Solution Review: Problem Challenge 2

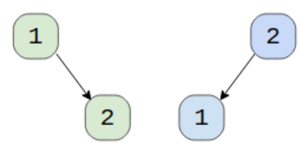
We'll cover the following

Structurally Unique Binary Search Trees (hard)

Given a number 'n', write a function to return all structurally unique Binary Search Trees (BST) that can store values 1 to 'n'?

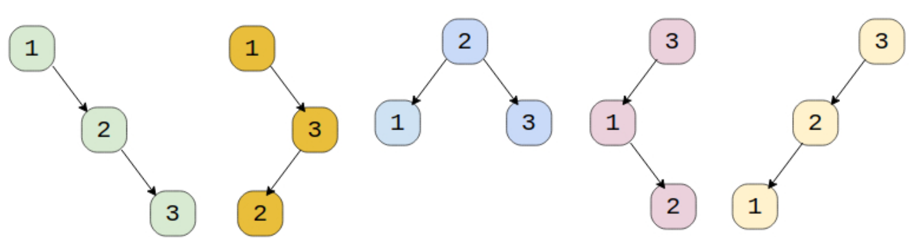
Example 1:

```
Input: 2
Output: List containing root nodes of all structurally unique BSTs.
Explanation: Here are the 2 structurally unique BSTs storing all numbers from 1 to 2:
```



Example 2:

```
Input: 3
Output: List containing root nodes of all structurally unique BSTs.
Explanation: Here are the 5 structurally unique BSTs storing all numbers from 1 to 3:
```



Solution

This problem follows the Subsets pattern and is quite similar to Evaluate Expression. Following a similar approach, we can iterate from 1 to 'n' and consider each number as the root of a tree. All smaller numbers will make up the left sub-tree and bigger numbers will make up the right sub-tree. We will make recursive calls for the left and right sub-trees

Code

Here is what our algorithm will look like:

Java | Python3 | C++ | JS

```python

class TreeNode:
  def __init__(self, val):
    self.val = val
    self.left = None
    self.right = None


def find_unique_trees(n):
  if n <= 0:
    return []
  return findUnique_trees_recursive(1, n)


def findUnique_trees_recursive(start, end):
  result = []
  # base condition, return 'None' for an empty sub-tree
  # consider n = 1, in this case we will have start = end = 1, this means we should have only one tree
  # we will have two recursive calls, findUniqueTreesRecursive(1, 0) & (2, 1)
  # both of these should return 'None' for the left and the right child
  if start > end:
    result.append(None)
    return result

  for i in range(start, end+1):
    # making 'i' the root of the tree
    leftSubtrees = findUnique_trees_recursive(start, i - 1)
    rightSubtrees = findUnique_trees_recursive(i + 1, end)
    for leftTree in leftSubtrees:
      for rightTree in rightSubtrees:
        root = TreeNode(i)
        root.left = leftTree
        root.right = rightTree
        result.append(root)

  return result


def main():
  print("Total trees: " + str(len(find_unique_trees(2))))
  print("Total trees: " + str(len(find_unique_trees(3))))


main()

```

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Time complexity

The time complexity of this algorithm will be exponential and will be similar to Balanced Parentheses. Estimated time complexity will be $O(n * 2^n)$ but the actual time complexity ($O(4^n/\sqrt{n})$) is bounded by the Catalan number and is beyond the scope of a coding interview. See more details here.

Space complexity

The space complexity of this algorithm will be exponential too, estimated at $O(2^n)$, but the actual will be ($O(4^n/\sqrt{n})$.

Memoized version

Since our algorithm has overlapping subproblems, can we use memoization to improve it? We could, but every time we return the result of a subproblem from the cache, we have to clone the result list because these trees will be used as the left or right child of a tree. This cloning is equivalent to reconstructing the trees, therefore, the overall time complexity of the memoized algorithm will also be the same.

Completed

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