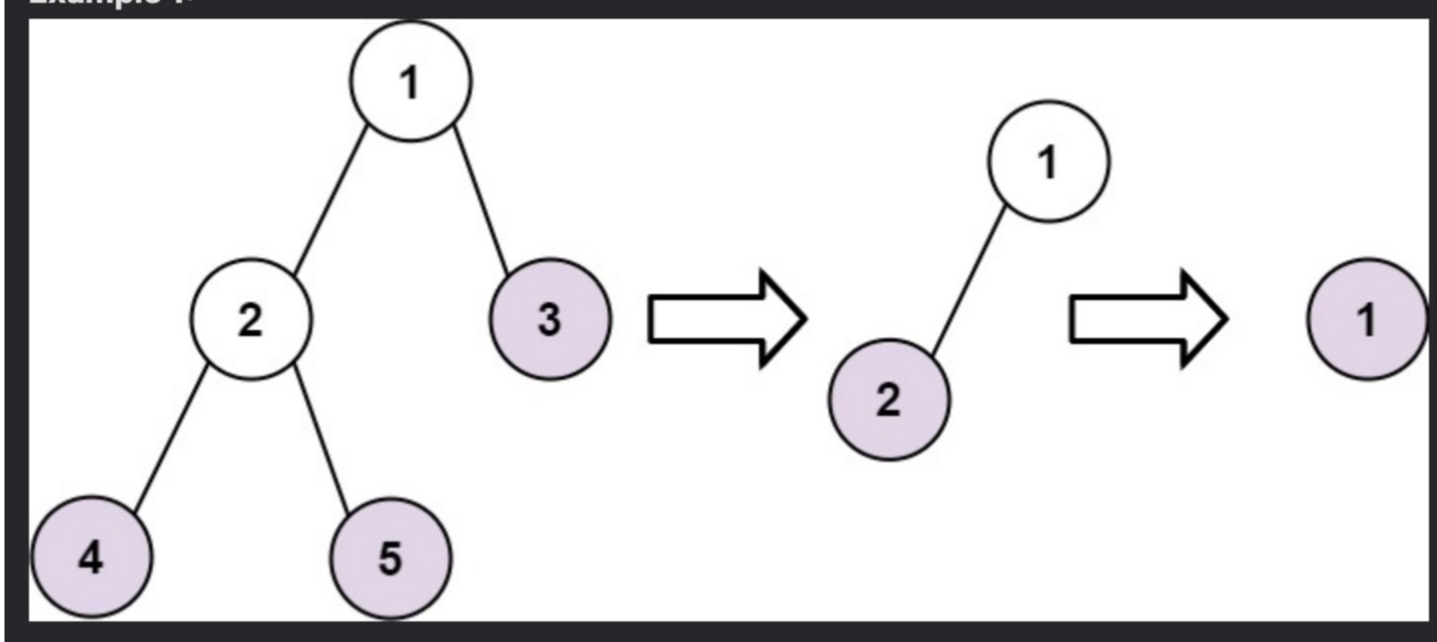
366. Find Leaves of Binary Tree

[Leetcode Link](#)

Given the `root` of a binary tree, collect a tree's nodes as if you were doing this:

- Collect all the leaf nodes.
- Remove all the leaf nodes.
- Repeat until the tree is empty.

Example 1:



Input: `root = [1,2,3,4,5]`
Output: `[[4,5,3],[2],[1]]`
Explanation:
`[[3,5,4],[2],[1]]` and `[[3,4,5],[2],[1]]` are also considered correct answers since per each level it does not matter the order on which elements are returned.

Example 2:

Input: `root = [1]` **Output:** `[[1]]`

Constraints:

- The number of nodes in the tree is in the range `[1, 100]`.
- `-100 <= Node.val <= 100`

Solution

Brute Force

We can simply implement a solution that does what the problem asks one step at a time.

First, we will run a [DFS](#) to find all leaf nodes. Then, we'll remove them from the tree. We'll keep repeating that process until the tree is empty.

Let N denote the number of nodes in the tree.

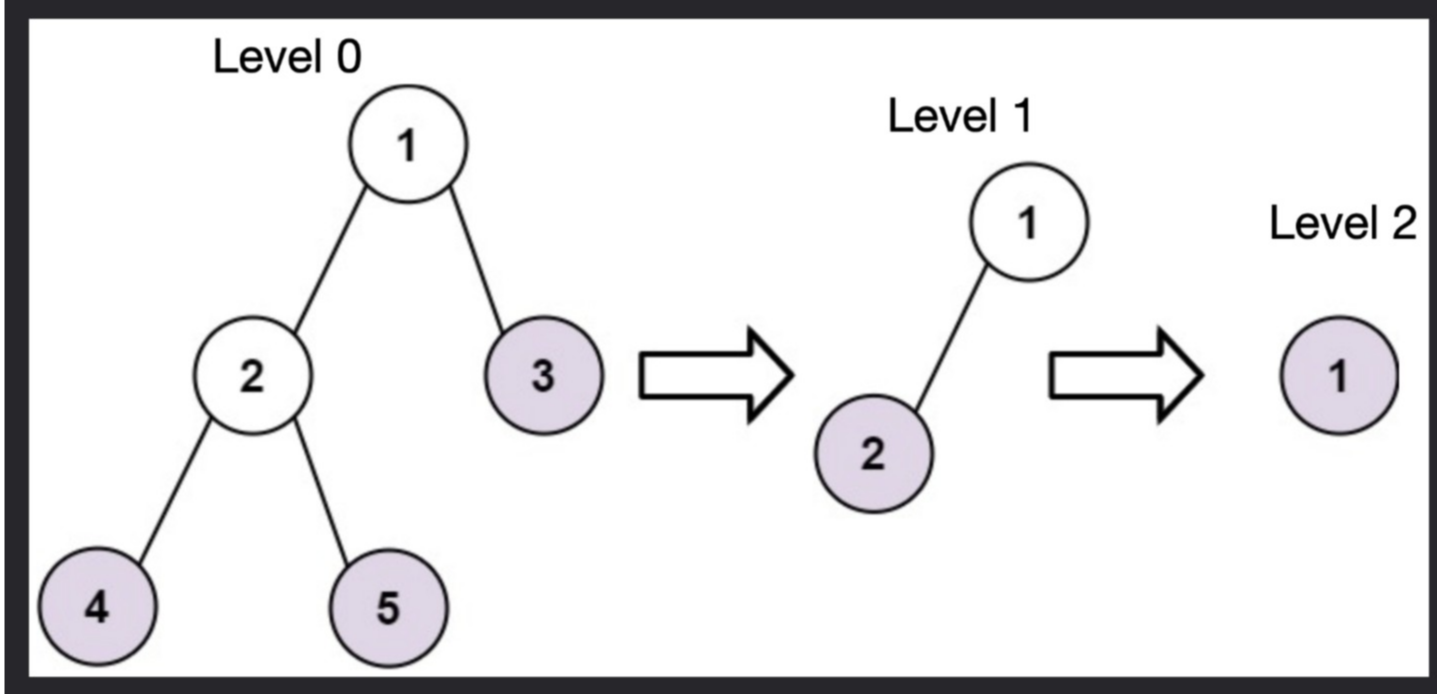
In the worst scenario (line graph), we will repeat this process $O(N)$ times and obtain a time complexity of $O(N^2)$.

However, a more efficient solution exists.

Full Solution

Let's denote the level of a node u as the step u will be removed as a leaf node. For convenience, we will start counting steps from 0.

Example



Here, nodes `3, 4, 5` have a level of 0. Node 2 has a level of 1 and node 1 has a level of 2.

How do we find the level of a node?

One observation we can make is that for a node to be removed as a leaf in some step, all the children of that node have to be removed one step earlier. Obviously, if a node is a leaf node in the initial tree, it will be removed on step 0.

If a node u has one child v, u will be removed one step after v (i.e. `level[u] = level[v] + 1`).

However, if a node u has two children v and w, u is removed one step after both v and w get removed. Thus, we obtain `level[u] = max(level[v], level[w]) + 1`.

For the algorithm, we will run a [DFS](#) and calculate the level of all the nodes in postorder with the method mentioned above. An article about postorder traversal can be found [here](#). For this solution, we need to visit the children of a node before that node itself as the level of a node is calculated from the level of its children. Postorder traversal is suitable for our solution because it does exactly that.

Time Complexity

Our algorithm is a [DFS](#) which runs in $O(N)$.

Time Complexity: $O(N)$

Space Complexity

Since we return $O(N)$ integers, our space complexity is $O(N)$.

Space Complexity: $O(N)$

C++ Solution

```cpp
/**
 * Definition for a binary tree node.
 * struct TreeNode {
 *     int val;
 *     TreeNode *left;
 *     TreeNode *right;
 *     TreeNode() : val(0), left(nullptr), right(nullptr) {}
 *     TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
 *     TreeNode(int x, TreeNode *left, TreeNode *right) : val(x), left(left),
 * right(right)
 * {}
 * };
 */
class Solution {
    vector<vector<int>> ans;  // ans[i] stores all nodes with a level of i
   public:
    int dfs(TreeNode* u) {    // dfs function returns the level of current node
        if (u == nullptr) {
            return -1;
        }
        int leftLevel = dfs(u->left);
        int rightLevel = dfs(u->right);
        int currentLevel =
            max(leftLevel, rightLevel) + 1;  // calculate level of current node
        while (ans.size() <=
               currentLevel) {  // create more space in ans if necessary
            ans.push_back({});
        }
        ans[currentLevel].push_back(u->val);
        return currentLevel;
    }
    vector<vector<int>> findLeaves(TreeNode* root) {
        dfs(root);
        return ans;
    }
};
```

Java Solution

```java
/**
 * Definition for a binary tree node.
 * public class TreeNode {
 *     int val;
 *     TreeNode left;
 *     TreeNode right;
 *     TreeNode() {}
 *     TreeNode(int val) { this.val = val; }
 *     TreeNode(int val, TreeNode left, TreeNode right) {
 *         this.val = val;
 *         this.left = left;
 *         this.right = right;
 *     }
 * }
 */
class Solution {
    List<List<Integer>> ans = new ArrayList<List<Integer>>();
    // ans[i] stores all nodes with a level of i
    public int dfs(TreeNode u) {
        if (u == null) {
            return -1;
        }
        int leftLevel = dfs(u.left);
        int rightLevel = dfs(u.right);
        int currentLevel = Math.max(leftLevel, rightLevel)
            + 1; // calculate level of current node
        while (ans.size()
            <= currentLevel) { // create more space in ans if necessary
            ans.add(new ArrayList<Integer>());
        }
        ans.get(currentLevel).add(u.val);
        return currentLevel;
    }
    public List<List<Integer>> findLeaves(TreeNode root) {
        dfs(root);
        return ans;
    }
}
```

Python Solution

```python
# Definition for a binary tree node.
# class TreeNode:
#     def __init__(self, val=0, left=None, right=None):
#         self.val = val
#         self.left = left
#         self.right = right
class Solution:
    def findLeaves(self, root: Optional[TreeNode]) -> List[List[int]]:
        ans = [[]]  # ans[i] stores all nodes with a level of i

        def dfs(u):
            if u == None:
                return -1
            leftLevel = dfs(u.left)
            rightLevel = dfs(u.right)
            currentLevel = (
                max(leftLevel, rightLevel) + 1
            )  # calculate level of current node
            while len(ans) <= level:  # create more space in ans if necessary
                ans.append([])
            ans[level].append(u.val)
            return level

        dfs(root)
        return ans
```

Got a question? [Ask the Teaching Assistant](#) anything you don't understand.