TIP102 | Intermediate Technical Interview Prep

Intermediate Technical Interview Prep Spring 2025 (@ Section 3 | Tuesdays and Thursdays 6PM - 8PM PT)
Personal Member ID#: 117667

Session 2: Binary Trees

Session Overview

Students will apply advanced techniques in tree traversal and restructuring to tackle challenges involving balanced trees, pathfinding, and tree transformations. Key topics covered include tree mirroring, root-to-leaf path sums, subtree identification, and handling tree-based inventory data.

> You can find all resources from today including session slide decks, session recordings, and more on the resources tab

🎢 Part 1 : Instructor Led Session

We'll spend the first portion of the synchronous class time in large groups, where the instructor will lead class instruction for 30-45 minutes.

👨‍💻 Part 2: Breakout Session

In breakout sessions, we will explore and collaboratively solve problem sets in small groups. Here, the **collaboration, conversation, and approach** are just as important as “solving the problem” - please engage warmly, clearly, and plentifully in the process!

In breakout rooms you will:

- Screen-share the problem/s, and verbally review them together
- Screen-share an interactive coding environment, and talk through the steps of a solution approach
    - ProTip: - An Integrated Development Environment (IDE) is a fancy name for a tool you could use for shared writing of code - like Replit.com, Collabed.it, CodePen.io, or other - your staff team will specify which tool to use for this class!
- Screen-share an implementation of your proposed solution
- Independently follow-along, or create an implementation, in your own IDE.

Your program leader/s will indicate which code sharing tool/s to use as a group, and will help break down or provide specific scaffolding with the main concepts above.

▶ **Note on Expectations**

🔎 Problem Solving Approach

To build a long-term organized approach to problem solving, we'll start with three main steps. We'll refer to them as **UPI: Understand, Plan, and Implement**.

We'll apply these three steps to most of the problems we'll see in the first half of the course.

We will learn to:

- **Understand** the problem,
- **Plan** a solution step-by-step, and
- **Implement** the solution

▶ Comment on UPI

▶ UPI Example

ℹ️ **Note: Testing your Binary Tree (Printing)**

To keep the amount of starter code manageable, we have chosen not to include a function to print a binary tree as part of each relevant problem statement. You may instead copy the function in the drop-down below `print_tree()` and use it as needed while you complete the problem sets.

▼ Print Binary Tree Function

Accepts the root of a binary tree and prints out the values of each node level by level from left to right. Values of `None` are used to indicate a null child node between non-null children on the same level. Prints `"Empty"` for an empty tree.

```
from collections import deque

# Tree Node class
class TreeNode:
    def __init__(self, value, left=None, right=None):
        self.val = value
        self.left = left
        self.right = right

def print_tree(root):
    if not root:
        return "Empty"
    result = []
    queue = deque([root])
    while queue:
        node = queue.popleft()
        if node:
            result.append(node.val)
            queue.append(node.left)
            queue.append(node.right)
        else:
            result.append(None)
    while result and result[-1] is None:
        result.pop()
    print(result)
```

Example Usage:

```
"""
          1
        /   \
       2     3
      /     / \
     4     5   6
"""

root = Node(1, Node(2, Node(4)), Node(3, Node(5), Node(6)))

print_tree(root)
print_tree(None)
```

Example Output:

```
[1, 2, 3, 4, None, 5, 6]
'Empty'
```

ℹ️ Note: Testing your Binary Tree (Generating a Tree)

Now that you have practice manually building trees for testing in previous sessions, we are providing a function that builds binary trees based off of a list of values to speed up the testing process. We have chosen not to include this function in the starter code for each problem to keep the length of problems manageable. You may instead copy the function in the drop-down below `build_tree()` and use it as needed while you complete the problem sets.

▼ Build Binary Tree Function

Takes in a list `values` where each element in the list corresponds to a node in the binary tree you would like to build. The values should be in level order (from top to bottom, left to right). Use `None` to indicate a null child between non-null children on the same level.

Some problems may ask you to build a tree where nodes have both keys and values. This function may be used to build trees with just values *and* trees with both keys and values:

- If building a tree with only values, `values` should be given in the form: `[value1, value2, value3, ...]`.
- If building a tree with both keys and values `values` should be given in the form `[(key1, value1), (key2, value2), (key3, value3), ...]`.

Returns the `root` of the binary tree made from `values`.

```
from collections import deque

# Tree Node class
class TreeNode:
  def __init__(self, value, key=None, left=None, right=None):
      self.key = key
      self.val = value
      self.left = left
      self.right = right

def build_tree(values):
  if not values:
      return None

  def get_key_value(item):
      if isinstance(item, tuple):
          return item[0], item[1]
      else:
          return None, item

  key, value = get_key_value(values[0])
  root = TreeNode(value, key)
  queue = deque([root])
  index = 1

  while queue:
      node = queue.popleft()
      if index < len(values) and values[index] is not None:
          left_key, left_value = get_key_value(values[index])
          node.left = TreeNode(left_value, left_key)
          queue.append(node.left)
      index += 1
      if index < len(values) and values[index] is not None:
          right_key, right_value = get_key_value(values[index])
          node.right = TreeNode(right_value, right_key)
          queue.append(node.right)
      index += 1

  return root
```

Example Usage:

```
"""
          1
        /   \
       2     3
      /     / \
     4     5   6
"""

tree_with_just_values = [1, 2, 3, 4, None, 5, 6]
val_tree = build_tree(tree_with_just_values)

"""
          (1, 'A')
          /       \
       (2, 'B')   (3, 'C')
      /           /      \
  (4, 'D')    (5, 'E')   (6, 'F')
"""

tree_with_keys_and_values = [(1, 'A'), (2, 'B'), (3, 'C'), (4, 'D'), None, (5, 'E
key_val_tree = build_tree(tree_with_keys_and_values)

# Using print_tree() function included above
print_tree(val_tree)
print_tree(key_val_tree) # Only values will be printed
```

Example Output:

```
[1, 2, 3, 4, None, 5, 6]
['A', 'B', 'C', 'D', None, 'E', 'F']
```

Breakout Problems Session 2

▸ Standard Problem Set Version 1

▸ Standard Problem Set Version 2

▾ Advanced Problem Set Version 1

Problem 1: Creating Cookie Orders from Descriptions

In your bakery, customer cookie orders are organized in a binary tree, where each node represents a different flavor of cookie ordered by the customers. You are given a 2D integer array `descriptions` where `descriptions[i] = [parent_i, child_i, is_left_i]` indicates that `parent_i` is the parent of `child_i` in a binary tree of unique flavors.

- If `is_left_i == 1`, then `child_i` is the left child of `parent_i`.

- If `is_left_i == 0`, then `child_i` is the right child of `parent_i`.

Construct the binary tree described by descriptions and return its root.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def build_cookie_tree(descriptions):
    pass
```

Example Usage:

```
descriptions1 = [
    ["Chocolate Chip", "Peanut Butter", 1],
    ["Chocolate Chip", "Oatmeal Raisin", 0],
    ["Peanut Butter", "Sugar", 1]
]

descriptions2 = [
    ["Ginger Snap", "Snickerdoodle", 0],
    ["Ginger Snap", "Shortbread", 1]
]

# Using print_tree() function included at top of page
print_tree(build_cookie_tree(descriptions1))
print_tree(build_cookie_tree(descriptions2))
```

Example Output:

```
['Chocolate Chip', 'Peanut Butter', 'Oatmeal Raisin', 'Sugar']
Example 1 Explanation:
The tree structure:
      Chocolate Chip
     /              \
Peanut Butter     Oatmeal Raisin
    /
 Sugar

['Ginger Snap', 'Shortbread', 'Snickerdoodle']
Example 2 Explanation:
The tree structure:
      Ginger Snap
     /           \
Shortbread   Snickerdoodle
```

Problem 2: Cookie Sum

Given the `root` of a binary tree where each node represents a certain number of cookies, return the number of unique paths from the `root` to a leaf node where the total number of cookies equals a given `target_sum`.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

```
class TreeNode:
    def __init__(self, val=0, left=None, right=None):
        self.val = val
        self.left = left
        self.right = right

def count_cookie_paths(root, target_sum):
    pass
```

```
"""
    10
   /  \
  5     8
 / \   / \
3   7 12  4
"""
# Using build_tree() function included at the top of the page
cookie_nums = [10, 5, 8, 3, 7, 12, 4]
cookies1 = build_tree(cookie_nums)

"""
    8
   / \
  4   12
 / \    \
2   6    10
"""
cookie_nums = [8, 4, 12, 2, 6, None, 10]
cookies2 = build_tree(cookie_nums)

print(count_cookie_paths(cookies1, 22))
print(count_cookie_paths(cookies2, 14))
```

Example Output:

```
2
1
```

Problem 3: Most Popular Cookie Combo

In your bakery, each cookie order is represented by a binary tree where each node contains the number of cookies of a particular type. The cookie combo for any node is defined as the total number of cookies in the entire subtree rooted at that node (including that node itself).

Given the `root` of a cookie order tree, return an array of the most frequent cookie combo in your bakery's orders. If there is a tie, return all the most frequent combos in any order.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def most_popular_cookie_combo(root):
    pass
```

Example Usage:

```
"""
       5
      / \
     2  -3
"""
cookies1 = TreeNode(5, TreeNode(2), TreeNode(-3))

"""
       5
      / \
     2  -5
"""
cookies2 = TreeNode(5, TreeNode(2), TreeNode(-5))

print(most_popular_cookie_combo(cookies1))
print(most_popular_cookie_combo(cookies2))
```

Example Output:

```
[2, 4, -3]
[2]
```

Problem 4: Convert Binary Tree of Bakery Orders to Linked List

You've been storing your bakery's orders in a binary tree where each node represents an order for a while now, but are wondering whether a new system would work better for you. You want to try storing orders in a linked list instead.

Given the root of a binary tree `orders`, flatten the tree into a 'linked list'.

- The 'linked list' should use the same `TreeNode` class where the `right` child points to the next node in the list and the `left` child pointer is always `None`.
- The 'linked list' should be in the same order as a preorder traversal of the binary tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def flatten_orders(orders):
    pass
```

Example Usage:

```
"""
        Croissant
       /         \
    Cupcake      Bagel
   /      \           \
Cake     Pie         Blondies
"""
# Using build_tree() function included at the top of page
items = ["Croissant", "Cupcake", "Bagel", "Cake", "Pie", None, "Blondies"]
orders = build_tree(items)

# Using print_tree() function included at the top of page
print_tree(flatten_orders(orders))
```

Example Output:

```
['Croissant', None, 'Cupcake', None, 'Cake', None, 'Pie', None, 'Bagel', None, 'Blon
Explanation:
'Linked List':
Croissant
    \
   Cupcake
       \
       Cake
         \
         Pie
           \
           Bagel
             \
              Blondies
```

Problem 5: Check Bakery Order Completeness

You have a customer order you are currently making stored in a binary tree where each node represents a different item in the order. Given the `root` of the order you are fulfilling, return `True` if the order is complete and `False` otherwise.

An order is complete if every level of the tree, except possibly the last, is completely filled with items (nodes), and all items in the last level are as far left as possible. It can have between `1` and `2^h` items inclusive at the last level `h` where levels are 0-indexed.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def is_complete(root):
    pass
```

Example Usage:

```
"""
        Croissant
       /         \
    Cupcake      Bagel
   /      \      /
Cake     Pie  Blondies
"""
# Using build_tree() function included at the top of page
items = ["Croissant", "Cupcake", "Bagel", "Cake", "Pie", "Blondies"]
order1 = build_tree(items)

"""
        Croissant
       /         \
    Cupcake      Bagel
   /      \           \
Cake     Pie         Blondies
"""
items = ["Croissant", "Cupcake", "Bagel", "Cake", "Pie", None, "Blondies"]
order2 = build_tree(items)

print(is_complete(order1))
print(is_complete(order2))
```

Example Output:

```
True
False
```

Problem 6: Vertical Bakery Display

Your bakery's inventory is organized in a binary tree where each node represents a different bakery item. To make it easier for staff to locate items, you want to create a vertical display of the inventory. The vertical order traversal should be organized column by column, from left to right.

If two items are in the same row and column, they should be listed from left to right, just as they appear in the inventory.

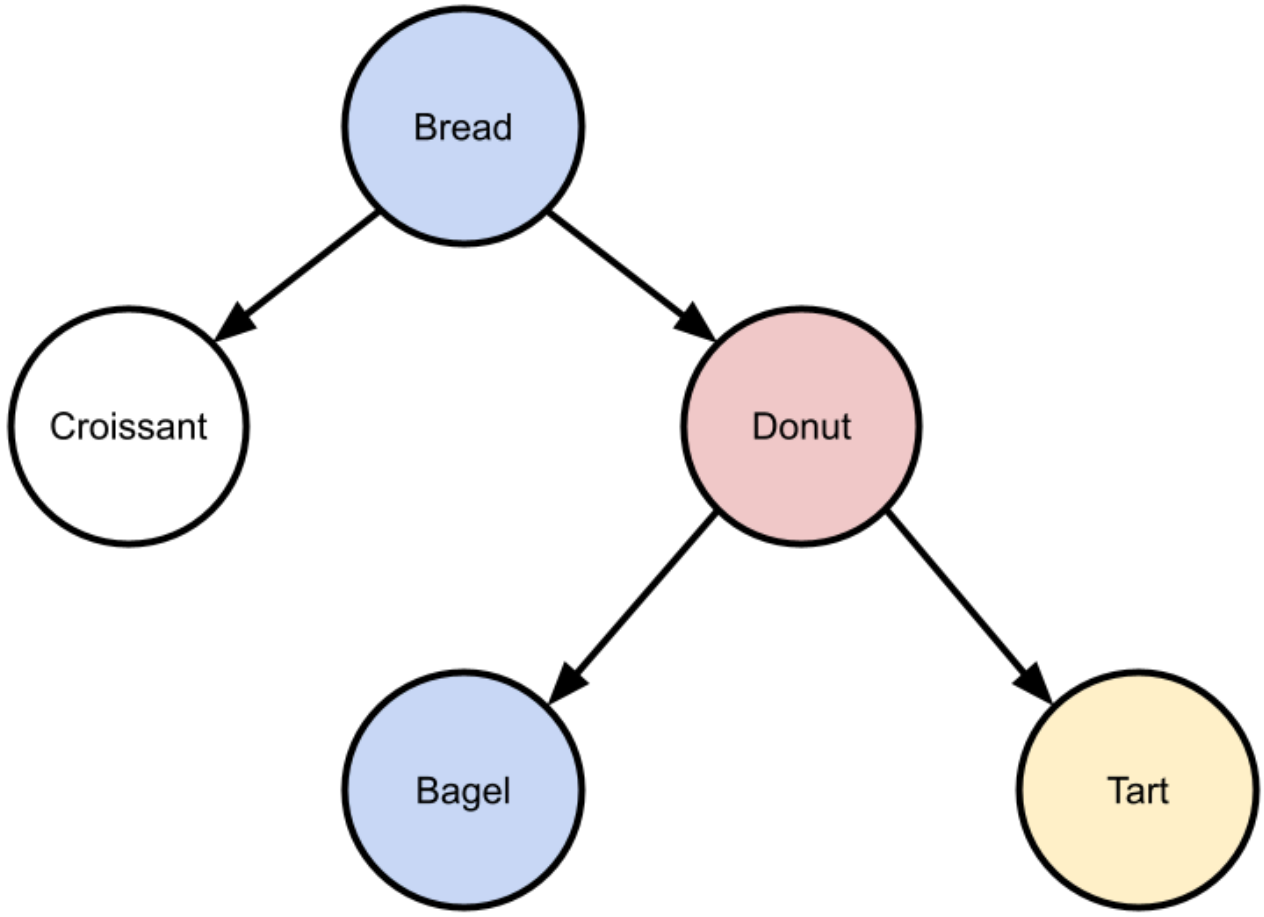
Given the `root` of the binary tree representing the inventory, return a list of lists with the vertical order traversal of the bakery items. Each inner list should represent the `ith` column in the inventory tree, and each inner list's elements should include the values of each bakery item in that column.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def vertical_inventoyr_display(root):
    pass
```

Example Usage 1:



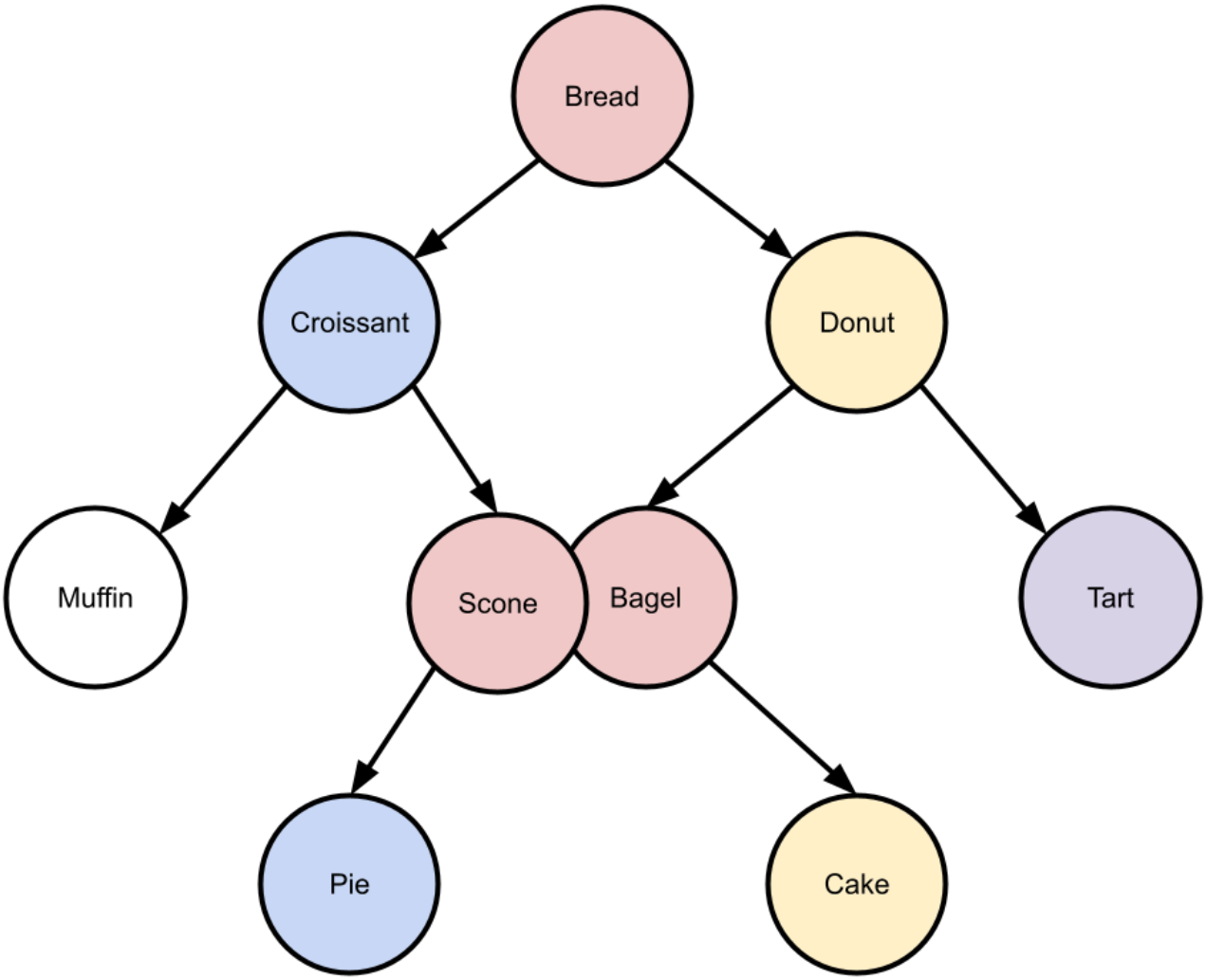

```
"""
         Bread
       /       \
   Croissant    Donut
                /   \
             Bagel Tart
"""
# Using build_tree() function included at the top of the page
inventory_items = ["Bread", "Croissant", "Donut", None, None, "Bagel", "Tart"]
inventory1 = build_tree(inventory_items)

print(vertical_inventory_display(inventory1))
```

Example Output 1:

```
[['Croissant'], ['Bread', 'Bagel'], ['Donut'], ['Tart']]
```

Example Usage 2:




```
"""
         Bread
       /       \
   Croissant    Donut
   /    \        /   \
Muffin  Scone Bagel Tart
        /       \
      Pie     Cake
"""
inventory_items = ["Bread", "Croissant", "Donut", "Muffin", "Scone", "Bagel", "Tart"
inventory2 = build_tree(inventory_items)

print(vertical_inventory_display(inventory2))
```

Example Output 2:

```
[['Muffin'], ['Croissant', 'Pie'], ['Bread', 'Scone', 'Bagel'], ['Donut', 'Cake'], [
```

▾ Advanced Problem Set Version 2

Problem 1: Largest Pumpkin in Each Row

Given the root of a binary tree `pumpkin_patch` where each node represents a pumpkin in the patch and each node value represents the pumpkin's size, return an array of the largest pumpkin in each row of the pumpkin patch. Each level in the tree represents a row of pumpkins.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def largest_pumpkins(pumpkin_patch):
    pass
```

Example Usage:

```
"""
    1
   /  \
  3    2
 / \    \
5   3    9
"""
# Using build_tree() function included at the top of the page
pumpkin_sizes = [1, 3, 2, 5, 3, None, 9]
pumpkin_patch = build_tree(pumpkin_sizes)

print(largest_pumpkins(pumpkin_patch))
```

Example Output:

```
[1, 3, 9]
```

Problem 2: Counting Room Clusters

Given the root of a binary tree `hotel` where each node represents a room in the hotel and each node value represents the theme of the room, return the number of **distinct clusters** in the hotel. A distinct cluster is defined as a group of connected rooms (connected by edges) where each room has the same theme (`val`).

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def count_clusters(hotel):
    pass
```

Example Usage:

```
"""
      👻
    /    \
  👻      👹
 /  \       \
👻  👹      👹
"""
# Using build_tree() function included at the top of the page
themes = ["👻", "👻", "👹", "👻", "👹", None, "👹"]
hotel = build_tree(themes)

print(count_clusters(themes))
```

Example Output:

```
3
```

Problem 3: Duplicate Sections of the Hotel

On one of your shifts at the haunted hotel, you find that you keep stumbling upon the same rooms in different halls. It's almost as if some parts of the hotel are being duplicated...

Given the root of a binary tree `hotel` where each node represents a room in the hotel, return a list of the roots of all duplicate subtrees. For each kind of duplicate subtree, you only need to return the root node of any **one** of them. Two trees are duplicate if they have the same structure and the same node values.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def find_duplicate_subtrees(hotel):
    pass
```

Example Usage:

```
"""
        Lobby
      /       \
    101      123
    /        /  \
  201      101  201
          /
         201
"""
# Using build_tree() function included at top of page
rooms = ["Lobby", 101, 123, 201, None, 101, 201, None, None, 201]
hotel = build_tree(rooms)

# Using print_tree() function included at top of page
subtree_lst = find_duplicate_subtrees(hotel)
for subtree in subtree_lst:
    print_tree(subtree)
```

Example Output:

```
[2, 4]
[4]
Explanation:
Subtrees:
   Subtree 1   Subtree 2
     101         201
     /
   201
```

Problem 4: Organizing Haunted Hallways

The haunted hotel is expanding, and the management wants to add new hallways filled with rooms that must be carefully arranged to maintain a spooky atmosphere. Given an integer array `rooms` sorted in ascending order where each element represents a unique room number, write a function that converts the array into a height-balanced binary search tree (BST) and returns the root of the balanced tree.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def array_to_bst(rooms):
    pass
```

Example Usage:

```
rooms = [4, 7, 13, 666, 1313]

# Using print_tree() function included at top of page
print_tree(array_to_bst(rooms))
```

Example Output:

```
[13, 7, 1313, 4, None, 666]
Explanation:
Balanced Tree:
       13
      /  \
    7    1313
  /       /
 4       666

[13, 4, 666, None, 7, 1313] is also an acceptable answer.

        13
      /  \
     4   666
      \     \
       7    1313
```

Problem 5: Count Cursed Hallways

The haunted hotel is known for its mysterious hallways, where guests often lose their way. Some hallways are said to be cursed, leading travelers to strange places when they follow a certain sequence of rooms. A hallway is said to be cursed if the sum of its room numbers adds up to a `target_sum`.

Given the root of a binary tree `hotel` where each node represents a room number in the hotel and an integer `target_sum` that represents the cursed sum, return the number of distinct paths in the hotel where the sum of the room numbers along the path equals `target_sum`

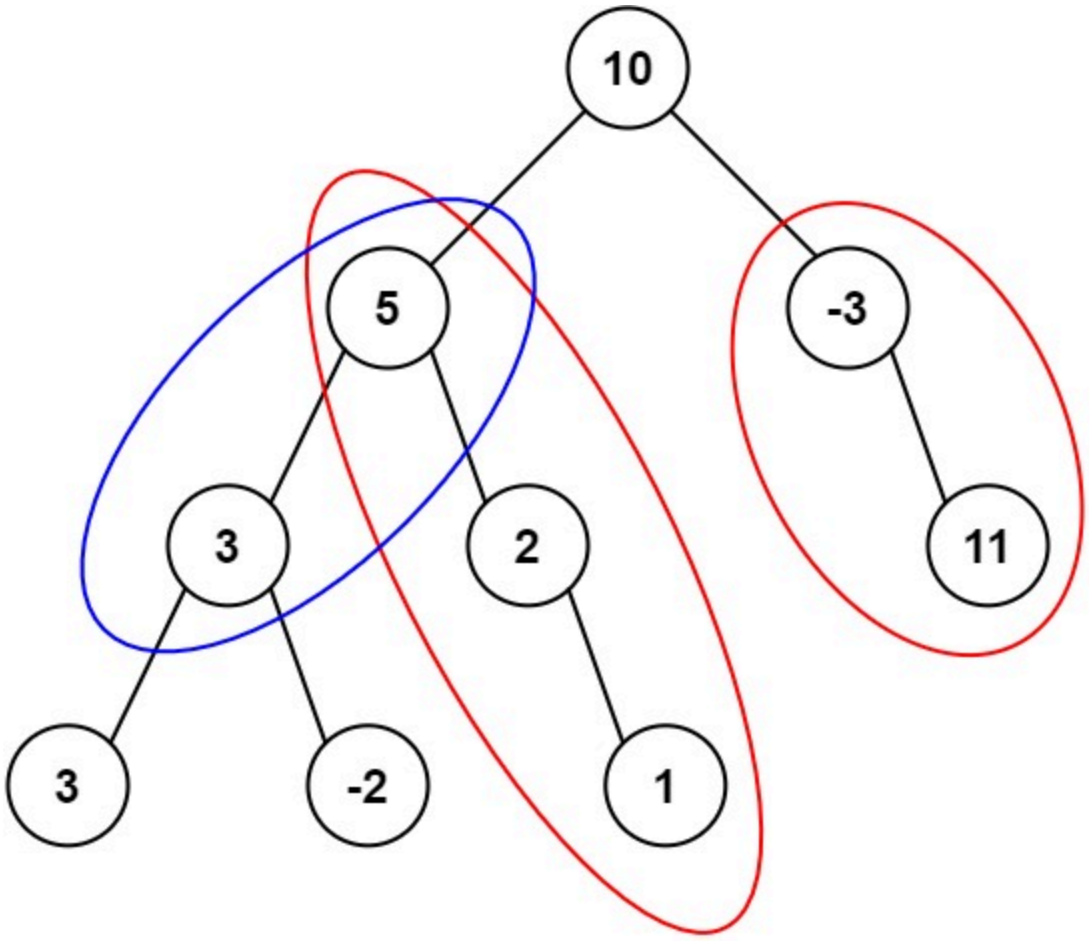
The path can start and end at any room but must follow the direction from parent rooms to child rooms. Your task is to count all such cursed paths that yield the exact `target_sum`.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def count_cursed_hallways(hotel, target_sum):
    pass
```

Example Usage:



```
"""
        10
       /  \
      /    \
     5      -3
    / \       \
   3   2      11
  / \   \
 3  -2   1
"""
# Using build_tree() function included at top of page
room_numbers = [10,5,-3,3,2,None,11,3,-2,None,1]
hotel = build_tree(room_numbers)

print(count_cursed_hallways(hotel, 8))
```

Example Output:

```
3
```

Problem 6: Step by Step Directions to Hotel Room

You have a lost guest who needs step by step directions to their hotel room. The hotel is stored in a binary tree where each node represents a room in the hotel. Each room in the hotel is uniquely assigned a value from `1` to `n`. You have the `root` of the hotel with `n` rooms, an integer `current_location` representing the value of the start node `s` and an integer `room_number` representing the value of the destination node `t`.

Find the shortest path starting from node `s` and ending at node `t`. Return step by step directions for the guest of this path as a string consisting of only uppercase letters `'L'`, `'R'`, and `'U'`. Each letter indicates a specific direction:

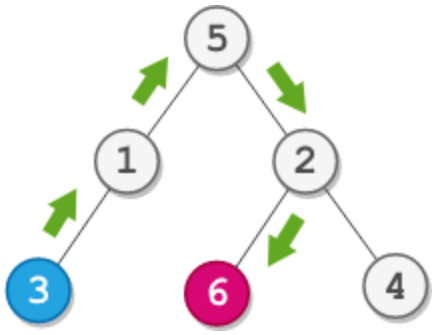
- `'L'` means to go from a node to its left child node.
- `'R'` means to go from a node to its right child node.
- `'U'` means to go from a node to its parent node.

Evaluate the time and space complexity of your function. Define your variables and provide a rationale for why you believe your solution has the stated time and space complexity. Evaluate the complexities for both a balanced and unbalanced tree.

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

def count_cursed_hallways(hotel, current_location, room_number):
    pass
```

Example Usage 1:



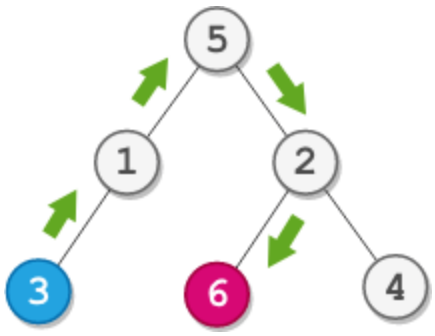

```
"""
       5
      / \
     1   2
    /   / \
   3   6   4
"""
# Using build_tree() function included at top of page
room_nums = [5,1,2,3,None,6,4]
hotel1 = build_tree(hotel1)

print(count_cursed_hallways(hotel1))
```

Example Output 2:

```
UURL
Explanation: The shortest path is: 3 -> 1 -> 5 -> 2 -> 6
```

Example Usage 2:



```
"""
  2
 /
1
"""
hotel2 = TreeNode(1, TreeNode(2))

print(count_cursed_hallways(hotel2))
```

Example Output 2:

```
L
Explanation: The shortest path is: 2 -> 1
```

Close Section