776. Split BST

Feb. 3, 2018 | 12K views

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Given a Binary Search Tree (BST) with root node `root`, and a target value `V`, split the tree into two subtrees where one subtree has nodes that are all smaller or equal to the target value, while the other subtree has all nodes that are greater than the target value. It's not necessarily the case that the tree contains a node with value `V`.

Additionally, most of the structure of the original tree should remain. Formally, for any child C with parent P in the original tree, if they are both in the same subtree after the split, then node C should still have the parent P.

You should output the root TreeNode of both subtrees after splitting, in any order.

Example 1:

```
Input: root = [4,2,6,1,3,5,7], V = 2
Output: [[2,1],[4,3,6,null,null,5,7]]
Explanation:
Note that root, output[0], and output[1] are TreeNode objects, not arrays.

The given tree [4,2,6,1,3,5,7] is represented by the following diagram:

          4
        /   \
      2      6
     / \    / \
    1   3  5   7

while the diagrams for the outputs are:

          4
        /   \
      3      6      and    2
            / \            /
           5   7          1
```

Note:

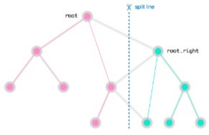
1. The size of the BST will not exceed `50`.
2. The BST is always valid and each node's value is different.

Approach #1: Recursion [Accepted]

Intuition and Algorithm

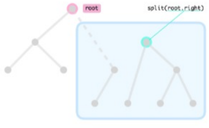
The `root` node either belongs to the first half or the second half. Let's say it belongs to the first half.

Then, because the given tree is a *binary search tree* (BST), the entire subtree at `root.left` must be in the first half. However, the subtree at `root.right` may have nodes in either halves, so it needs to be split.



In the diagram above, the thick lines represent the main child relationships between the nodes, while the thinner colored lines represent the subtrees after the split.

Lets say our secondary answer `bns = split(root.right)` is the result of such a split. Recall that `bns[0]` and `bns[1]` will both be BSTs on either side of the split. The left half of `bns` must be in the first half, and it must be to the right of `root` for the first half to remain a BST. The right half of `bns` is the right half in the final answer.



The diagram above explains how we merge the two halves of `split(root.right)` with the main tree, and illustrates the line of code `root.right = bns[0]` in the implementations.

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```python
class Solution(object):
    def splitBST(self, root, V):
        if not root:
            return None, None
        elif root.val <= V:
            bns = self.splitBST(root.right, V)
            root.right = bns[0]
            return root, bns[1]
        else:
            bns = self.splitBST(root.left, V)
            root.left = bns[1]
            return bns[0], root
```

Complexity Analysis

- Time Complexity: $O(N)$, where N is the number of nodes in the input tree, as each node is checked once.
- Space Complexity: $O(N)$.

Analysis written by: @awice.

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kenteng ★116 February 9, 2018 12:23 AM

Why is this problem medium? it is so convoluted. If given at an interview, I don't think I can write out clear codes like this.

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shikleinlk ★21 October 2, 2018 9:36 PM

What 'bns' stands for?

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calvinchankf ★2515 February 22, 2019 9:01 AM

Here is a potential follow-up: what if it is an **exclusive split**? e.g. for a BST root=[1,2,3,4,5], V=3, we want to output [[1,2], [4,5]]

BTW I think this question should also be included in the Explore/Learn session, along with other classic operations such as Search, Insert, Delete and Merge.

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srm012345 ★443 October 2, 2018 6:56 PM

I got so much grey hair trying to understand what "The left half of bns must be in the first half, and it must be to the right of root for the first half to remain a BST." means.

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StefanPochmann ★46955 February 4, 2018 6:59 PM

> Time Complexity: O(N), where N is the number of nodes in the input tree, as each node is checked once.

You could also say O(height), right? Your *"each node is checked once"* sounds so absolute, like that's always the case, not just in worst cases.

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aimjwizardslint ★8 August 10, 2018 4:32 AM

time complexity is the height of the tree, at any level, only one node is visited.

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dannyli0818 ★115 June 11, 2019 12:09 PM

I was thinking about in order traverse, but after seeing this one... forget about it LOL

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kofkofkof ★12 February 27, 2018 10:44 PM

@kenteng, isn't this the reason why we are looking around here, eh? this question and delete a node in BST are both convoluted to me. guess just need to think more and adapt to those questions.

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coder_93 ★16 September 3, 2018 3:08 AM

What an elegant solution!

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powelhuang17 ★50 April 12, 2018 2:46 AM

Very clear! Nice work awice!

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