE based on the heuristic!

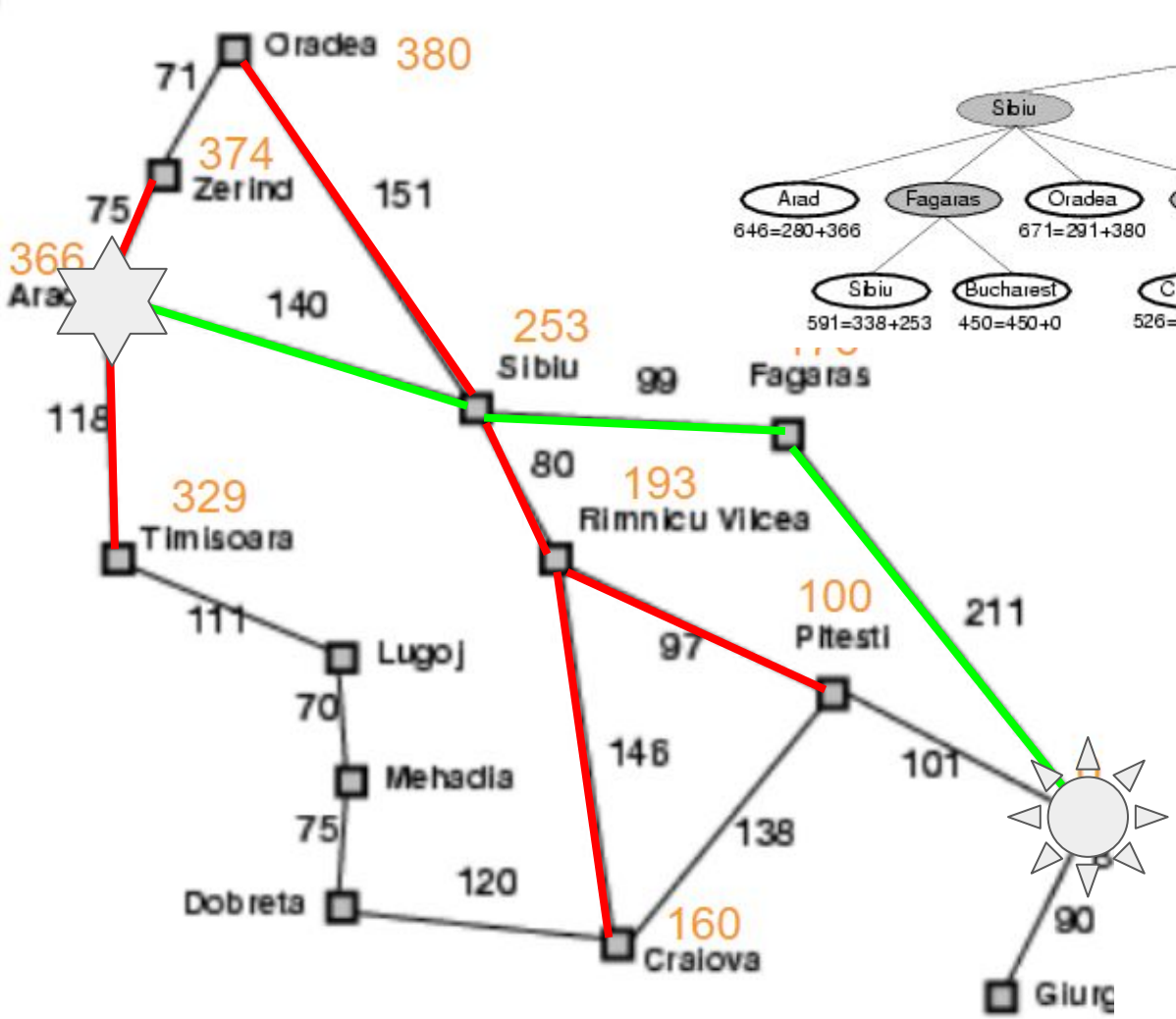
Which other city MIGHT be a viable option?

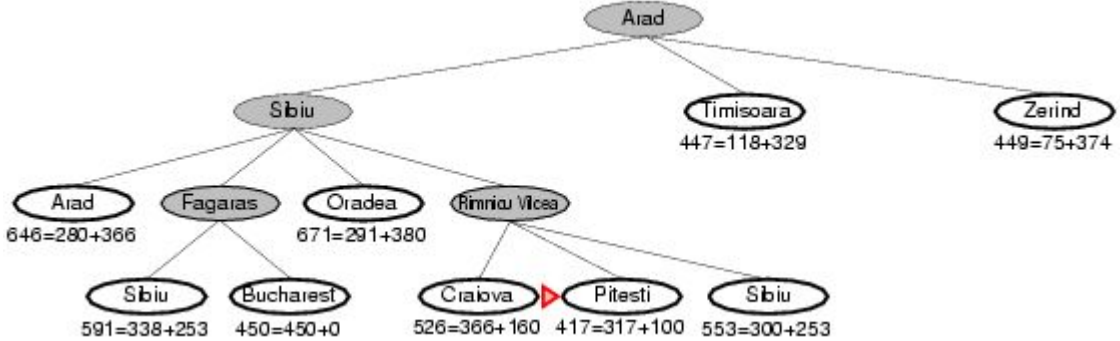




Which branch should we explore next?

Since the Arad-->Sibiu-->Fagaras route has an estimated total cost of 415, which is lower than all of the options available from Rimnicu Vilcea, we will look in that direction instead.

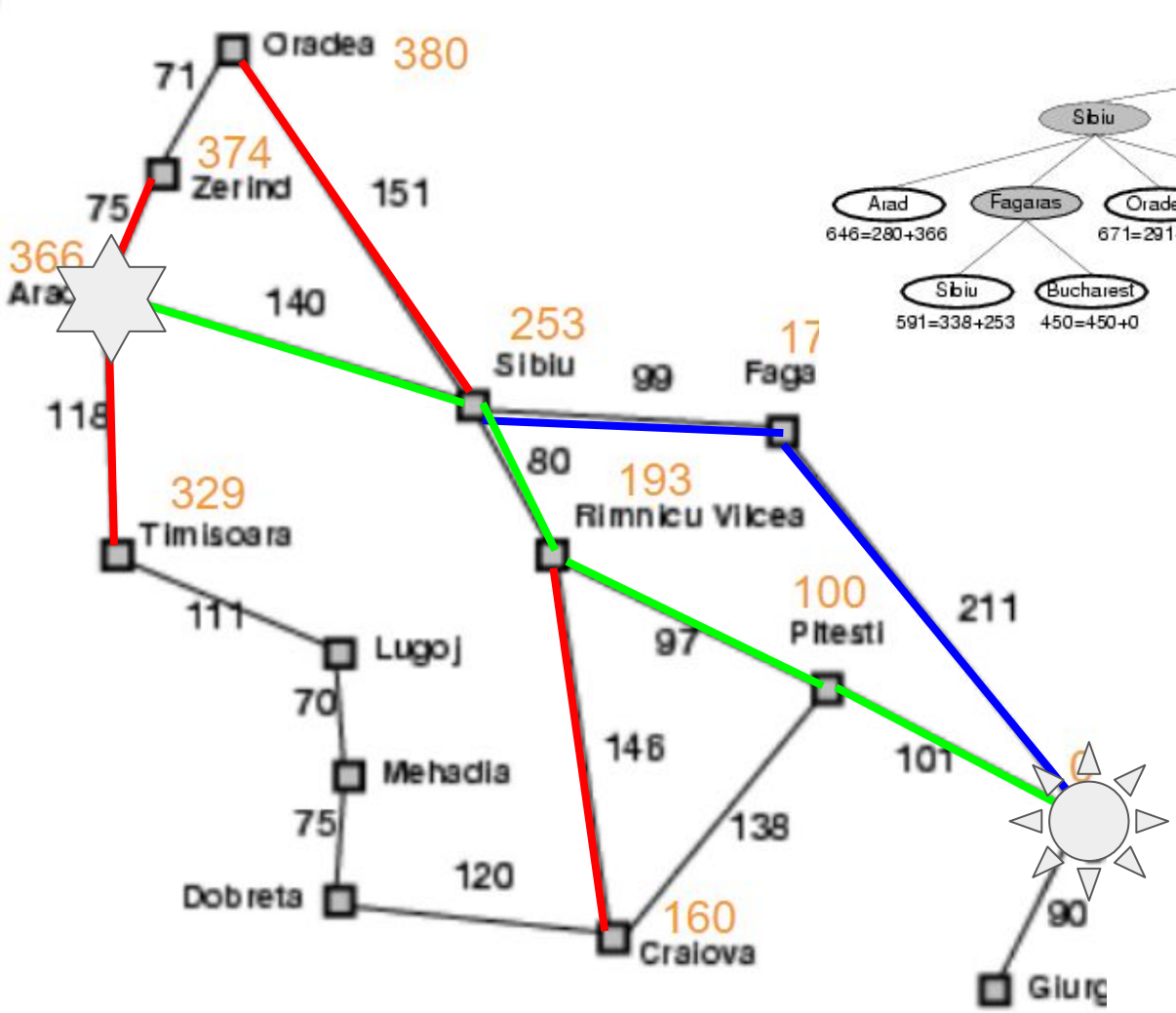


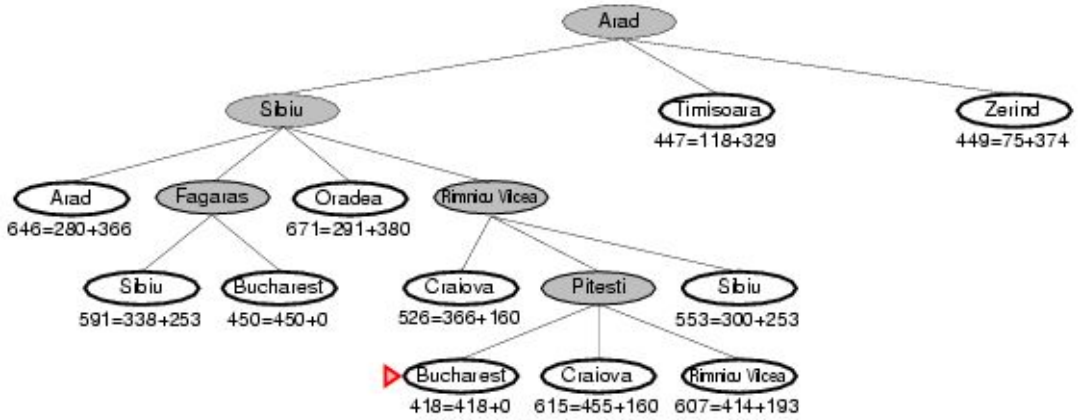


Are we done?

Although we made it to Bucharest, the total actual cost was 450, which may not be the lowest overall, as a previously explored branch has a minimum overall value of 417.

So let's check that one, too!





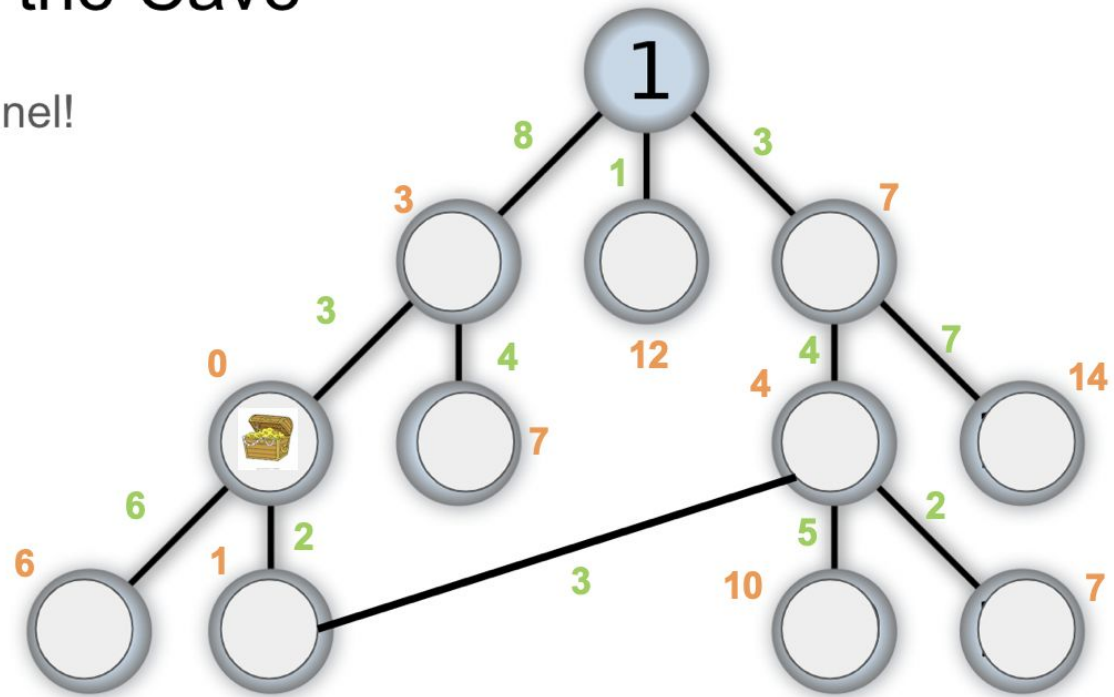
Are we done?

The total actual cost for the highlighted branch is 418. This is lower than the MINIMUM VALUES of all other possible branches to the solutions.

Back to the Cave!

Map of the Cave

Secret Tunnel!



Day 2 - **Coding Exercise**

In your designated teams of 2:

Subgoal Label the A* Search in the Tree class.

Guiding Questions:

How will we keep track of the distance traveled?

How will we figure out the h-value of each node?

Extension: Write out pseudo-code for your A* Search with your partner.

Day 2 - **Wrap Up Discussion Questions**:

- What is the difference between uninformed and informed search methods?

- Why is A* generally so much more efficient than BFS or DFS?

- What are some potential real world applications of the A* search?