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700. Search in a BST (/problems/search-in-a-binary-search-tree/)

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Given the root node of a binary search tree (BST) and a value. You need to find the node in the BST that the node's value equals the given value. Return the subtree rooted with that node. If such node doesn't exist, you should return NULL.

For example,

```
Given the tree:
        4
       / \
      2   7
     / \
    1   3

And the value to search: 2
```

You should return this subtree:

```
      2
     / \
    1   3
```

In the example above, if we want to search the value `5`, since there is no node with value `5`, we should return `NULL`.

Note that an empty tree is represented by `NULL`, therefore you would see the expected output (serialized tree format) as `[]`, not `null`.

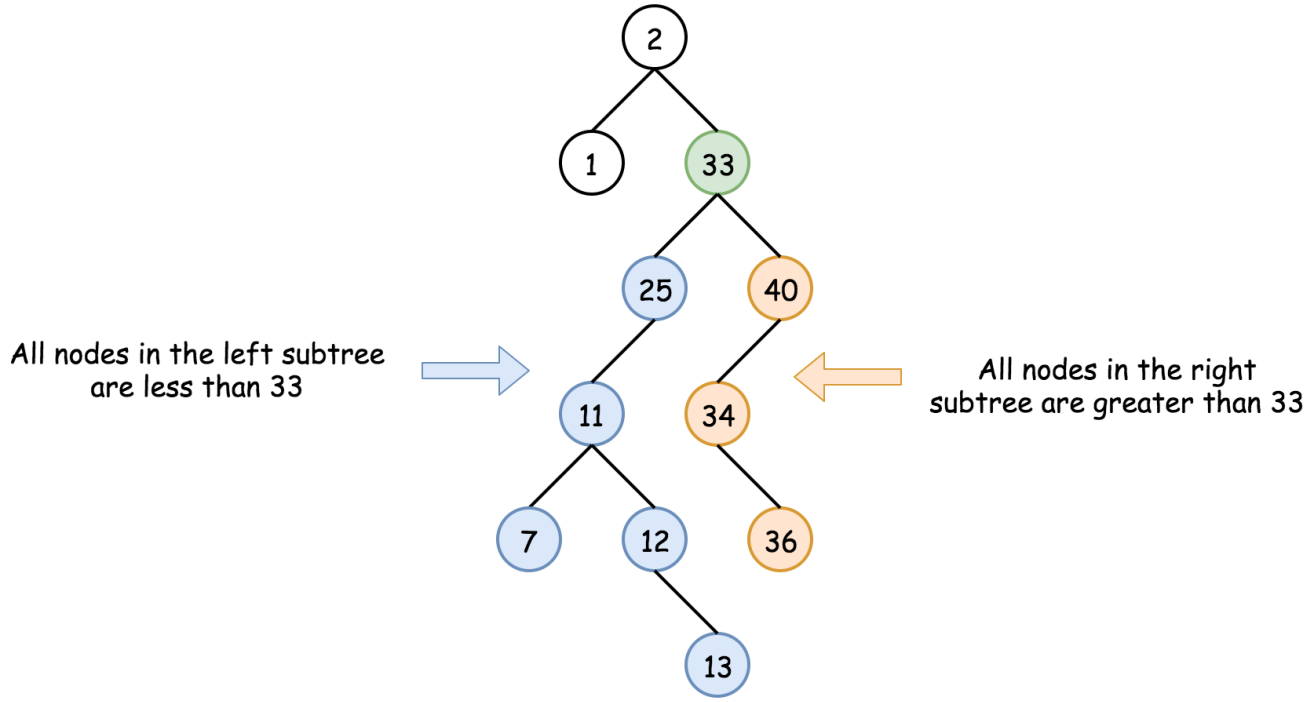
Solution

Binary Search Tree.

Binary Search Tree is a binary tree where the key in each node

- is greater than any key stored in the left sub-tree,
- and less than any key stored in the right sub-tree.

Here is an example:



Such data structure provides the following operations in a logarithmic time:

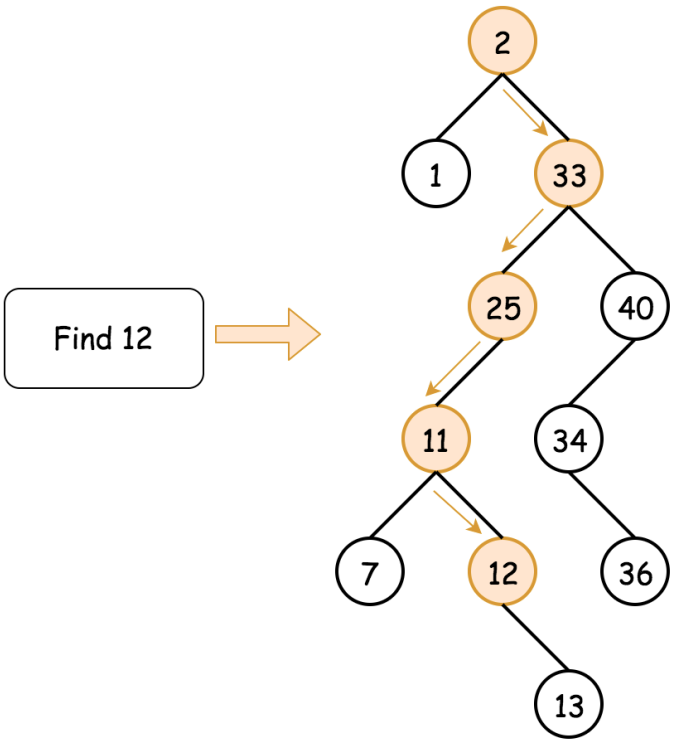
- Search.
- Insert (https://leetcode.com/articles/insert-into-a-bst/).
- Delete (https://leetcode.com/articles/delete-node-in-a-bst/).

Approach 1: Recursion

Algorithm

The recursion implementation is very straightforward:

- If the tree is empty `root == null` or the value to find is here `val == root.val` - return root.
- If `val < root.val` - go to search into the left subtree `searchBST(root.left, val)`.
- If `val > root.val` - go to search into the right subtree `searchBST(root.right, val)`.
- Return `root`.



Implementation

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```
class Solution:
    def searchBST(self, root: TreeNode, val: int) -> TreeNode:
        if root is None or val == root.val:
            return root

        return self.searchBST(root.left, val) if val < root.val \
            else self.searchBST(root.right, val)
```

Complexity Analysis

- Time complexity : $\mathcal{O}(H)$, where H is a tree height. That results in $\mathcal{O}(\log N)$ in the average case, and $\mathcal{O}(N)$ in the worst case.

  Let's compute time complexity with the help of master theorem (https://en.wikipedia.org

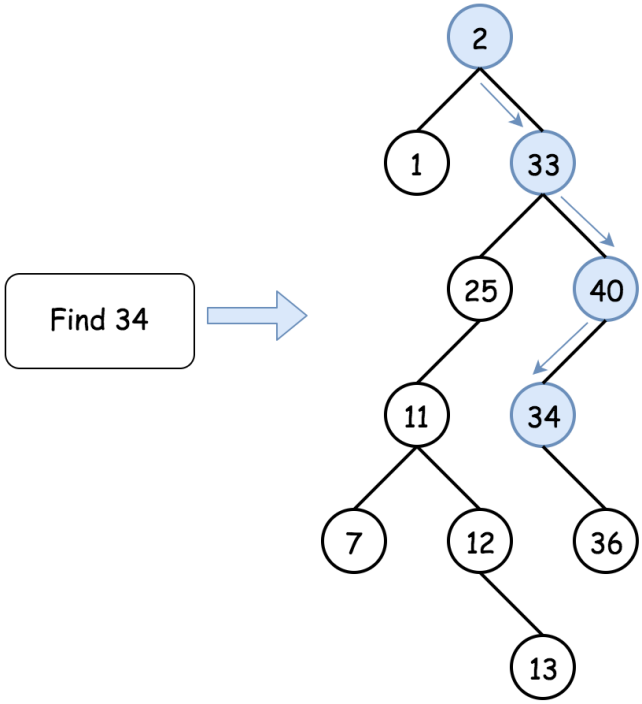
/wiki/Master_theorem_(analysis_of_algorithms)) $T(N) = aT\left(\frac{N}{b}\right) + \Theta(N^d)$. The equation represents dividing the problem up into a subproblems of size $\frac{N}{b}$ in $\Theta(N^d)$ time. Here at step there is only one subproblem `a = 1`, its size is a half of the initial problem `b = 2`, and all this happens in a constant time `d = 0`, as for the binary search. That means that $\log_b a = d$ and hence we're dealing with case 2 (https://en.wikipedia.org/wiki/Master_theorem_(analysis_of_algorithms)#Case_2_example) that results in $\mathcal{O}(n^{\log_b a} \log^{d+1} N) = \mathcal{O}(\log N)$ time complexity.

- Space complexity : $\mathcal{O}(H)$ to keep the recursion stack, i.e. $\mathcal{O}(\log N)$ in the average case, and $\mathcal{O}(N)$ in the worst case.

Approach 2: Iteration

To reduce the space complexity, one could convert recursive approach into the iterative one:

- While the tree is not empty `root != null` and the value to find is *not* here `val != root.val`:
  - If `val < root.val` - go to search into the left subtree `root = root.left`.
  - If `val > root.val` - go to search into the right subtree `root = root.right`.
- Return `root`.



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```
class Solution:
    def searchBST(self, root: TreeNode, val: int) -> TreeNode:
        while root is not None and root.val != val:
            root = root.left if val < root.val else root.right
        return root
```

Complexity Analysis

- Time complexity : $\mathcal{O}(H)$, where H is a tree height. That results in $\mathcal{O}(\log N)$ in the average case, and $\mathcal{O}(N)$ in the worst case.

  Let's compute time complexity with the help of master theorem (https://en.wikipedia.org/wiki/Master_theorem_(analysis_of_algorithms)) $T(N) = aT\left(\frac{N}{b}\right) + \Theta(N^d)$. The equation represents dividing the problem up into a subproblems of size $\frac{N}{b}$ in $\Theta(N^d)$ time. Here at step there is only one subproblem `a = 1`, its size is a half of the initial problem `b = 2`, and all this happens in a constant time `d = 0`, as for the binary search. That means that $\log_b a = d$ and hence we're dealing with case 2 (https://en.wikipedia.org/wiki/Master_theorem_(analysis_of_algorithms)#Case_2_example) that results in $\mathcal{O}(n^{\log_b a}\log^{d+1} N) = \mathcal{O}(\log N)$ time complexity.

- Space complexity : $\mathcal{O}(1)$ since it's a constant space solution.

Analysis written by @liaison (https://leetcode.com/liaison/) and @andvary (https://leetcode.com/andvary/)

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(/ajaay)

ajaay (ajaay) ★ 4 September 13, 2019 1:58 PM

If the compiler supports tail-recursion optimization, I think the recursive solution would also use O(1) memory. GCC supports this if the -O2 or -O3 flags are used.

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(/qiuqiushasha)

qiuqiushasha (qiuqiushasha) ★ 9 September 14, 2019 8:24 AM

@tailrec in Scala is my favoriate

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